Posterolateral Approach to the Thoracic Spine for Spinal Tuberculosis: A Technical Note and an Analysis of Results

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Abstract

Introduction: Surgical pathologies in the thoracic spine are principally located anteriorly within the vertebral body resulting in vertebral body destruction, kyphotic deformity, and anterior or anterolateral compression of the spinal cord. Adequate decompression of the neural elements and vertebral body reconstruction requires access to the anterior spinal column. The posterolateral approach through a posterior midline incision allows circumferential spinal cord decompression, anterior column reconstruction, correction of thoracic kyphosis, and posterior spinal stabilization to be safely performed through a single incision, at a single sitting with excellent outcomes.

Keywords: Thoracic spine tuberculosis, Posterolateral approaches, Transpedicular approach, Costotransversectomy approach

Introduction

The thoracic region is the most common site for tubercular infection within the spine [1]. Spinal tuberculosis predominantly affects the anterior spinal column [2]. Progressive infection results in vertebral destruction and pathological fractures with loss of anterior column support and resultant kyphotic deformity. Epidural extension of pus and infective granulation tissue and retropulsed bone from pathological fractures may result in spinal cord compression. Surgical treatment, when indicated, is directed at decompressing the spinal cord, reconstructing the anterior spinal column, and restoring spinal alignment.

Over the past decade, the posterolateral approach through a posterior midline incision has become the workhorse when dealing with surgical pathologies within the thoracic spine, including tuberculosis, trauma, tumors, thoracic discs, and ossification of posterior longitudinal ligament [3, 4, 5, 6, 7]. It allows circumferential spinal cord decompression, anterior column reconstruction, and posterior spinal stabilization to be safely performed through a single incision, at a single sitting [8]. The present article describes the technique and results of the posterolateral approach for tubercular involvement of the thoracic spine.

Posterolateral Approaches to the Thoracic Spine

The posterolateral approach to the thoracic spine allows access to the spinal canal and the anterior spinal column through one of three oblique corridors (Fig. 1), namely:

I. Transfacetal/Transpedicular
ii. Costotransversectomy
iii. Lateral extracavitary.

From the transpedicular/transfacetal approach to the costotransversectomy approach and finally the lateral extracavitary approach, the working area that is available lateral to the spinal cord progressively increases (Fig. 2) [9]. This allows greater visualization and access for decompression anterolateral and anterior to the spinal cord without excessive retraction of neural structures. The extra room also enables greater and safer access to the anterior spinal column for debridement and reconstruction [10].

The transpedicular and the transfacetal approaches are is two stories in the same corridor. The transfacetal approach is indicated for paradiscal tuberculosis with anterior spinal cord compression but without significant bone destruction [5]. It involves excision of the thoracic facet joint at the level of the diseased disc to access the spinal canal and the anterior column. The transpedicular approach is indicated when there is more extensive vertebral body destruction [5]. It involves excision of the entire posterolateral pillar from the pedicle

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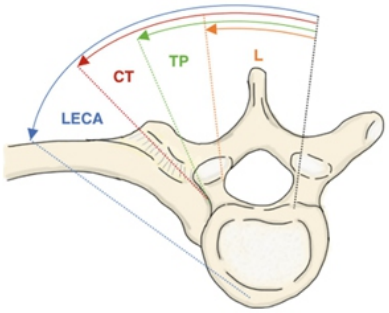

Figure 1: The various corridors for posterior/ posterolateral approach to the thoracic spine
L- Laminectomy, TP- Transpedicular, CT- Costotransversectomy, LECA- Lateral extracavitary approach

above the diseased vertebra up to the pedicle below the diseased vertebra.

In the upper and middle thoracic spine from D1 to D7/8, the spinal canal is smaller with the spinal cord occupying a larger area within the spinal canal. The fixed ribs in this region are not malleable and project vertically backward, obstructing the path for decompression anterior to the spinal cord and for insertion of an anterior strut. Hence, in this region, generally a costotransversectomy approach is preferred [5]. This involves removal of the medial 3–4 inches of the rib along with the pedicle allowing greater room lateral to spinal cord for safer insertion of a strut graft/cage.

The lateral extracavitary is rarely indicated in the setting of acute tubercular spondylodiscitis [5]. It is

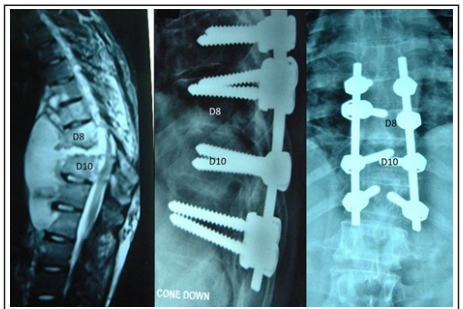

Figure 4: 25y M with complete loss of D9 vertebra and paraplegia with bladder & bowel involvement, Significant kyphosis. Treated with posterior column shortening procedure. Note bone to bone apposition anteriorly between D8 and D10.

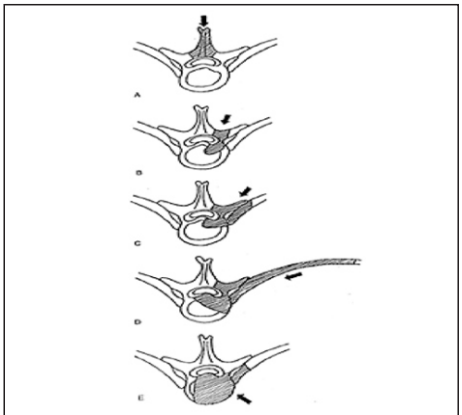

Figure 2: Diagrammatic representation of the various approaches to the spine showing the angle of approach, the amount of bone resection needed and the amount of anterior access provided. (a) Laminectomy (b) Transpedicular (c) Costotransversectomy (d) Lateral extracavitary (e) Transthoracic.

mainly used when performing a posterior vertebral column resection for severe post-tubercular kyphosis. It involves excision of the posterior half of the rib, so that the anterior spine can be visualized from laterally.

Anterior Column Reconstruction

The anterior spinal column bears 80% of the body weight. About 98% of tubercular infections involve the anterior column resulting in destruction of the vertebral body and the intervertebral disc, often rendering them incapable of bearing the body weight [1]. Reconstruction of the anterior spinal column is essential to restore the weight bearing function of the spine, as well as for correction of kyphotic deformity. In

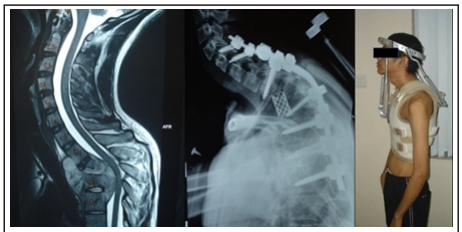

Figure 5: 19y M with complete destruction of D2 and D3 with severe kyphotic deformity and paraparesis. Treated with anterior column reconstruction using a mesh cage through a costotransversectomy approach. Postoperatively, halovest was applied for 3 months.

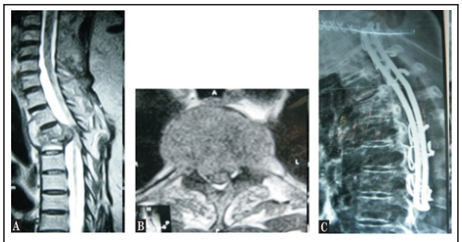

Figure 3: 23y M with paradiscal infection and paraparesis. Minimal kyphosis with vertebra collapse treated with transpedicular decompression and insitu posterior stabilization and posterior fusion.

addition, a restored anterior column shares the load with the posterior spinal implants, minimizing the risk of implant failure.

Anterior column continuity can be restored by employing three different techniques [5]:

i. In situ fusion
ii. Spinal column shortening
iii. Anterior strut insertion.

Patients, who present with a significant neurologic deficit but have minimal vertebral destruction and where the vertebrae have settled into a position of acceptable kyphosis, are candidates for a transpedicular decompression with in situ posterior stabilization (Fig. 3) [5]. Aggressive intervertebral debridement must be avoided as it results in a larger anterior void. If the anterior column is not completely apposed, then chip grafts can be tightly packed into the defect.

Anterior reconstruction in patients with paradiscal infections where <½ the vertebral body is destroyed on either side can also be achieved with spinal column shortening (Fig. 4) [5]. Here, the entire

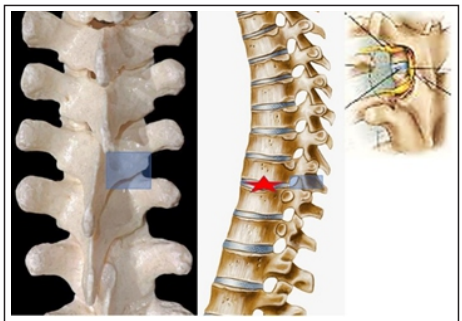

Figure 6: Pictoral representation of Transfacet approach for paradiscal infection in thoracic spine.

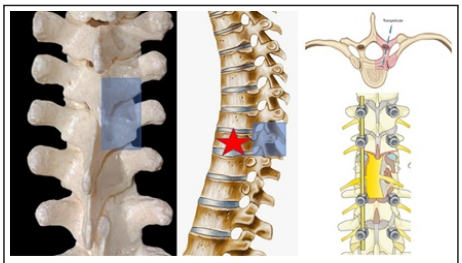

Figure 7: Pictoral representation of Transpedicular approach for vertebral destruction in thoracic tiuberculosis.

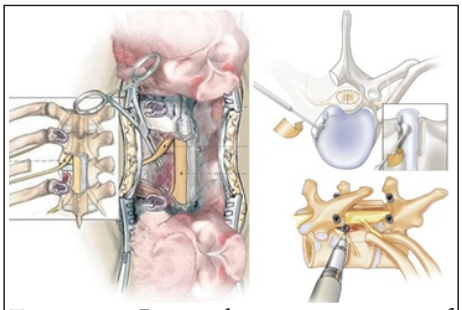

Figure 8: Pictoral representation of costotransversectomy approach useful in the upper and mid thoracic spine for anterior column reconstruction.

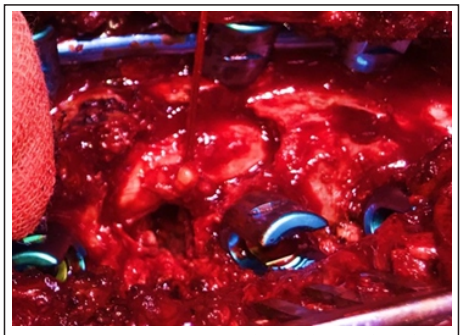

Figure 9: Nerve root isolated, ligated and cut preganglionic during a transpedicular approach.

posterior column at the level of the anterior defect is excised and then compression applied across the defect until bone-to-bone apposition is obtained anteriorly. With shortening of the spinal column, there is buckling of the spinal cord which can get kinked under the lamina. Hence, a generous laminectomy is essential. Tomita et al. have shown that excessive shortening can result in compromise of the blood supply to the spinal cord [5].

The most commonly used technique of anterior column reconstruction is insertion of a mechanical strut [5]. The strut used could be harvested from the iliac crest or the fibula. Alternatively, a cage packed with locally harvested bone graft can be inserted into the defect (Fig. 5).

Surgical Technique

Positioning

All patients are positioned in the prone position over two horizontally placed cylindrical bolsters – one placed below the lower chest and the other under the pelvis, taking care to avoid pressure on the abdomen. The table is tilted into reverse Trendelenburg position so as to place the operative site parallel to the floor. The arms are placed next to the head by abducting them at the shoulder and flexing the elbow, so as to allow adequate visualization of the vertebrae on the lateral projection with fluoroscopy.

For surgery at the cervicothoracic junction and in the upper thoracic spine up to D3/4, a horseshoe headrest is used to position the head, and the arms are strapped down, parallel to the trunk.

Incision and exposure

A posterior midline incision centered over the pathological levels is used in all patients. In case, a transpedicular/transfacetal approach is planned, muscle dissection is extended laterally up to the tip of the transverse processes, while the dissection is extended up to the medial 1/4th of the ribs for the costotransversectomy approach.

Posterior stabilization

Pedicle screws are the preferred anchors when performing the posterolateral approach. Not only do, they provide rigid three column stabilization which permits utilization of shorter instrumentation constructs, but they also allow compression and distraction to be applied across the pathological segments. In general, pedicle screws are inserted at two levels above and two levels below the diseased segment. However, in osteoporotic bone and when spanning multiple diseased/destroyed vertebrae, longer instrumentation constructs are often necessary. An appropriately contoured rod is assembled in distraction on the side opposite to the side from which the posterolateral approach is planned. This stabilizes the spine and reduces the risk of anterior translation of the vertebrae after decompression.

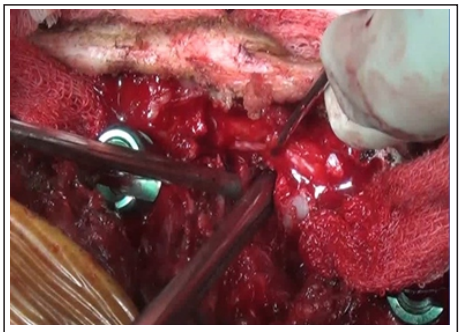

Figure 10: Anterior debridement being performed through a unilateral transpedicular approach. Note minimal retraction of neural structures.

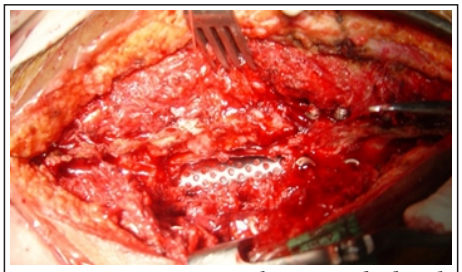

Figure 11: Anterior mesh cage packed with locally harvested bone graft being inserted Note the ligated nerve roots.

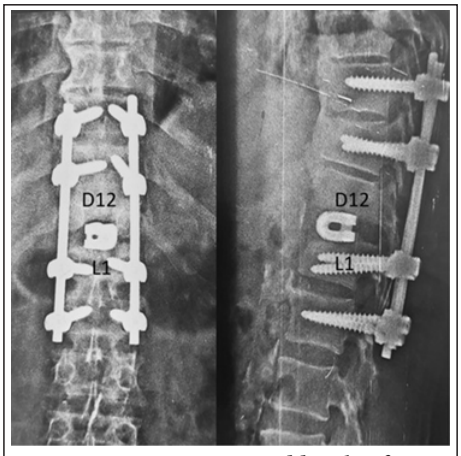

Figure 12: D12- L1 paraddiscal infection with minimal vertebral destruction reconstructed with a bullet shaped cage.

Posterolateral approach

The posterolateral approach is preferably performed from the side of the worse neurological deficit or maximum spinal cord compression. If there is asymmetric destruction of the vertebral body, the author prefers approaching from the side of more severe destruction.

The amount of lamina to be excised depends on the nature and severity of spinal cord compression. A complete laminectomy is necessary; in case, there is circumferential spinal cord compression. More often, the hemilamina on the side opposite to the posterolateral approach is kept intact, preserving stability. In case of a transfacetal approach, the facet joint is excised This entails excision of the D10/11 facet joint along with the adjacent hemilaminae for a patient with D10/11 paradiscal tuberculosis (Fig. 6). In case of a transpedicular approach, the posterolateral gutter needs to be excised along with the hemilaminae from the pedicle of the vertebra above the destroyed vertebra to the pedicle of the vertebra below the destroyed vertebra. The ligamentum flavum too is excised along the length of the hemilaminectomy. For D10 vertebral destruction, the posterolateral pillar would need to be excised from the lower border of the D9 pedicle to the upper border of the D11 pedicle (Fig. 7). In case a vertebral shortening is planned as the method of anterior reconstruction, the posterolateral pillar has to be excised on both sides.

In case of a costotransversectomy approach, the medial 1/3 of the rib is dissected subperiosteally and then excised along with the corresponding transverse process. Often this results in drainage of pus from the pre/paravertebral abscess. This is followed by excision of the posterolateral pillar, as in the transpedicular approach. For a D6 vertebral body destruction, the costotransversectomy approach would involve excision of the posterolateral pillar from the lower border of D5 pedicle to the upper border of the D7 pedicle along with excision of the medial 1/4th of the sixth rib (Fig. 8).

Nerve root ligation

In case of a transpedicular approach, the author prefers to isolate, ligate, and then cut the exiting thoracic nerve root (Fig. 9). The ligature is kept long and used to gently retract the spinal cord as necessary when working anterior to the spinal cord.

Anterior decompression

After ligating the nerve root, the dural sac must be carefully dissected from any infective granulation tissue posterior or anterolateral to the dural sac. The dural sac is then gently dissected away from the PLL and any anterior infective tissue/pus that is compressing the spinal cord is excised. A unilateral transpedicular approach allows decompression anterior to the dural sac up to the midline. Tilting the table toward the opposite side or performing a costotransversectomy allows anterior decompression across the midline. However, if there is anterolateral granulation tissue on the opposite side that requires to be excised, then a bilateral approach is preferable.

Excessive curetting of the intervertebral bone anteriorly must be avoided because infected bone is soft and will easily be curetted out resulting in a large anterior void. However, pus, sequestra, necrotic disc, and soft granulation must be removed and a solid and healthy bed created for the strut graft (Fig. 10).

Anterior column reconstruction

The author generally uses a mesh cage filled with local bone graft for reconstruction of large defects in the anterior column (Fig. 11). The cage is introduced through the posterolateral corridor avoiding undue retraction or injury to the dural sac. Placement of the cage must be anterior and as close to the midline as possible. A cage with a wider diameter is preferred as it allows a greater surface area for fusion. Furthermore, load transmission is more evenly spread minimizing subsidence and displacement of the cage.

In case the peridiscal vertebral destruction is minimal, than the author uses a bullet-shaped cage (14–16mm in height) packed with autograft introduced through the transfacetal approach (Fig. 12). Bone graft is also packed within the disc space anterior to the cage.

Rod assembly

The rod on the side of the posterolateral approach is now assembled. Sequential compression is then applied across the pathological segment to wedge the anterior strut tightly in position. The cage holder must be held in position during this maneuver to prevent cage tilting or displacement.

When vertebral shortening is being attempted, sequential compression is applied across the diseased segments until bone-to-bone apposition is achieved anteriorly or the dural sac starts buckling and bulging posteriorly through the laminectomy defect. In case, the dura is getting kinked below the laminar edge, the laminectomy must be extended cephalad and caudad as necessary, taking care to avoid a dural injury.

Great care must be exercised when applying compression/distraction in soft tubercular bone for fear of pull out of pedicle screws or fracture of the pedicle.

Posterior fusion

A posterior spinal fusion is performed along the length of the instrumentation construct by decorticating the posterior elements and then overlaying locally harvested bone graft. Bone graft harvested from the posterior ilium or allograft can be utilized if the local graft is insufficient.

Closure

The wound is then closed in layers over a suction drain, local anesthetic (0.25% bupivacaine) is infiltrated into the skin

and muscle.

Post-operative protocol

In general, the patient is mobilized the same day without a brace and sent home after 48- 72 hours, following a wound check and drain removal. Antitubercular therapy is started the day following the surgery.

Outcomes

Between 2002 and 2019, 237 patients with active thoracic tuberculosis underwent posterior surgery at our institution. This included 154 females and 83 males. Mean age of patients was 38.6 years (range 6–81 years) with 60 patients being <18 years of age. C7/D1-D4/5 involvement was seen in 48 patients, D5-D10 involvement in 121 patients, and D11-L1 involvement in 68 patients. The average number of vertebrae involved was 2.7 (range: 1–5). Neurologic deficits of varying duration (1 day–2 months) were present in 209/237 patients (Frankel A – 12, Frankel B – 66, Frankel C – 111, and Frankel D – 20). The average pre-operative kyphosis was 38.8° (Range: 15°–70°). Bilateral posterolateral approaches were more commonly used from 2002 to 2007. A unilateral approach has been performed in most patients since 2007. A costotransversectomy was performed in 45/48 patients with lesions from C7/D1-D4/5, in 31/121 patients with D6-D10 involvement and in only 2/68 patients with D11-L1 involvement. In situ fusion was performed in 53 patients, vertebral shortening in 35 patients and an anterior strut was inserted in 149 patients. Pedicle screws were used for posterior stabilization in most patients. A Hartshill rectangle with sublaminar wires was used in 32 patients, all of who underwent an in situ fusion. Postoperatively, all patients were given antitubercular chemotherapy based on the drug sensitivity and as per recommendations by the World Health Organization. Patients were made to sit up in bed on the day of surgery itself and made to stand and walk as permitted by their neurology. Although braces were used in the early part of this series, in the past few years, we have given up the use of post-operative bracing.

The average blood loss was 375 cc (150cc–800cc) and the mean operative time was 171 min. About 229/237 patients were followed up for a minimum of 1 year following surgery with serial clinical evaluation, blood tests, X-rays, and a magnetic resonance imaging, if necessary. One hundred and ninety-five patients were available for a 2-year follow-up and 65 patients for a 5-year follow-up. 203/209 (97%) patients with neurologic deficits showed significant neurologic recovery. 212 and 229 patients were declared healed at the end of 12 and 18 months of antitubercular therapy, respectively, based on their clinical status, normalization of erythrocyte sedimentation rate and C-reactive proteins and radiological evaluation. The pre-operative kyphosis was corrected from a mean 38° preoperatively to a mean 18° postoperatively and was found to be 22° at follow-up.

Intraoperatively, dural tears were observed in eight patients. They were treated with a fat graft and watertight closure. 2/8 patients required a re-exploration. Transient worsening of the neurologic deficit was found in 3/237 patients. One patient required a reoperation for medially placed pedicle screws that resulted in post-operative neurologic

worsening. All but one patient went on to recover completely. Surgical site infections were seen in 3/237 patients. Two of these three were seen in HIV-positive patients.

Eight patients developed a paradoxical reaction between 3 and 6 weeks after surgery. They presented with either a swelling or a discharging sinus at the surgical site. Clinically, all these patients were better in terms of constitutional symptoms, pain, and neurology compared to preoperatively. These patients were re-explored. A sticky translucent fluid was drained. The pedicle screws were loose in one patient and had to be replaced. The same anti-tubercular treatment (ATT) was continued and all patients went on to heal uneventfully thereafter. Paradoxical reactions are thought to be due to immune reconstitution in severely immunosuppressed individuals after starting of ATT.

At longer follow-up, cage displacement/tilting was seen in seven patients. None of these patients required a revision surgery. Implant-related problems including screw pullout/breakage of sublaminar wires were observed in three patients. Two elderly patients with severe osteoporosis developed a distal junctional fracture with local kyphosis. Both were successfully managed nonoperatively.

Discussion

Up until the 1930s, surgery for thoracic spine tuberculosis was primarily limited to posterior laminectomy for indirect spinal cord decompression [11]. However, results were largely unsatisfactory because laminectomy was insufficient for relieving the anterior spinal cord compression in thoracic tuberculosis. Besides laminectomy further destabilized a spine that was already weakened by anterior spinal column destruction, resulting in progressive kyphotic deformity [12].

Ito et al. (1934) described a radical new operation for Pott's disease using an anterior approach to the thoracic spine [13]. This was later popularized by Hodgson and Stock and the anterior surgery consisting of radical anterior debridement, direct anterior decompression of the neural elements, and fusion with a strut autograft came to be known as the "Hong Kong Operation" [14]. However, anterior surgery was plagued by graft fractures, displacement,

subsidence, and non-union, especially in junctional regions and when the graft had to span multiple spinal segments [15]. Initially, posterior instrumentation [16] and later anterior fixation [17] were coupled with the Hong Kong Operation to reduce the risk of graft complications as well as to permit early mobilization of the patient.

However, most spine surgeons are not familiar with the anterior approach to the thoracic spine, often necessitating an access surgeon. Adhesions between the lung and the chest wall in patients with old tuberculosis of the lung can result in lung punctures during the anterior approach. The anterior approach puts both the visceral and vascular structures at risk of injury. Postoperatively, the patient may require monitoring in the intensive care unit [18]. In addition, the pullout strength of screws inserted anteriorly within the trabecular bone of vertebral bodies is significantly lesser than pedicle screws. Anterior fixation is also much less rigid than posterior tension band fixation. In most Asian patients, the thoracic vertebral bodies are small and can accommodate only one vertebral body screw which is insufficient to provide rotational stability. Finally, it is difficult to extend anterior fixation to multiple levels and anterior fixation has limited ability to effect kyphosis correction. Although, the radical anterior surgery has been coupled with posterior instrumentation, this requires two different approaches with additional morbidity and complications.

Although, posterolateral approaches to the thoracic spine had been described much earlier, they had not gained popularity because of the resultant posterior destabilization, pain, and progressive kyphosis. With the evolution of strong posterior pedicle screw instrumentation that provided three column spinal stability, the posterolateral approach started gaining popularity, especially in the setting of thoracic/thoracolumbar trauma, tumors, and disc herniation [10, 19, 20]. The author started using the posterolateral transpedicular approach for spinal cord decompression with posterior pedicle screw instrumentation from 2002 onward and presented his work in the clinical meeting of the Bombay Orthopaedic Society in 2003 and subsequently at the annual meeting of the Association of Spine Surgeons of India in Bangalore (2005) [3, 4, 5]. The posterior approach is familiar to the spine surgeon. It allows debridement, abscess drainage, spinal cord decompression, kyphosis correction, anterior column reconstruction, and posterior stabilization to be performed through a single posterior approach, in a single sitting. Moreover, posterior instrumentation is more rigid, allows superior kyphosis correction, and can easily be extended cephalad or caudad as necessary.

Our results over a period of almost two decades have proven the efficacy and safety of the posterolateral approach when operating on patients with tuberculosis of the thoracic spine. Similar excellent results have been reported by a number of authors. Zhang et al. reported a 98% fusion rate and maintained kyphosis correction at 5-years following single-stage transpedicular decompression, posterior instrumentation, and fusion [21]. All patients improved in neurology by one ASA grade and had significantly improved pain scores. Garg et al., when comparing the outcomes following anterior versus posterior surgery, reported longer duration of surgery, higher blood loss, and more frequent complications in the anterior group compared to the posterior group. The posterior group also had superior kyphosis correction [22].

Conclusion

The posterolateral approach to the thoracic spine for spinal tuberculosis allows circumferential spinal cord decompression, anterior column reconstruction, and posterior stabilization to be performed through a single-posterior incision in a single sitting. The outcomes in terms of pain relief, neurological improvement, correction of kyphosis, and disease healing are excellent. Its familiarity among spine surgeons and its safety have contributed to its rapid rise in popularity over the last couple of decades. At present, the anterior transthoracic approach to active thoracic tuberculosis has largely been given up in favor of the posterolateral approach.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of Interest: NIL; **Source of Support:** NIL

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