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Outcome of thoracic and lumbar spine tuberculosis after minimally invasive surgical techniques

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ABSTRACT

Objectives: Various approaches, including anterior, posterior, and combined, have been described to treat surgical candidates with tuberculosis of the spine.

Minimally invasive spine surgery (MIS) is a relatively new approach. Our study aims to evaluate MIS as a practical option for improving the recovery of patients with tubercular spondylodiscitis.

Material and Methods: The study design was a retrospective study conducted from June 2022 to December 2024. A total of 20 patients who fulfilled the inclusion criteria were included in this study.

Results: We identified a mean preoperative Japanese Orthopaedic Association (JOA) score of 14 ± 0.74 to be increased to a mean postoperative (at 6-month follow-up) JOA of 16.33 ± 0.88 and 16.75 ± 0.45 at 1-year follow-up ($p < 0.05$). The mean preoperative Oswestry Disability Index (ODI) score was 44.92 ± 3.26, reduced to a mean postoperative ODI score of 11.08 ± 6.4 in the 6th month and 6.92 ± 3.554 at 1-year follow-up ($p < 0.05$). We found a statistically significant reduction of the Numeric Rating Scale score (8.17 ± 0.72 vs. 1.75 ± 1.14 vs. 1.25 ± 0.75) in our postoperative patients by 6-month and 1-year follow-up, respectively. The grades of spinal fusion based on computed tomography (CT) scan at 1-year follow-up have been demonstrated as follows: Grade 1-5%, Grade 2-30%, Grade 3-55%, and Grade 4-10%.

Conclusion: MIS is a safe and effective option for managing selected patients with tuberculosis of the spine. Overall, MIS in tuberculosis spine surgery is a promising approach that should be considered for patients needing surgical intervention.

Keywords: Minimally invasive technique, Thoracolumbar spine, Tuberculosis

INTRODUCTION

Tuberculosis of the spine is the most common skeletal manifestation of tuberculosis, which constitutes 50% of skeletal tuberculosis. The disease has a haematogenous spread from its primary source. An arterial arcade at the subchondral region of each vertebra, comprising connections from anterior and posterior spinal arteries, facilitates tuberculosis to spread in the paradiscal areas[1] Besides, Batson's venous plexus contributes to spinal lesions due to its bidirectional valveless flow characteristics. Central vertebral lesions are manifestations of the intraosseous blood flow system[1] Spinal Tuberculosis (TB) can be classified into four types, namely, paradisiacal, central,

anterior, and appendiceal types. The paradisical type is more common at a young age, as the intervertebral disc remains more vascular than it is for older persons[1] Characteristically, tuberculosis destroys the vertebral body and intervertebral disc space involvement, leading to anterior wedging of the vertebral column and deformity.

Consequently, the decision to treat tuberculosis has been subject to evolution. Surgical intervention to cure tuberculosis of the spine dates back to the pre-antibiotic era. However, the poor outcomes of these surgeries, namely costotransversectomy and laminectomy, made Albee and Hibbs to introduce posterior spinal fusion as an interesting option bearing the principle of providing internal stability to the spine to prevent paraplegia and to shorten the periods of immobilisation in bed.[2] However, anterior surgery is considered the gold standard in treating the spine.[3] Proponents of posterior instrumentation argue that the anterior approach alone makes preexisting kyphosis challenging to correct.[4] Also, posterior instrumentation is superior in providing stability and correcting sagittal imbalance with less chance of graft slippage.[5] Evidence shows that both approaches have similar neurological recovery and union rates.[5,6]

Minimally invasive spine surgery (MIS) is a relatively newer approach with less blood loss, length of stay, recovery time, and complications. It is an optimum approach for adequate fixation and debridement. Tan *et al* showed that the MIS technique could be employed for quick functional recovery and adequate debridement.[7] The literature has also demonstrated that the MIS technique can be utilised not only for stabilisation of the vertebral column but also for percutaneous lavage and obtaining adequate tissue samples for bacteriologic assessment.[8,9] Madhavan *et al.* stated that the traditional anterior or anterolateral approach is problematic in the case of treating infections owing to the altered pathology of the involved segment, and encountering and securing a bleeding segmental vessel are pretty cumbersome in the presence of disease, which, consequently, leads to more blood loss and may deteriorate a patient's recovery.[10] However, the evidence for the MIS technique in infective spondylodiscitis is low in the existing literature. Our study aims to evaluate MIS surgery as a practical option for improving the recovery of patients with tubercular spondylodiscitis.

MATERIAL AND METHODS

The study design was a retrospective study conducted in the Department of Orthopaedics, Nil Ratan Sircar Medical College and Hospital, Kolkata, from June 2022 to December 2024. Twenty patients who fulfilled the inclusion criteria were included in this study.

Patients with tuberculosis of the spine (clinically, radiologically, and microbiologically) who had involvement of the thoracolumbar spine at a single level with back pain with or without any focal neurological deficit, with wet lesions only, and instability of the vertebral column (according to Rajasekaran *et al.*) were included in this study.[11]

The patients with involvement of tuberculosis of the thoracolumbar spine with dry lesions and/or with rigid kyphosis and participation of multiple skip lesions were excluded from this study.

Clinically, patients were evaluated based on (i) subsidence of back pain, (ii) improvement of neurological impairment, and (iii) improvement from preoperative ambulation status, and the operative time, duration of hospital stay, perioperative blood loss, and complications were studied. Functional assessments were based on the Numerical Rating Scale for pain relief, the Japanese Orthopaedic Association score for disability assessment, and the Oswestry Disability Index for disability assessment. Bony union was assessed at 1 year, according to Newton *et al.*[12]

Data Analysis

We have put the patients' required clinical, radiological, demographical, and functional details in an MS Excel spreadsheet. We recorded the phone numbers and addresses of the subjects separately so that we could reach them whenever necessary during required follow-ups. The data were analysed with the help of SPSS software with the help of paired student t-tests. A statistically significant outcome is defined as $p < 0.05$.

Surgical Procedure

We performed our procedure in the patients' prone position under general anaesthesia on a fluoroscopy-compatible table. Following careful skin preparation and draping, the midline and percutaneous pedicle entry locations were identified using fluoroscopic guidance, and guidewires were inserted through a 3 cm incision.

On each side of the midline, which generally corresponds to 2–3 mm lateral to the lateral border of the pedicle, is visualised on the antero posterior (AP) view of the spine on the fluoroscope. If the pedicles of the affected bodies were intact and the vertebral body was partly damaged, guidewires were inserted into the affected bodies. In instances where the pedicle and a large part of the body were destroyed, an adjacent intact vertebra was selected for screw placement.

After screws are placed over the guidewire, contoured, optimum long connecting rods are applied through the submuscular plane. The preoperative magnetic resonance imaging (MRI) image identified the vertebra and

paravertebral or prevertebral abscess locations. A Jamshidi needle was applied to the affected vertebrae transpedicularly, and with a gentle rocking motion of the hand, the anterior vertebral body was penetrated under fluoroscopic control. A negative suction with a 50 ml syringe was applied through the Jamshidi needle, and the required sample was obtained [Figures 1a, b]. The specimen was sent for histopathological examination and culture, and GeneXpert was sent for TB. All of our patients had positive results for Mycobacterium tuberculosis, and none showed any resistance pattern. Histopathology reports were conclusive for tuberculosis in 15 patients, and the rest were nonconclusive but showed granulomatous lesions. Vicryl sutures and staples were used to close the wound conventionally. The wound was closed in a standard fashion with Vicryl sutures and staples. All the patients received antitubercular treatment according to the National Tuberculosis Elimination Programme, i.e., starting with a 2-month intensive phase that includes four medications: isoniazid, rifampicin, pyrazinamide, and ethambutol. This is then followed by a continuation phase that lasts between 10 and 16 months, depending on the disease's location and the patient's clinical progress.

RESULTS

There were 20 study subjects, of which eight were female and 12 were male. The mean age of our study subjects was 45.6 years. All of our patients had thoracolumbar spine involvement. Six patients (30%) had lower dorsal involvement, 10 patients (50%) had lumbar spine involvement, and the rest of four patients (20%) had thoracolumbar spine involvement (T12-L1). All of our patients had axial back pain with variable degrees of disability. Twelve of our patients had focal neurological deficits. Our average follow-up duration was 14.2 months.

Our study subjects had radiographically demonstrable wet lesions involving thoracolumbar vertebrae. We demonstrated the distribution of the involved vertebrae. Preoperatively, we also evaluated the degree of spinal instability from radiographs.

We evaluated our study subjects, and the mean operative time was 66 minutes, and the mean blood loss was 56 ml.

Japanese Orthopaedic Association score (JOA), Oswestry Disability Index (ODI), and Numeric Rating Scale (NRS) were evaluated preoperatively and postoperatively. Statistically significant ($p < 0.005$) changes have been observed in the postoperative period at 6-month and 1-year follow-up. TB spine bears significant morbidity in an individual. A systematic review by Yong *et al*. reviewed available databases and identified the JOA and the ODI as two valuable functional outcome parameters that correlate with disability assessment in caries spine patients in whom surgical intervention was planned.[13] We utilised the JOA and ODI scores to assess functional outcomes. The only modification we used was to omit the 'sex score' of the ODI scoring system, as most of our study subjects were reluctant to provide information. We identified a mean preoperative JOA of 14 ± 0.74 to be increased to a mean postoperative (at 6-month follow-up) JOA of 16.33 ± 0.88 and 16.75 ± 0.45 at 1-year follow-up. The increment was statistically significant ($p < 0.05$). The mean preoperative ODI score was 44.92 ± 3.26, reduced to a mean postoperative ODI score of 11.08 ± 6.4 in the 6th month and 6.92 ± 3.554 at 1-year follow-up. This was also statistically significant ($p < 0.05$). Another disabling clinical feature in our patients was pain, and our assessment of the severity of pain was by using the NRS. We found a statistically significant reduction of NRS score (8.17 ± 0.72 vs. 1.75 ± 1.14 vs. 1.25 ± 0.75) in our postoperative patients by 6-month and 1-year follow-up, respectively.

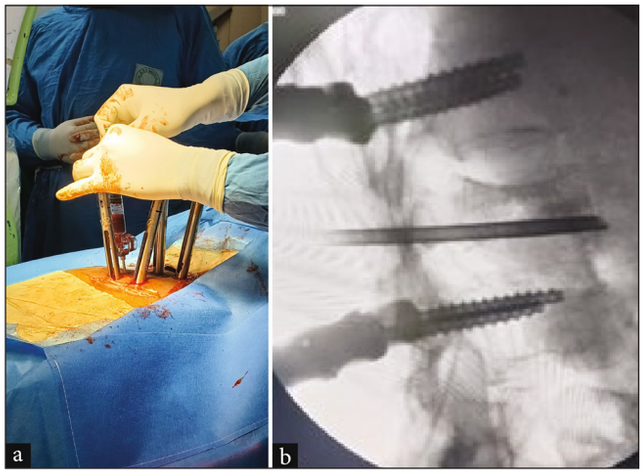

Figure 1: (a) Using MIS technique for stabilisation. (b) Decompression under fluoroscopic control. MIS: Minimally invasive surgery.

The subjects were evaluated for the grade of spinal fusion at the postoperative 1-year follow-up. The grades of spinal fusion have been demonstrated as follows: Grade 1-5%, Grade 2-30%, Grade 3-55%, and Grade 4-10%.

The mean hospital stay for our subjects was 5.33 days. We identified no complications in the intraoperative and immediate postoperative period. At the presentation, eight of our patients were unable to ambulate due to backache and/or focal neurological deficits. The 12 other patients were ambulatory with aid, with axial back pain with or without neurodeficit at presentation. We allowed protected ambulation in all of our patients on postoperative day 1 with the help of a walking aid and put them in a supervised, individualised physiotherapy protocol. At the 6-month follow-up, all of our study subjects could ambulate without assistance and were satisfied with their outcomes. However, we have found one patient who showed screw backout at the 6th-month follow-up [Figure 2].

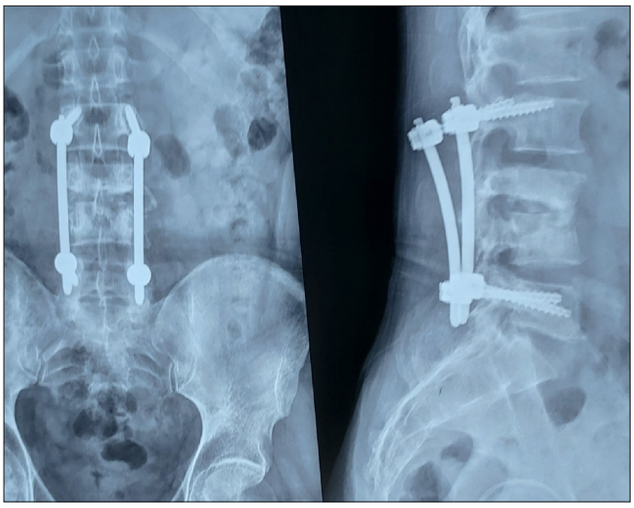

Figure 2: Complication—backout of one screw.

DISCUSSION

Spondylodiscitis is a clinical term indicating infection of the vertebral body and disc. In the Indian subcontinent, tuberculosis is a significant etiological factor in spondylodiscitis, which results in spinal instability and/or focal neurological deficit. Surgery helps maintain adequate spinal column stability and debrides the tubercular lesion.

The gold standard test for assessing spondylodiscitis is MRI.

A T1- and T2-weighted MRI image can demonstrate intraosseous and paraspinal soft tissue abscess, vertebral column abnormalities like scoliosis and kyphosis, and spinal cord encroachment with or without root lesions.[14] Skip lesions, a widespread occurrence of spinal tuberculosis, are also identifiable by MRI due to its multiplanar imaging capability. The rationale for obtaining an MRI also includes identifying the nature of the lesions and classifying them as 'wet' or 'dry,' which is shown to influence overall stability.[15] 'Wet' lesions are defined as the presence of intraosseous and paraspinal abscesses characterised by low signal intensity in T1-weighted images (T1WI) and high signal intensity in T2-weighted images (T2WI), and 'dry' lesions are defined as granulomatous lesion, preferably from a healing disease characterized by hyperintensity in T1WI and hypo intensity in T2WI.[16] Wet lesions have a higher incidence in the TB spine than dry lesions. Jain *et al.* reported that 100% of their case series had wet lesions, and no dry lesions were noted.[16] Desai *et al.* reported that only 25% of dry lesions in MRI were in their case series of 24 subjects.[17] Our case series also reports 100% of wet lesions in preoperative MRI, which follows the stated facts in the literature.

Back pain is the most constant clinical presentation cited in literature, with or without focal neurodeficit. Ahuja *et al.* included mechanical back pain as an essential criterion for categorising instability in the tubercular spine.[18] However, we have utilised the requirements and scoring system proposed by Rajasekaran *et al.* to determine the degree of instability in the spine, which was proposed to have a sensitivity of 70% and a specificity of 100%.[11] The thoracolumbar, including lower thoracic and upper lumbar vertebral involvement in the caries spine, inherently renders the spinal column unstable due to biomechanical factors and leads to progressive collapse and an increase in the intensity of back pain due to the larger canal diameter and more space for the spinal cord. Lumbar caries spine subjects have milder to moderate neurological involvement than the thoracic or thoracolumbar caries spine subjects.[11] This is also demonstrable in our subjects, as all nine patients with neuro deficits had thoracic spine involvement.

Significant factors to improve the recovery of patients with spinal tuberculosis include reduction of pain, decompression of the spinal cord, and rehabilitation.[13] Kandwal *et al.* showed that MIS in TB spine patients significantly improves ODI scores.[19] Kelly *et al.* showed that the MIS approach bypasses the morbidities but enjoys most of the advantages of traditional techniques.[20] Yong *et al.* suggested that a better rehabilitation protocol could be applied to the patients if they had undergone MIS rather than conventional open approaches.[18] Ito *et al.* published a case series of three patients with tubercular spondylodiscitis, and they demonstrated significant and rapid pain relief postoperatively by this technique.[21] They also suggested MIS as an effective technique for stabilising the spinal column and preventing vertebral collapse.[21] MIS percutaneous pedicle screw fixation serves as an adjunct to stabilise infectious bursts or compression fractures.[22,23] Ran *et al.* also demonstrated statistically significant improvement in JOA and ODI scores in their case series.[24]

Moreover, an anterior approach is superior regarding debridement since it can directly access the disease process. However, the altered anatomy from the disease process, fragile blood vessels, and thick and sticky tissue all increase the risk of potentially injuring vital structures.[25] Chances of injury to the ureter and hypogastric nerve leading to retrograde ejaculation in male patients following anterior interbody fusion have been well described in the literature.[26–28] Another aspect of favouring MIS in spondylodiscitis is to minimise surgical trauma in a multiply comorbid patient. TB is often associated with a significant immunocompromised state and/or comorbidities that diminish wound healing potential and/or tolerance to more prolonged surgical procedures.[29,30] MIS also confers benefits regarding these aspects. In the setting of broadly available early diagnosis of tuberculosis, percutaneous stabilisation and drainage promote the natural healing process at the

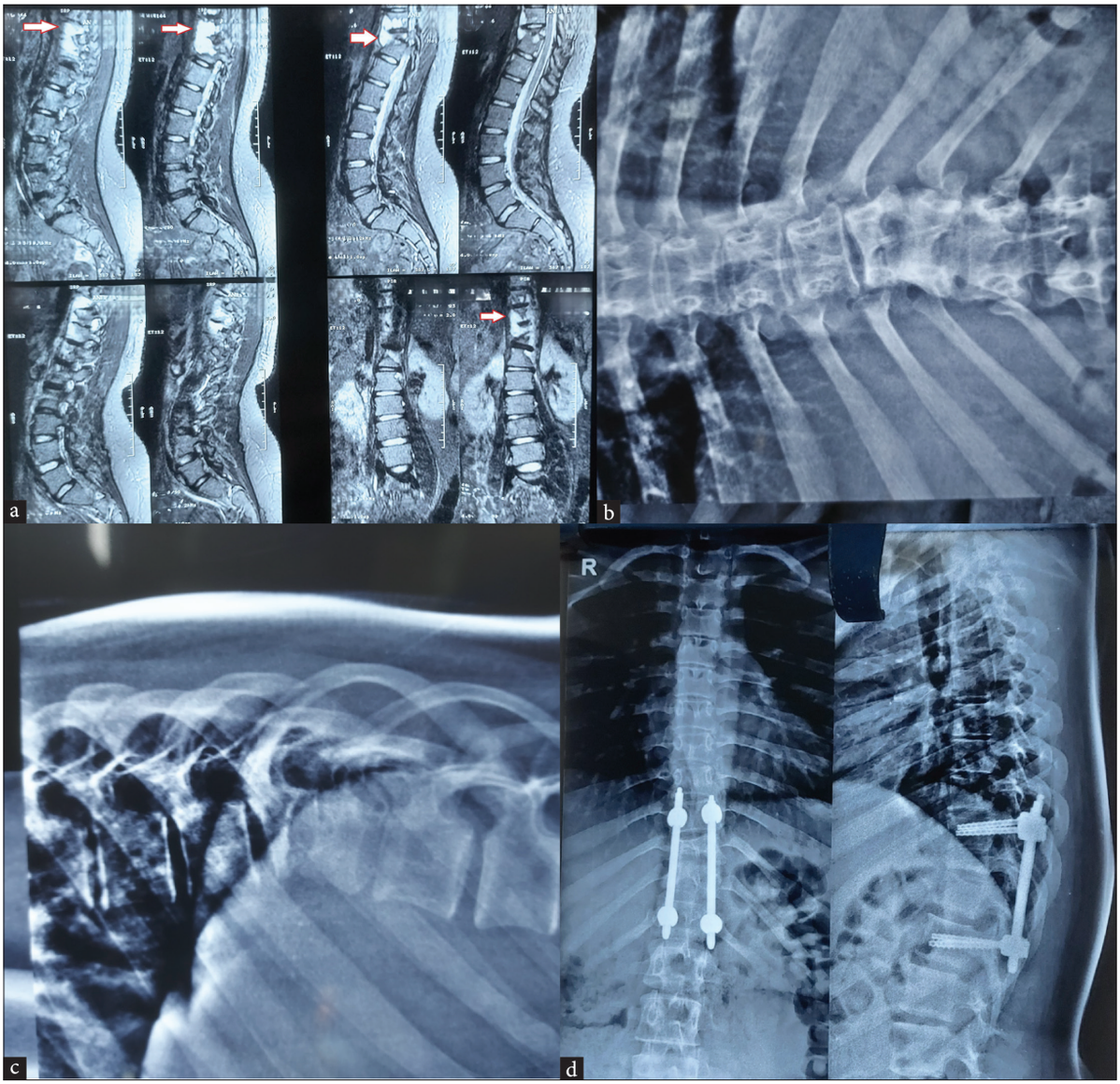

Figure 3: (a) Pre-op MRI of a patient with a thoracic wet lesion arrows showing wet lesion (abscess). (b) Pre-op x-ray AP view of the same patient. (c) Pre-op x-ray LAT view of the same patient. (d) Post-op x-ray AP and lateral view of the same patient. MRI: Magnetic resonance imaging, AP: Antero posterior, LAT: Lateral.

trade of minimising surgical trauma to the patients. Ishihara *et al*. showed a significant recovery in their study subjects after MIS, for which they hypothesised that the posterior splinting with less soft tissue damage and less blood loss promoted earlier healing in their study subjects.[31]

Our study's average operating time and blood loss were lower than traditional anterior or posterior open fixation. Our study's operating time was 66 ± 1.2 minutes, and the average intraoperative blood loss was 50 ml. One drawback of MIS appears to be a low culture positivity rate. A meta-analysis by Arimbawa *et al*. states that open surgery is superior in obtaining a positive culture.[32] However, the literature shows that MIS is sufficient to obtain adequate samples and debride infectious pathology to promote earlier recovery.[12] MIS has a faster operating time and lesser blood loss due to the fact that it requires a shorter duration of paraspinal muscle preparation and wound closure.[32] However, the meta-analysis by Arimbawa *et al*. mentions higher radiation exposures during the MIS approach, though they claim it to be reduced with experience and gradual progression through the learning curve.[32]

In our study, we experienced a satisfactory fusion of spinal segments, which was intended at the 6-month follow-up [Figures 3a, b, c and d]. We utilised Newton *et al*.'s criteria for

postoperative spinal fusion.[12] In our study, one patient achieved grade 1 fusion (5%), six had grade 2 fusion (30%), 11 had grade 3 fusion (55%), and two had grade 4 fusion (10%). Our results are comparable to those described in the literature.[33] The meta-analysis by Arimbawa *et al*. also showed that the MIS approach does not necessarily compromise fusion. Instead, minimal soft tissue injury and adequate debridement promote better fusion at subsequent follow-ups.[32] Ran *et al.* showed their subjects achieved fusion within 4–12 months of the period, which is comparable to our study.[24]

Biomechanically, TB of the spine mainly involves the anterior portion of vertebral bodies and discs. The body weight gradually produces a kyphotic bending moment, leading to deformity, which may or may not predispose to neurodeficit. Rajasekaran *et al*. demonstrated this in their study and devised a formula to judge the surgical candidacy of TB spine patients[11] MIS instrumentation with pedicle screws and connecting rods augments the posterior tension band without losing the inherent stability already provided by them. Since the TB spine is an anterior disease, the posterior tension band mostly fails in tensile loading from loss of anterior column support. However, anatomical integrity is not lost significantly except in the advanced disease process. Thus, further minimising soft tissue trauma, MIS augments and shares the load with the posterior tension band. Early stabilisation in the potentially unstable or unstable spine in cases of TB spine renders benefit to both the patient and surgeon.

limitation

Our study has the following limitations. The study subjects are less in number. Prolonging the follow-up duration could have yielded a better evaluation of outcome parameters and helped us evaluate late complications (if any) that occur with MIS. A control arm of conventional approaches could have enlightened the significance of our findings in a contrasting background. Also, we lacked objective criteria for selecting candidate patients suitable for the MIS approach.

CONCLUSION

MIS is a safe and effective option for the management of selected patients with tuberculosis of the spine. With advancements in technology and surgical techniques, MIS offers numerous benefits, such as reduced blood loss, shorter hospital stays, and quicker recovery times. It also provides excellent clinical outcomes with lower rates of complications. MIS acts as an 'internal external fixator' which stabilises the spine and thereby controls infection, prevents and corrects deformity, and relieves pain in patients with tubercular spondylodiscitis. Overall, MIS in tuberculosis spine surgery is a promising approach that should be considered for patients needing surgical intervention.

Ethical approval: Institutional Review Board approval is not required because it is retrospective study.
Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent.
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Conflicts of interest: There are no conflicts of interest.
Use of artificial intelligence (AI)-assisted technology for manuscript preparation: The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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