ORIGINAL ARTICLE

Single-stage anterior debridement, posterior instrumentation and global fusion in thoracic and thoracolumbar tubercular spondylodiscitis

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Abstract

Purpose The present study evaluated the clinical and radiological outcomes in patients with tuberculosis of the thoracic and thoracolumbar spine, treated by an operative technique in which anterior debridement with posterior instrumentation and global fusion was performed through a single-stage posterior approach.

Methods Ninty-seven patients with spinal tuberculosis, between T1 and L1, in whom anterior debridement, bone grafting, with posterior instrumentation and fusion was performed through a single-stage posterior approach, with a minimum follow-up of 2 years, formed the basis of this study. During each follow-up, neurological recovery was assessed using modified American Spinal Injury Association grading, healing of the disease was assessed by appearance of sclerosis and interbody fusion and the degree of kyphotic deformity was analysed using the modified Konstam's angle.

Result Two hundred and twenty-six lesions were found in the radiographs of 97 patients with 28.9% of them having multiple lesions. The mean $\pm$ SD preoperative, post-operative, and 2-year follow-up kyphotic angle were $49.5 \pm 18.4°$, $22.6 \pm 7.1°$ and $24.5 \pm 7.6°$, respectively, and showed significant kyphosis correction ($P < 0.01$). Sclerosis was seen as early as 3 months in 82(84.5%) patients whereas interbody fusion started appearing at the end of 6 months in 38.14% of patients and peaked at 1 year. All patients recovered neurologically, with no significant loss of kyphosis correction, at final follow-up.

Conclusion The surgical technique described in this study had favourable clinical and radiological outcomes. Early surgery helps in having a definitive diagnosis and detects the presence of drug-resistant strains.

Keywords Spinal tuberculosis · Anterior debridement · Posterior instrumentation · Global fusion

Introduction

Tuberculosis of spine is the commonest form of osteoarticular tuberculosis [1]. It is associated with bone destruction leading to kyphosis and paraplegia. The aim of treatment in these cases is the eradication of infection and restoration of spinal stability by interbody fusion [2]. Following multicentric trials, the medical research council recommended that the mainstay of treatment for spinal tuberculous is chemotherapy, and all other forms of treatment are only supplementary [3]. Even though these studies have shown good results with non-operative treatment, long-term follow-up of these cases revealed the progression of kyphosis leading to late-onset paraplegia and pulmonary insufficiency [4].

Tuberculosis of the spine can mimic other disorders and may be missed, mistaken, or misdiagnosed [5]. Thus, in recent times, many authors have advocated early surgical treatment to confirm the diagnosis and prevent late complications. Advances in biomaterials and safe anaesthetic technique have popularised the use of internal fixation devices, for better outcomes. Studies done by Oga et al. [6] and Chen et al. [7] demonstrated that implants can safely be used in tubercular lesions. Currently, the surgical procedures described for spinal tuberculosis are: (1) anterior debridement, bone grafting/cage with internal fixation; (2) posterior spinal stabilization and fusion; (3) anterior debridement, bone grafting/cage combined with posterior instrumentation and fusion, which may be performed as a one- or two-stage procedure [8–15].

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We describe an operative technique in which anterior debridement and bone grafting, with posterior spinal instrumentation and fusion, was performed through a single-stage posterior approach. The aim of the present study was to evaluate the outcomes in patients with tuberculosis of the thoracic and thoracolumbar spine, treated by this technique, with regard to healing of the disease, neurological recovery, correction and prevention of kyphotic deformity.

Materials and methods

In a retrospective study, 186 consecutive patients, who presented with clinical and radiological features of spinal tuberculosis, between January 2011 and December 2015, were analysed. Sixty-one patients with nontubercular spondylodiscitis, tumours and those managed non-operatively were excluded. Twenty-eight patients with lesions isolated to the cervical and lumbar spine were also excluded. Thus, 97 patients with spinal tuberculosis, between T1 and L1, proven by histological or cartridge-based nucleic acid amplification test, with a minimum follow-up of 2 years, formed the basis of this study. All patients were operated and followed up by the senior author (SPM). The surgical technique was similar in all cases. Institutional ethical committee clearance was obtained prior to commencement of the study.

Preoperative assessment

All patients underwent a thorough clinical examination to evaluate the site of tenderness and spinal deformity. Neurological examination was done and its status was classified according to the American Spinal Injury Association (ASIA) modification of Frankel grading [16]. The erythrocyte sedimentation rate and baseline liver function tests were done in all cases, and they were also screened for HIV-1 and -2. Digitalised anteroposterior and lateral radiographs of the dorsolumbar spine from T1 to L5 and posteroanterior chest radiographs were analysed by two independent observers (MPK and YKB) in a blinded fashion. The level, type of lesion and the extent of vertebral destruction were noted. The preoperative kyphotic deformity was measured using the modified Konstam's angle [17, 18]. The same method was later used to determine the immediate post-operative and follow-up kyphotic angles. Magnetic resonance imaging of the whole spine was obtained to determine the presence of skip lesions, epidural and paravertebral abscesses and extent of cord involvement.

Operative technique

The anaesthetised patient was positioned prone on a Relton–Hall frame. Using a lateral fluoroscopic image, the diseased, upper and lower vertebrae to be instrumented were marked. The spine was exposed through a posterior midline approach, up to the transverse processes on either side. At the level of the diseased vertebrae, the transverse processes were resected bilaterally using a rongeur. The ribs at these levels were exposed subperiosteally (Fig. 1). Care was taken to ensure that the pleura was not injured. Seven centimetres of the rib at the diseased level was resected using a rib shear, and the rib head was dislodged from the costovertebral joint, thereby completing the costotransversectomy. The rib proximal to it was resected in a similar manner. The intervening intercostal neurovascular bundle was doubly ligated and transected. The paravertebral abscess was drained by blunt dissection. A similar procedure was carried out on the other side. Pedicle screws or hooks were inserted two levels above and below the diseased vertebrae. After temporary stabilization of the spine, a thorough debridement of the diseased vertebrae was carried out from both sides. Pus from the cold abscess and tissue obtained during debridement were sent for aerobic culture, Gram staining, Ziehl–Neelson staining, cartridge-based nucleic acid amplification test and histopathological examination. A sterile gauze was passed from one side to the other, and the debrided area was packed (Fig. 2). The lower borders of the spinous processes and laminae were trimmed and the ligamentum flavum was removed, exposing the dural sac. This facilitated shortening of the posterior column during kyphosis correction. The rod used for temporary stabilization was removed and definitive stabilization was done using contoured rods to correct kyphosis. Additional segmental stabilization was achieved using sublaminar wires. A tricortical graft of appropriate size was harvested from the iliac crest. The gauze was removed and the bone graft was passed anteriorly and placed in the gap created following debridement (Fig. 3). In cases with kyphosis less than 30°, grafts were placed only on the sides of the vertebral body. The facet joints, laminae and transverse processes were decorticated, and morselised corticocancellous graft was placed (Fig. 4). The wound was closed in layers over a suction drain. In case of inadvertent pleural injury, an intercostal drainage tube with underwater seal was inserted.

Follow-up

All patients with a confirmed diagnosis of tuberculosis were treated with four drugs for 3 months (intensive phase), followed by two drugs for a minimum period of 9 months (continuation phase). Post-operatively, they were immobilized in a custom-made polyethelene moulded body jacket. Drug-related complications were treated accordingly. They were followed up at 3 months, 6 months, 1 year and annually thereafter for a minimum period of 2 years (mean follow-up 3.8 years). At each follow-up, neurological evaluation was

Fig. 1 Intraoperative photograph **a** of patient positioned prone on a Relton–Hall frame. Illustration **b,** and intraoperative photograph **c**, showing exposure up to bilateral transverse processes through a midline posterior approach
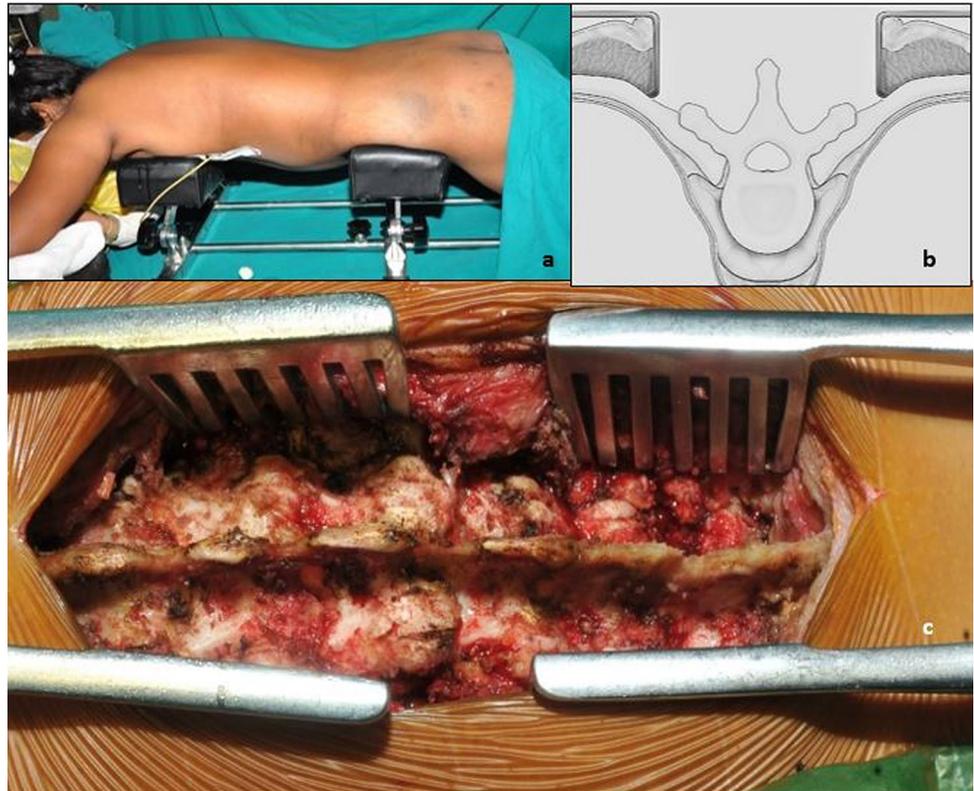

Fig. 2 Illustration showing **a** resection of the transverse processes and ribs bilaterally, **b** two Lane's retractors placed anterior to the vertebral body to facilitate debridement. Intraoperative photograph **c** showing packing of the void following anterior debridement
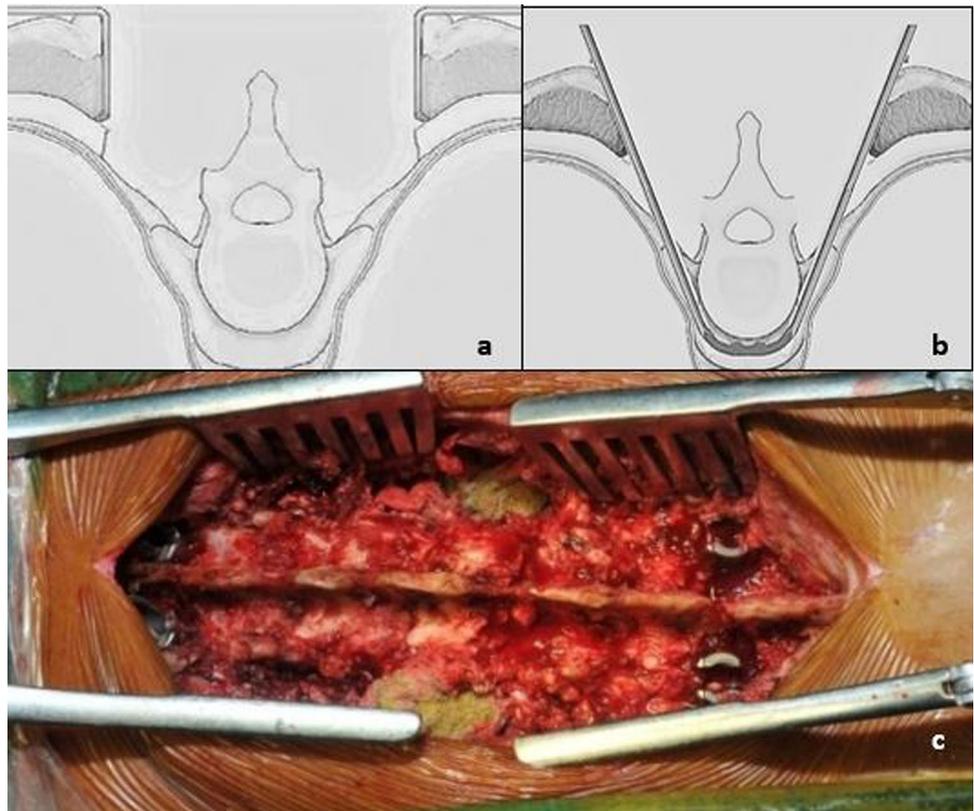
Fig. 3 Intraoperative photograph **a** showing posterior spinal stabilization, **b** tricortical iliac crest graft of appropriate size, **c** drill holes made on either end of the graft for anchoring, **d** tricortical iliac crest graft being passed anteriorly into the defect created following debridement
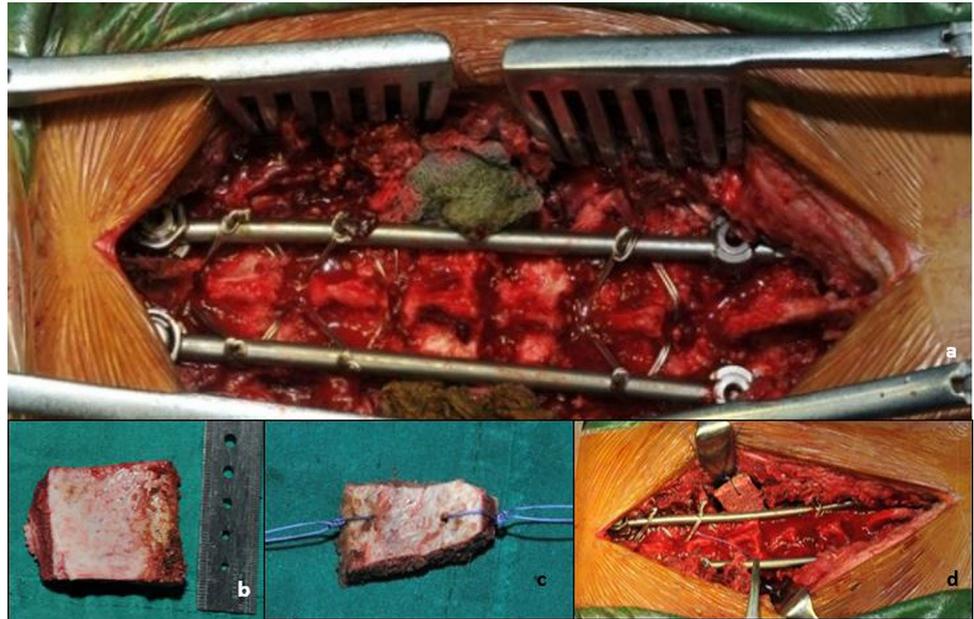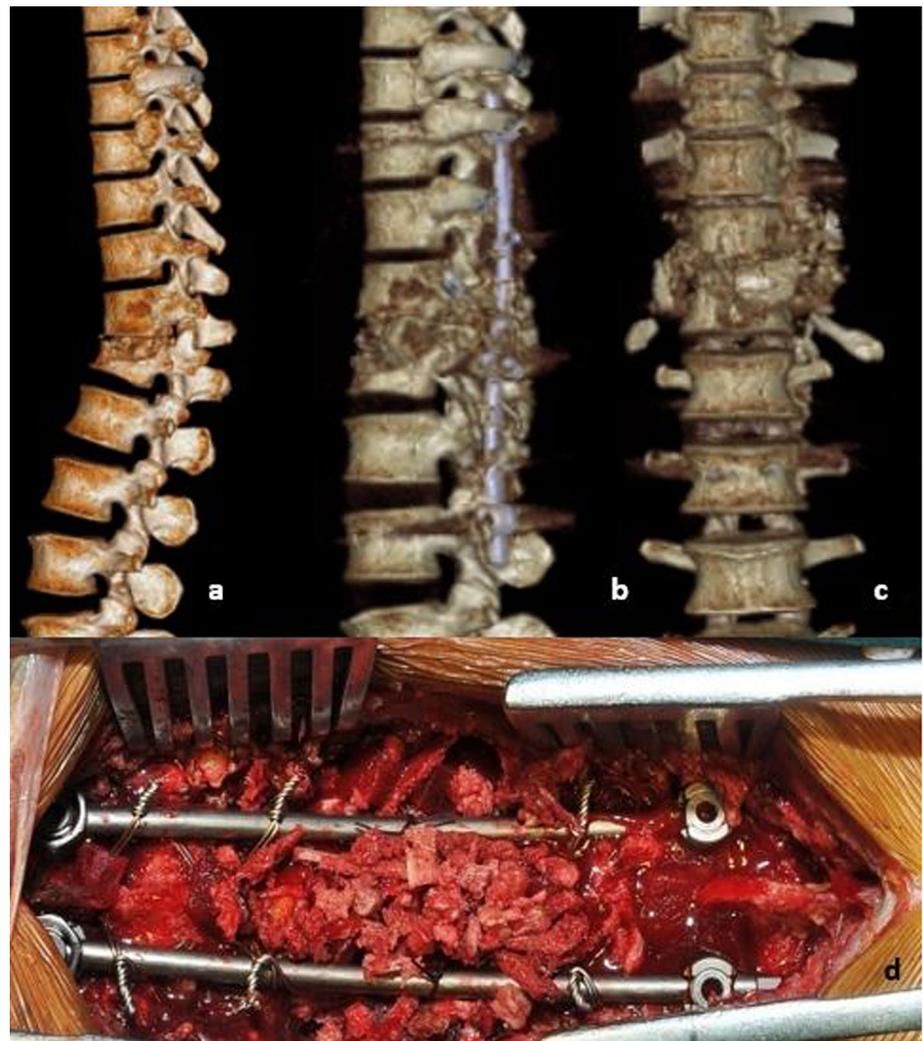

Fig. 4 Preoperative computed tomographic scans with 3D reconstruction **a** showing a paradiscal lesion and kyphosis. Post-operative computed tomographic scans with 3D reconstruction, **b, c** showing correction of kyphosis and position of the tricortical graft following surgery. Intraoperative photograph **d** showing placement of graft posteriorly

carried out to determine degree of neurological recovery. The erythrocyte sedimentation rate and liver function tests were monitored. Anteroposterior and lateral radiographs were obtained to evaluate the status of healing in the form of sclerosis and interbody fusion. The kyphotic angle was measured, and the position of the implants was noted.

Statistical analysis

All statistical analyses were done using Statistical Package for Social Sciences for Windows Version 15. The intraclass correlation coefficient was used to measure inter- and intraobserver variability in measurement of the kyphotic angle. Continuous variables like age, pre- and post-operative and final follow-up kyphotic angle were expressed as mean $\pm$ SD, while categorical variables like gender and presenting symptoms were expressed as percentages. The independent-sample t test was used to compare pre- and post-operative kyphotic angles and loss of correction at final follow-up. The Chi-squared test was used to compare the appearance of interbody fusion at 6-month and 1-year follow-up. A P value less than 0.05 was considered to be statistically significant.

Results

The intraobserver variability ranged from 0.91 to 0.93, and interobserver ranged between 0.87 and 0.92 for preoperative, post-operative and 2-year follow-up kyphotic angle. The mean age of patients at the time of presentation was 41.7 years. Of the 97 patients, 64(65.9%) were males, and 33(34.1%) were females. Eighty-nine (91.8%) patients presented with a backache, whereas 56(57.7%) patients also had a kyphotic deformity. Seven patients had transient deterioration of neurological status, that recovered by 3 months. The neurological status of the patients at admission and at 2-year follow-up is depicted in Table 1.

The mean $\pm$ SD ESR was 45.2 ± 19.7 mm/h at the time of diagnosis. Two hundred and twenty-six lesions were found in the radiographs of 97 patients with 28.9% of them having multiple lesions. Paradiscal lesions were seen in 63.1% of the patients, while central lesions were seen in 30.6%. All patients had histopathological evidence of tuberculosis, whereas cartridge-based nucleic acid amplification test was positive in 91(82.0%) patients. None of the patients had multi-drug-resistant tuberculosis.

In this study, the mean $\pm$ SD preoperative kyphotic angle was $49.5° \pm 18.4°$ with 37 patients having a kyphotic angle more than 60°. The mean $\pm$ SD post-operative and 2-year follow-up kyphotic angle was $22.6° \pm 7.1°$ and $24.5° \pm 7.6°$, respectively. The mean correction of kyphotic deformity was 26.9° which was found to be statistically significant ($P < 0.01$). The mean loss of correction at end of 2-year

Table 1 Neurological status of patients at admission and final follow-up

Neurological status at admission[a]	Neurological status at final follow-up[a]				
	A	B	C	D	E
A			1		2
B				2	2
C				1	10
D					18
E					61

[a]American Spinal Injury Association's modification of Frankel's grading of neurological deficit

follow-up was 1.9° which was not statistically significant (Fig. 5). Sclerosis was seen as early as 3 months in 82(84.5%) patients, whereas interbody fusion started appearing at the end of 6 months in 38.14% of patients and peaked at 1 year. Subgroup analysis revealed that appearance of interbody fusion at 6-month follow-up was significantly less in patients with kyphosis greater than 60° ($P < 0.01$). However, at 1-year follow-up, there was no statistically significant difference in interbody fusion between patients with preoperative kyphosis greater than 60°, compared to those with preoperative kyphosis less than 60°. Two patients had early infection, five patients had late infection, and one had implant loosening which were managed accordingly.

Discussion

Even though non-operative treatment of tuberculosis of the spine was shown to be as effective as surgical treatment in terms of the eradication of the disease and interbody fusion, correction of kyphosis was found to be superior in those treated surgically [3, 4]. However, long-term follow-up showed progression of kyphosis and late-onset paraplegia to be more frequent in those treated non-operatively [4, 17]. During the active phase, the diseased anterior and middle columns are not strong enough to support physiological loads. Thus early ambulant treatment may result in healing with kyphosis, which subsequently places abnormal stresses on the posterior column. In children, this may result in further progression of deformity and late-onset paraplegia [2, 19]. To prevent these unresolvable complications, in recent times, many authors advocate more aggressive surgical treatment even in milder cases. Debridement and bone grafting with stabilization of the diseased vertebrae not only helps confirm the diagnosis, but also ensures kyphosis correction and early interbody fusion [4, 13].

Spinal tuberculosis predominantly affects the anterior and middle columns. Hodgson et al. [20] advocated the anterior approach for debridement and bone grafting as it

Fig. 5 Preoperative lateral radiograph and magnetic resonance imaging **a**, **b** showing tubercular spondylodiscitis involving D11, D12 and L1 with kyphosis. Post-operative lateral radiograph **c** at 1-year fol- low-up showing interbody fusion with correction of kyphosis and **d** at 4-year follow-up showing minimal loss of correction

allowed direct access to the infected focus. Even though they reported high rates of bony fusion with low rate of kyphosis progression, their results could not be reproduced by other investigators. The recurrence of kyphosis was attributed to graft failure in a diseased osteoporotic bone, which could not bear physiological loads. Radical debridement also results in a large defect anteriorly, especially when more than two vertebrae were involved, and this takes a longer time to heal [2, 9, 10, 19]. Studies done by Oga et al. [6] and Chen et al. [7] demonstrated that implants can safely be used in spinal tuberculosis. Thus many authors recommended implantation of titanium cages filled with bone graft supplemented by other internal fixation devices. However, in the thoracic and thoracolumbar spine, anterior instrumentation to provide stability may be tenuous, as the concomitant osteoporosis, due to the infection renders the vertebrae structurally weak. Furthermore, anterior surgery alone does not adequately correct kyphosis and complications following it are difficult to treat [1, 2, 18]. Thus to overcome these limitations, some authors advocated posterior spinal stabilization and fusion. While the posterior approach allows rigid instrumentation and better kyphosis correction, access to the infected focus is limited. Moreover, the fused posterior column delays healing by preventing collapse of the diseased vertebrae [1, 10, 12]. Thus Moon et al. and others advocated a two-stage anterior–posterior approach to overcome stability-related drawbacks of the anterior approach while providing ease of access to the infected focus. However, it necessitated two surgeries with increased operating time and morbidity [14, 15].

In the current study, anterior debridement with posterior spinal stabilization and global fusion was done in a single stage, through a midline posterior approach. The average correction of kyphosis was 26.9° and was comparable with the results of other authors [8–15]. The loss of correction of kyphosis at the end of 2 years was only 1.9° and can be attributed to the high rate of interbody fusion in this study. Rajshekharan et al. [19] have shown that following good interbody fusion, kyphosis does not significantly progress after 2 years. Posterior instrumentation supplemented interbody fusion and did not allow worsening of kyphosis and prevents late-onset paraplegia. In the current study, neurological recovery following surgery was similar to other authors [8–15]. Five cases with secondary infection were treated by implant removal and antibiotic bead application.

Postioning of the patient prone on a Relton–Hall frame helped in correction of kyphosis and decreased intraoperative blood loss. The midline posterior incision allowed ease of access to perform anterior debridement, adequate decompression and bone grafting. The current approach being extrapleural was associated with less morbidity. Shortening of the posterior column by trimming the spinous processes and laminae facilitated kyphosis correction. However, neither laminectomy nor excision of the pedicle was done to access the infected focus, to avoid further destabilizing the spine. The tricortical bone graft provided structural support to the anterior and middle column, while the posterior spinal stabilization and fusion protected it until incorporation. The limitations of the current study include its retrospective nature and medium-term follow-up. Long-term follow-up of

these patients is necessary to determine the effectiveness of this procedure in preventing late complications.

It is known that spinal tuberculosis can mimic other disease and can be missed, mistaken or misdiagnosed. Early surgery helps in having a definitive diagnosis and detects the presence of drug-resistant strains. Tuberculosis of the thoracic and thoracolumbar spine can be successfully treated through a single-stage posterior approach. The surgical technique described in this study is relatively simple and carries minimal intraoperative complications. The neurological and radiological outcomes were comparable to other surgical procedures described for tuberculosis of the spine.

Compliance with ethical standards

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