Comparison of Three Surgical Approaches for Thoracic Spinal Tuberculosis in Adult

Minimum 5-Year Follow Up

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Study Design. Retrospective study.

Objective. To assess the minimum 5-year follow up outcomes of the surgical management of adults with thoracic tuberculosis by comparing posterior only (PO), anterior only (AO), and combined posterior and anterior (AP) surgical approaches.

Summary of Background Data. Surgeons use multiple methods to treat spinal tuberculosis, including an anterior, posterior, and combined anterior and posterior approach. However, there are a few reports comparing the mid- and long-term outcomes of these surgical methods.

Methods. The medical records for 184 patients treated for thoracic tuberculosis between January 2003 and November 2010 were retrospectively reviewed. Among them, 62 patients were treated with a single-stage posterior debridement and interbody fusion with instrumentation (Group A), 65 patients with posterior instrumentation, anterior debridement, and bone graft in a single or two-stage procedure (Group B), and 57 patients with anterior debridement and strut grafting with instrumentation (Group C). Operative time, blood loss, Visual Analog Scale for pain, complications, recovery of neurological function, Cobb angle, correction rate, and loss angle were compared among all groups.

Results. Groups A, B, and C were followed for 72.7 ± 3.8 months, 74.3 ± 4.2 months, and 73.6 ± 4.5 months, respectively. The operative time, blood loss, and rate of complications for Group A were significantly less than Groups B and C (P < 0.05). The correction rate and loss angle were superior in Groups A and B compared with C, whereas the Visual Analog Scale for pain and fusion time showed no statistically significant difference among the groups (P > 0.05).

Conclusion. For patients with thoracic tuberculosis, use of the AO approach should be limited. Although the AP approach produced satisfactory outcomes, it remains more traumatic. Therefore, the PO approach is recommended, not only because it achieves good results, but because it has reduced complications, operative time, and blood loss.

Key words: anterior approach only, combined posterior and anterior approach, complication, debridement, fusion, instrumentation, outcomes, posterior approach only, surgical management, thoracic spinal tuberculosis.

Level of Evidence: 3

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With the increase of HIV infection and drug-resistant strains of tuberculosis (TB), the incidence of spinal TB has also increased.1–3 Spinal TB often involves the anterior column, including the vertebrae and intervertebral disc, which leads to spinal instability, kyphotic deformity, and compression of spinal cord, causing neurological deficits. As a result, these patients often need to be treated with anti-TB chemotherapy or chemotherapy combined with surgery. However, the choice of surgical intervention is still controversial.4–7 Posterior instrumentation, anterior debridement, and bone grafting in a single or two-stage procedure (combined anterior and posterior, AP approach) is regarded as the standard surgical intervention for the treatment of spinal TB.8–10 Likewise, anterior debridement and strut grafting with instrumentation (anterior only, AO approach) is also widely used, and can eliminate TB and alleviate nerve compression via direct visualization, correct kyphosis without causing destruction of the posterior column, and be used to reconstruct the spine, maintaining spine stability in one-stage.11–14 Although they have optimal clinic results with regard to the treatment of TB, these procedures may increase the risk of cardiovascular disease, mortality, and surgical complications such as vascular injury, pneumothorax, or pleural effusion, leading to extended recovery time. In addition, the
exposure of the upper thoracic vertebral segments is a great challenge to surgeons.\textsuperscript{15}

With additional research on spinal TB and the development of the posterior pedicle screw fixation system, a posterior only (PO) surgical approach is becoming progressively more accepted by surgeons. Some surgeons\textsuperscript{16} reported that single-stage posterior debridement and interbody fusion with instrumentation can remove local disease, decompres the nerves, and correct the spinal deformity in a single-stage procedure with less trauma, fewer complications, lower fees, and a shorter recovery time.

In our study, we have presented the clinical details of three surgical methods for the treatment of patients with thoracic spinal TB and retrospectively compared the 5-year follow up outcomes.

\textbf{MATERIALS AND METHODS}

\textbf{Patient Data}

This study was approved by the ethics board of our hospital. Between January 2003 and November 2010, 184 patients with a diagnosis of thoracic TB underwent surgery at our spine center. All surgical procedures were performed by the same surgeons at the same institution. Only patients with lesions confined to one segment or two adjacent segments without extensive TB abscess were included (or if multiple segments were involved, only one or two vertebral bodies needed to be addressed surgically). In addition, the patient was required to have one or more of the following conditions: (i) vertebral collapse and spinal instability caused by bone destruction; (ii) severe kyphotic deformity or progressive worsening of kyphosis; (iii) spinal cord compression by abscess or necrosis; or (iv) formation of a hollow or sequestrum. The diagnosis of TB spondylitis was based on clinical presentation (thoracodorsal pain, night sweats, afternoon hot flashes and weight loss, and neurological dysfunction), nonspecific laboratory findings such as elevation of erythrocyte sedimentation rate (ESR), C-reaction protein (CRP), anemia and hypoproteinemia, and radiologic findings [x-ray films, computed tomography (CT), and magnetic resonance imaging (MRI)]. Sixty-two patients underwent a PO approach (Group A), whereas 65 patients underwent an AP approach (Group B), and 57 patients were treated by an AO approach (Group C). In clinical practice, it is not possible to randomly select a surgical treatment method. Therefore, in our study, the patients in groups A and B underwent surgery more recently (as the emergence of pedicle screw technology) whereas the patients in group C underwent surgery during an earlier period. The same surgeons reviewed all surgical indications and performed the procedures. Clinical details of the surgical groups are presented in Table 1. The clinical details for each group had no statistically significant differences. American Spinal Injury Association (ASIA) classification was applied to assess the neurological deficits, and the neurological details of each group are listed in Table 2. The diseased segments are presented in Figure 1.

\textbf{Preoperative Management}

All patients had a clinical diagnosis of thoracic TB. Patients with open-lung TB or active TB in other places were excluded. Patients received anti-TB drugs containing HRZE for 2 to 4 weeks before the operation. When ESR and CRP had significantly decreased, anemia and hypoproteinemia were rectified completely, and TB toxicity symptoms were relieved, surgery was performed. If a patient experienced paralysis during pre-surgical chemotherapy, the surgery was performed even if ESR values did not decrease.

\textbf{Surgical Procedure}

\textit{Group A: PO Approach}

The posterior elements were exposed and the pedicle screws were placed. The spinous process, unilateral facet joint, and

\begin{table}
\centering
\caption{Clinical Data of Patients}
\begin{tabular}{|l|c|c|c|c|}
\hline
 & Group A & Group B & Group C & \multicolumn{2}{|c|}{\textit{P}_{A-B}/\textit{P}_{A-C}/\textit{P}_{B-C}} \\
\hline
Sex (Male/Female) & 34/28 & 36/29 & 31/26 & \textit{<0.05}/\textit{<0.05}/\textit{<0.05} \\
\hline
Average age (years) & 39.3 ± 15.1 & 38.5 ± 14.5 & 40.1 ± 13.2 & \textit{<0.05}/\textit{<0.05}/\textit{<0.05} \\
\hline
Course of the disease (months) & 9.5 ± 4.9 & 9.8 ± 5.2 & 9.6 ± 4.8 & \textit{<0.05}/\textit{<0.05}/\textit{<0.05} \\
\hline
Preoperative VAS score & 6.5 ± 1.4 & 5.8 ± 1.6 & 6.2 ± 1.5 & \textit{<0.05}/\textit{<0.05}/\textit{<0.05} \\
\hline
Spinal cord dysfunction (n) & 27 & 24 & 23 & \textit{<0.05}/\textit{<0.05}/\textit{<0.05} \\
\hline
Operation time (min) & 170.6 ± 31.0 & 388.2 ± 45.7 & 256.6 ± 55.1 & \textit{<0.05}/\textit{<0.05}/\textit{<0.05} \\
\hline
Blood loss (mL) & 625.0 ± 127.3 & 1167.9 ± 200.7 & 798.7 ± 72.5 & \textit{<0.05}/\textit{<0.05}/\textit{<0.05} \\
\hline
Final follow-up VAS score & 1.1 ± 0.8 & 1.2 ± 0.8 & 1.4 ± 0.8 & \textit{<0.05}/\textit{<0.05}/\textit{<0.05} \\
\hline
Mean fusion time (months) & 7.5 ± 1.1 & 7.2 ± 1.2 & 7.7 ± 1.0 & \textit{<0.05}/\textit{<0.05}/\textit{<0.05} \\
\hline
Follow-up in month (months) & 72.7 ± 3.8 & 74.3 ± 4.2 & 73.6 ± 4.5 & \textit{<0.05}/\textit{<0.05}/\textit{<0.05} \\
\hline
\end{tabular}
\end{table}

\textit{There is homogeneity of variances between group A, group B, and group C. Analysis of variance was used to test, When }\textit{P}>0.05, \textit{there is no statistically significant difference in all the group, when }\textit{P}<0.05, \textit{then using Student-Newman-Keuls test to compare group A and B, group B and C, group A and C, respectively.}
the upper or lower costotransverse articulation with a small fragment of the rib were resected to decompress the spinal cord from 270° and debride the area completely (Figure 2). The anterior defect was packed with appropriately-sized autologous bone or allograft bone block and correction of the kyphotic deformity was performed. Strips of autogenous bone or allograft bone were positioned to reconstruct the posterior column (Figures 3A–H and 4A–H).

**Group B: AP Approach**

Posterior instrumentation without fusion was applied first, and then anterior debridement and bone grafting were performed in a single or two-stage procedure (Figure 5A–H).

**Group C: AO Approach**

The diseased segments were exposed via a thoracic cavity or extrapleural approach. Anterior decompression of the spinal cord was performed and the area was debrided completely. The anterior defect space was packed with appropriately-sized autologous bone or allograft bone block; a rod system were placed in the adjacent normal vertebral bodies (Figure 6A–H).

**Postoperative Management**

The patients lay in bed for 2 weeks postoperatively and were encouraged to ambulate early using a thoracic brace for 6 to 8 months. The drainage tube was withdrawn when the volume was less than 20 mL per 24 hours. Stitches were removed 2 weeks postoperatively. All patients received anti-TB chemotherapy with HRZE for at least 18 months. Hepatorenal function, ESR, and CRP were monitored once a month.

**Follow Up Index and Statistical Analysis**

All patients were examined clinically and radiologically at 3, 6, and 12 months after surgery, and then once a year thereafter. Blood loss and operative time were recorded during the procedure. The following indexes were recorded preoperatively, postoperatively, and during follow-up: (i) kyphosis angle as determined by the Cobb angle; (ii) neurologic status according to ASIA classification; (iii) blood indicators such as ESR, CRP, and hepatorenal function;
and (iv) intraoperative and postoperative complications. Definitions for various outcome measures are as follows:

(i) Correction rate = \( \frac{(\text{preoperative Cobb angle} - \text{postoperative Cobb angle})}{\text{preoperative Cobb angle}} \times 100\% \)

(ii) Loss of corrective angle = postoperative Cobb angle – final follow up Cobb angle

(iii) Improvement rate = number of patients with an improvement in ASIA classification by 1 or more levels/total number of patients with spinal cord dysfunction

Results were recorded and analyzed using SPSS software version 17.0 (SPSS Inc., Chicago, IL). Operative time, blood loss, mean fusion time, kyphosis angle, ESR, and CRP were statistically analyzed using analysis of variance first, then using the Student-Newman-Keuls test to compare each group. Complications in the three groups were statistically analyzed using the \( \chi^2 \) test first, and then by partitioning the \( \chi^2 \) test to compare each group. Discrepancy in the normal distribution was analyzed by a rank-sum test with a significance level of 0.05.
RESULTS

Surgical Condition
The mean operative time, blood loss, duration of follow up, and fusion time were 170.6 ± 31.0 minutes, 625.0 ± 127.3 mL, 72.7 ± 3.8 months, and 7.5 ± 1.1 months, respectively in group A. In group B, 388.2 ± 45.7 minutes, 1167.9 ± 200.7 mL, 74.3 ± 4.2 months, and 7.2 ± 1.2 months, respectively. In group C, 256.6 ± 55.1 minutes, 798.7 ± 72.5 mL, 73.6 ± 4.5 months, and 7.7 ± 1.0 months, respectively (Table 1).

Laboratory Data
Fast pathologic diagnosis performed during the operation showed granulomatous infection and specimen cultures were consistent with TB. Preoperative ESR and CRP were 48.6 ± 25.3 mm/hour and 29.3 ± 17.3 mg/L in group A. In group B, 47.5 ± 23.5 mm/hour and 30.5 ± 16.8 mg/L. In group C, 50.3 ± 25.2 mm/hour and 28.2 ± 15.2 mg/L. These values returned to normal in all patients within 3 months (Table 1).

Neurologic Function
Results were evaluated by ASIA classification and are listed in Table 2. Eighteen patients demonstrated an improvement in postoperative ASIA classification in group A, as did 17 and 15 patients in groups B and C, respectively. The rate of spinal cord function improvement was 92.6% in group A, 91.7% in Group B, and 91.3% in Group C at final follow up.

Radiological Data
The preoperative thoracic Cobb angle averaged 28.4 ± 9.1° in group A, 29.3 ± 9.1° in group B, and 27.3 ± 8.1° in group C. The postoperative Cobb angle decreased significantly to 6.8 ± 1.1° in group A, 7.0 ± 1.1° in group B, and 14.0 ± 1.7° in group C. At final follow up, the kyphosis angle was 8.6 ± 1.1°, 8.6 ± 1.7°, and 16.4 ± 1.6° in groups A, B, and C, respectively. CT was performed as a routine examination to evaluate bone fusion, using the radiologic criteria of Bridwell et al.17 (Table 3).

Figure 4. One patient in group A. A–C, Preoperative images showing spinal tuberculosis involving the T9 and T10 vertebrae, leading to kyphotic deformity and compression of the spinal cord. D, Postoperative CT and E, MRI demonstrating correction of the kyphotic deformity and decompression of the spinal cord. F, Four-year follow-up CT and G, x-ray image showing good positioning of the bone graft. H, Five-year postoperative CT demonstrating solid bone fusion in the previously diseased segments.
Complications
The complication rate of group A, group B, and group C were 12.9%, 40.0%, and 28.1%, respectively. Superficial wound infections occurred in eight patients (two in group A, five in group B, and one in group C) and were successfully treated with antibiotics. Water-electrolyte imbalance occurred in 10 patients (two in group A, five in group B, and three in group C), and cerebrospinal fluid leakage occurred in six patients (two in each group). Five patients suffered vascular injury during anterior exposure (three in group B and two in group C), and five patients suffered postoperative pleural effusion with improvement after several days of closed drainage (three in group B and two in group C). Local abscesses were observed in four patients (two in group B and two in group C) that were caused by irregular anti-TB chemotherapy and treated by minimally invasive CT-guided percutaneous catheter drainage. Pneumothorax occurred in three patients in group B and two in group C. In group A, one patient experienced pseudarthrosis, which led to the breakage of a pedicle screw 20 months after the operation, and underwent a revision surgery. Another patient suffered refractory intercostal neuralgia after surgery, which was relieved by nonsteroidal anti-inflammatory drugs. In group B, three patients experienced sinus formation at the incision after the surgery and were treated by excision of the sinus. Two patients in group C experienced screw pullout at 4 months and 6 months after surgery, respectively, secondary to early removal of the brace, and subsequently underwent revision surgery (Table 4).

DISCUSSION
Most cases of spinal TB can be cured by conservative treatment. For patients who are not sensitive to anti-TB drugs or who suffer from kyphosis and neurological deficits, surgical management is necessary. The small volume of the spinal canal makes surgical intervention a great challenge. Tan et al reported that the widest and narrowest portions of the thoracic lateral width are 18 mm and 11.5 mm, respectively, whereas the anteroposterior depth of the thoracic canal is almost 13.5 mm from T1 to T12. The middle zone (T3 to T9) is of the greatest importance because of the presence of the...
combination of a narrow spinal canal and a critical vascular supply. As a result, patients with thoracic TB are especially vulnerable to spinal cord injury. However, choice of surgical management method remains controversial.

AO Approach

Spinal TB often involves the anterior column, and the AO approach was long considered to be the gold standard because it allowed for direct debridement of the abscess, reconstruction of spinal stability, neural decompression, and correction of the spinal deformity in one stage. Hodgson et al\textsuperscript{11} first reported their “Hong Kong operation” and its satisfactory outcomes for spinal TB in 1960. Nevertheless, adjacent vertebral levels are often affected by the abscess or by necrosis, which easily destroys the vertebra, leading to osteoporosis, and it is difficult to place screws in the upper thoracic spine because of the special anatomical structure.

Figure 6. A patients in group C. A–D, Preoperative images showing disease involving T9, T10, and intervertebral space leading to the formation of dead bone. E, F, Postoperative x-ray demonstrating good internal fixation. G, H, Five-year follow-up images showing the formation of callus and intervertebral fusion.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>PREOPERATIVE COBB ANGLE (°)</th>
<th>POSTOPERATIVE COBB ANGLE (°)</th>
<th>IMPROVEMENT RATE (%)</th>
<th>POSTOPERATIVE COBB ANGLE (°)</th>
<th>ANGLE LOST (°)</th>
<th>POSTOPERATIVE ESR (mm/h)</th>
<th>POSTOPERATIVE CRP (mg/L)</th>
<th>POSTOPERATIVE 3 MONTHS</th>
<th>POSTOPERATIVE 3 MONTHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>28.4 ± 3.4</td>
<td>6.8 ± 3.4</td>
<td>72.5 ± 1.3</td>
<td>8.6 ± 3.4</td>
<td>1.9 ± 1.4</td>
<td>48.6 ± 2.3</td>
<td>8.5 ± 3.2</td>
<td>29.3 ± 1.5</td>
<td>5.2 ± 1.9</td>
</tr>
<tr>
<td>B</td>
<td>29.3 ± 3.1</td>
<td>7.0 ± 3.1</td>
<td>73.1 ± 1.4</td>
<td>8.6 ± 3.7</td>
<td>1.6 ± 1.1</td>
<td>47.5 ± 2.3</td>
<td>8.1 ± 3.5</td>
<td>30.5 ± 1.6</td>
<td>5.4 ± 1.7</td>
</tr>
<tr>
<td>C</td>
<td>27.3 ± 3.1</td>
<td>14.0 ± 3.1</td>
<td>54.0 ± 1.6</td>
<td>16.4 ± 1.6</td>
<td>2.8 ± 1.3</td>
<td>50.3 ± 2.5</td>
<td>9.1 ± 3.1</td>
<td>28.2 ± 1.5</td>
<td>4.9 ± 2.0</td>
</tr>
<tr>
<td>PA–B</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>PA–C</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>PB–C</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
</tr>
</tbody>
</table>

There is homogeneity of variances between group A, group B, and group C. Analysis of variance was used to test. When $P > 0.05$, there was no statistically significant difference in all the group; when $P < 0.05$, then using Student-Newman-Keuls test to compare group A and B, group B and C, group A and C, respectively.
and position (e.g., narrow operation space, extensive blood vessels and nerves, and complex anatomical layers). In the upper thoracic spine, the vertebra is blocked by the scapula, clavicles, costal bones, and mediastinal organs. Consequently, the results of spinal deformity correction are often dissatisfying and the complications related to exposure and instrumentation increase. In our study, the operative time, blood loss, and improvement rate of the Cobb angle were worse in group C than group A, and during the follow-up period of 73.6±4.5 months, group C demonstrated a complication rate of 28.1% and a larger Cobb angle loss than groups A and B.

AP Approach
The AP approach is a mature surgical method that is widely used in the treatment of spinal TB and described as 360° reconstruction of the vertebra.10,21 This method not only allows direct debridement of the abscess and neural decompression, but also separates the debridement area from the area of internal fixation to decrease the spread of TB. Furthermore, the strong internal fixation system can provide satisfactory outcomes for deformity correction and maintain the long-term stability of the spine. However, this method does not avoid the complications related to exposure from an anterior approach, and it adds another incision posteriorly. Furthermore, during the operation, it is necessary to reposition the patient, which increases the risk of infection. In our study, although the improvement rate of the Cobb angle and the rate of angle loss were satisfactory, the operative time, blood loss, and complication rate were much greater than the other groups.

Allen D. Hamdan22 reported that intraoperative vascular injury occurs in 11% of patients during an anterior approach. Of these, 1.9% patients have major vascular injuries, which can lead to serious consequences, although the majority are identified and treated during the exposure and not during the spinal fusion. Ikard23 reported that complications of the thoracic anterior approach are related to the complex structure, and the majorities are respiratory and venous complications. S.G. Memtsoudis24 reported that the incidence of procedure-related complications was 18.68% among anterior approaches, 15.72% in the posterior approach, and 23.81% in patients with combined approaches. Inhospital mortality rates after combined AP approaches were approximately twice those of posterior approaches.

PO Approach
With the development of the posterior pedicle screw fixation system, PO surgery has become progressively more accepted for the treatment of spinal TB. J.S. Mehta25 reported satisfactory outcomes treating TB using posterior transpedicular debridement, bone fusion, and posterior fixation. F.K. Guzey26 reported that the posterior approach is associated with easy access to the spinal canal for neural decompression, prevention of loss of corrected vertebral alignment in the long term, and facilitation of early mobilization. Rath27 reported good neurological results after posterior debridement and instrumentation, which were similar to the results obtained via anterior decompression. Likewise, X. Pu28 compared posterior and anterior approaches for the treatment of thoracic and lumbar TB, and found that the posterior approach can help maintain spinal stabilization and prevent loss of the corrected vertebral alignment as effectively as the anterior approach. In our study, to achieve complete debridement and decompression, the surgeon resected the spinous process, unilateral facet joint, and the upper or lower costotransverse articulations with a small fragment of rib in order to create enough operating space to reach 270° of the vertebra. This procedure allowed decompression of the spinal cord, debridement of the abscess, strut bone grafting, and correction of thoracic kyphosis in a single-stage procedure via one incision without damaging the anterior organs and blood vessels. However, the main controversy

<table>
<thead>
<tr>
<th>TABLE 4. Complications</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial wound infections</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Cerebrospinal fluid leakage</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Water-electrolyte imbalance</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Break or pullout of screws</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Vascular injury</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Recurrence</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Sinus formation</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Refractory intercostal neuralgia</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>26</td>
<td>16</td>
<td>50</td>
</tr>
</tbody>
</table>

P_A–B, P_A–C, and P_B–C are the P value of comparison between groups A and B, A and C, B and C, by χ² test, which is 0.001, 0.039, and 0.166, respectively.
around the PO approach to treat thoracic TB is not whether the lesion can be cleared completely via the posterior approach, but whether the posterior laminectomy destroys the normal structure of the posterior column and thereby increases the instability of the spine. In our minimum 5-year follow up study, we did not observe recurrence in group A, illustrating that the range of clearance was sufficient. Weinstein et al. found that the vertebral pedicles contribute to at least 60% of the pullout strength and 80% of the axial pullout strength, while vertebral cancellous bone contributes to only 15% to 20% of the fixation strength, showing that posterior instrumentation is far stronger than anterior instrumentation. This is why the AO approach did not provide satisfactory outcomes for spinal deformity correction. Deniz suggested that the biomechanical behavior of a total facetectomy is equivalent to that of a medial facetectomy, and that additional facet removal may be incorporated without further biomechanical consequences. In our study, the operative time, blood loss, and complication rates were far better than other groups, and during the follow-up period, group A achieved the same satisfactory outcomes as group B.

For thoracic TB, use of the AO approach should be limited, especially in the upper thoracic spine (Table 5). Although the combined AP approach has satisfactory outcomes during follow up, it results in longer operative time, greater blood loss, and higher complications. The PO approach not only achieves good results, but also reduces the complications related to exposure and instrumentation, operative time, and blood loss.

### TABLE 5. Proposed Treatment Algorithms in the Treatment of Thoracic Tuberculosis

<table>
<thead>
<tr>
<th>Surgical Methods</th>
<th>Indications of Surgery</th>
<th>Surgical Contraindication</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO approach8,10,11</td>
<td>(i) the damaged portion of the vertebra is mainly located in the anterior and middle columns of the spine</td>
<td>AO approach should be avoided in patients with a lesion above T4 (as instrumentation above that level is difficult), in patients with severe kyphosis more than 60°, in patients with damage in the posterior column, and in patients with poor health of the chest and abdomen</td>
</tr>
<tr>
<td></td>
<td>(ii) abscess or sequestrum formation causing compression is mainly located in regions anterior to the vertebral body</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(iii) the number of damaged vertebrae is less than 3.</td>
<td></td>
</tr>
<tr>
<td>AP approach8,10</td>
<td>(i) the vertebral bodies are severely damaged and the total number involved is more than 3</td>
<td>The combined AP approach should be avoided in patients who are in poor general health or have other serious diseases like heart disease, pneumonia, or renal failure</td>
</tr>
<tr>
<td></td>
<td>(ii) there is severe kyphosis that would be hard to correct using an AO or PO approach</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(iii) there is obvious paravertebral abscess or sequestrum formation</td>
<td></td>
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<tr>
<td></td>
<td>(iv) anterior fixation would be hard to perform or the patient has previously failed anterior fixation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(v) spinal stability would be severely altered after the diseased tissue is resected</td>
<td></td>
</tr>
<tr>
<td>PO approach10,31,32</td>
<td>(i) the lesion is confined to one segment or two adjacent segments, or if multiple segments are involved, only one or two vertebral bodies need to be addressed surgically</td>
<td>A PO approach should be avoided in patients who have more than 3 damaged vertebrae and in patients with an extensive TB abscess which is hard to eliminate through a posterior approach</td>
</tr>
<tr>
<td></td>
<td>(ii) the patients has had several previous anterior surgeries or the anatomical structure is unclear</td>
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<tr>
<td></td>
<td>(iii) the lesion is confined to one side of the spine and abscess or sequestrum formation could be debrided through a posterior approach</td>
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### Key Points

- Spinal TB often involves the anterior column, which leads to spinal instability, kyphotic deformity, and compression of the spinal cord, causing neurological deficits.
- Posterior instrumentation, anterior debridement, and bone grafting in a single or two-stage procedure (AP approach) and anterior debridement and strut grafting with instrumentation are regarded as the standard surgical procedures for TB.
- Mid- to long-term follow up indicates that the posterior approach can achieve satisfactory outcomes with less trauma, fewer complications, lower fees, and shorter recovery time.
References


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