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Comparison of the Effectiveness Between Surgical Therapy and Conservative Therapy in the Management of Tuberculosis Spondylitis: A Comprehensive Systematic Review and Meta-Analysis

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Abstract
Spinal tuberculosis (TB) is the most common form of skeletal TB, with the thoracolumbar junction being the most frequently affected region, while cervical spine TB remains relatively rare, accounting for only 3% to 5% of cases. Historically, non-operative treatment was the only option in the pre-antibiotic era. However, with the introduction of effective combination chemotherapy in the early 1950s, the mortality rate for spinal TB significantly decreased to 1%–3%. Despite advancements in medical therapy, surgical intervention remains crucial in cases involving neurological complications and kyphosis prevention, with instrumentation playing an integral role in managing spinal pathologies. This study aims to evaluate the effectiveness of surgical therapy versus conservative therapy in the management of tuberculosis spondylitis through a systematic review and meta-analysis following PRISMA guidelines and the PICO format. The research includes randomized controlled trials (RCTs), observational, quasi-experimental, and case-control studies, while studies not directly assessing treatment effectiveness were excluded. A comprehensive literature search using PubMed, Sage Journal, The Lancet, and ScienceDirect initially retrieved 1,499 publications. Through a rigorous three-stage screening process, only 10 articles published between 2014 and 2024 were selected for final analysis. The findings indicate that both conservative anti-TB drug therapy and surgical treatment are safe and effective, particularly for early-diagnosed patients with fewer affected vertebrae. Conservative therapy provides good clinical and radiological outcomes, while surgical intervention offers advantages such as thorough debridement, spinal cord decompression, and improved spinal stabilization. The implications of this study suggest that treatment selection should be tailored based on disease severity and patient-specific conditions. Further research should focus on long-term comparative studies, minimally invasive surgical techniques, and biomechanical modeling to optimize treatment strategies for spinal TB..
Keywords: Tuberculosis, spondylitis, pott's disease, surgical therapy, conservative

Introduction
The aim of this study is to systematically review and conduct a meta-analysis of effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis. By comprehensively synthesizing existing literature, this research seeks to explore effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis. Through rigorous evaluation and statistical analysis, the study aims to provide valuable insights into the effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis. The systematic review and meta-analysis intend to inform healthcare practitioners, researchers, and policymakers about effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis for future research and development in this critical area of public health.

Pott's disease is one of the earliest known human infectious diseases triggered

by Mycobacterium tuberculosis (TB). The musculoskeletal apparatus is the third most common site of extra-pulmonary tuberculosis (EPTB) following pleural and lymphatic disease, accounting for 10–35% of all EPTB cases. TB spondylitis is the most common manifestation of skeletal TB, representing approximately 50% of all cases of skeletal TB. Immunosuppression and human immunodeficiency virus infection may be significant risk factors for TB. It usually occurs in the thoracic and lumbar regions of the spine. Clinically, back pain is the most common initial symptom, which may progress slowly and insidiously. It may develop three major clinical features: cold abscesses, neurologic deficits and long-term kyphotic deformity.(Mansour et al., 2023; Rajasekaran et al., 2018)

Spinal tuberculosis (TB) accounts for approximately half of the cases of osteo-articular TB. The WHO global TB report of 2020 has estimated the incidence of TB for 2019 to be 10 million cases worldwide. Out of these, approximately 12% of the affected population is of children. The prevalence of spinal TB is around 4.5% of all childhood TB. The incidence of spinal tuberculosis is increasing due to the expanding use of immunosuppressants and biological therapies, the emergence of drug-resistant bacterial strains and immigration of people from disease prevalent zones. Anti-Tubercular drugs are effective in the management of uncomplicated spinal TB.(Ahuja et al., 2022; Upadhyaya et al., 2023)

Alternate routes for tuberculous bacilli to reach the spine include lymphatic outflow to the para-aortic lymph nodes or Batson's paravertebral venous plexus. Early detection is crucial for preventing neurological sequelae and preventing the infection from spreading further. A particular medical intervention, on-demand operation, and a precise rehabilitative schedule form the basis of Pott's multidisciplinary therapeutic care.(Mandhane et al., 2023)

Adults' kyphosis keeps getting worse when they receive conservative treatment and even after surgical treatment. The diaphragm is forced into the chest cavity and the rib borders move closer to the iliac crest, further worsening the breathing ability. Patients with severe thoracic kyphosis caused by TB may experience respiratory failure within a few years. Spinal canal stenosis and deformity are caused by lacking diagnosis and treatment. Typically, thoracic TB of the spine involves the vertebral body and is localized there. The edges of the vertebrae, especially the anterior part of the vertebrae, are where tuberculous infection typically first manifests itself. Over 70% of individuals having spinal TB develop a paraspinal abscess, which frequently occurs in concordance with epidural extension.(Guo et al., 2022; Mandhane et al., 2023)

In order to treat patients with TB spine, goal-oriented medical as well as physiotherapy management is required. For Pott's disease, decompressive surgery followed by anti-TB chemotherapy is still the best treatment option. Medical management along with planned physiotherapy rehabilitation helps in easing the symptoms of the sick individual, timely recovery, and improved quality of life.(Mandhane et al., 2023; Yong et al., 2021)

Methods

This systematic review meta analysis was conducted in adherence to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines. Our health care question was defined a priori using the PICO (Population, Intervention, Comparator and Outcomes) format. Population: Individuals diagnosed with tuberculois spondylitis.

Intervention: Surgical therapy. Comparison: Conservative. Outcome: The effects of each therapy.

Eligibility Criteria

For inclusion in this systematic review and meta-analysis on the exploration of effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis, studies with diverse designs will be considered. This encompasses randomized controlled trials (RCTs), observational studies, quasi-experimental designs, and case-control studies. Studies must specifically investigate about albumin serum as predictor of effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis, such as effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis.

The eligible population includes individuals at albumin serum as predictor of effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis, with no restrictions based on age, gender, or geographical location. Exclusion criteria encompass studies not directly relevant to albumin serum as predictor of effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis, reviews lacking original data, and studies solely not focusing on effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis.

Comparison groups are essential for this analysis, and eligible studies must incorporate a comparison group using the other methods for effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis. Excluded are studies without a comparison group or those comparing effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis.

Outcome measures of interest include effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis. Studies reporting outcomes unrelated to these measures or not directly addressing the effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis. These criteria are designed to ensure the comprehensive inclusion of studies exploring the effectiveness between surgical therapy and conservative therapy in the management of tuberculosis spondylitis, facilitating a thorough systematic review and meta-analysis of the current literature.

Results and Discussions

Using reputable resources like PubMed, Sage journal, lancet, and Science Direct, our research team first gathered 26054 publications. A thorough three-level screening strategy was used to identify only ten articles that have a direct relationship with the current systematic review have been selected for further screening based on full-text reading and analyses. The selected articles and their respective publication year along with the distribution of the publications years have been shown in Figure 1 above.

Author	Origin	Method	Sample Size	Result
Jiang, T et al., 2015(Jiang et al., 2015)	China	This study retrospectively reviewed 53 patients with lumbosacral tuberculosis who were treated in our institution between January 2005 and January 2011. There were 29 males and 24 females with average ages of 37.53 ± 17.28 years (range 6–72 years).	53	The mean lumbosacral angles were 23.00°± 2.90°in the conservatively treated patients and 22.36°± 3.92o in the surgically treated patients. At the final follow-up, this had improved to 24.10o ± 2.96°in the conservatively treated patients and 28.13° ± 1.93°in the surgically treated patients (all P < 0.05). There were statistically significant differences before and after treatment in terms of ESR and CRP (all P < 0.05). All patients achieved bone fusion. The mean follow-up period was 32.34 ± 8.13 months (range 18 to 55 months). The neurological deficit did not worsen in any of the patients.
Fazal, A & Chaudry, A., 2018(Fazal et al., 1960)	Kenya	All patients who had complete medical records and had surgery for spinal tuberculosis were recruited into the study. The study period was from 2005 to 2015. Relevant data was collected and appropriately analyzed.	18	For all the patients, chemotherapy was started immediately after tuberculosis of the spine was diagnosed. Five patients had involvement of the lumbar region, one patient with involvement of the cervical region and the rest had involvement of the thoracic region. One patient had 3 vertebrae involved, 3 patients had one vertebrae involved and 14 patients had 2 vertebrae involved. Out of the 18 patients, 12 showed improvement after surgery, 4 patients had no difference after surgery and 2 patients worsened after surgery. Two patients showed improvement after 1 week; 3 patients after 2 weeks; 3 patients after 1 month; 4 patients after 2 months. Of the patients who worsened; 1 patient worsened by 1 grade while another worsened by 2 grades. No patient had any SSI. This was irrespective of whether they had instrumented spine surgery or not.
Huang, J et al., 2014(Huang et al., 2014)	China	We performed a retrospective review of clinical and radiographic data that were prospectively collected on 550 consecutive spinal tubercular patients including 27 patients who were diagnosed and treated as NSTB in our institution from June 2005 to June 2011.	27	23 patients (15 M/8F), averaged 44.6±14.2 years old (range, 19 to 70 yd), who received surgical treatment, were followed up after surgery for a mean of 52.5±19.5 months (range, 24 to 72 months). The kyphotic angle was changed significantly between pre- and postoperation (P<0.05). The mean amount of correction was 12.6±7.2 degrees, with a small loss of correction at last follow-up. All patients achieved solid bone fusion. No patients with neurological deficit deteriorated postoperatively. Neither mortalities nor any major complications were found. There was a significant difference of Oswestry Disability Index scores between preoperation and the final follow-up.
Kilinc, F et al., 2023(Kilinc et al., 2023)	Germany	This study was performed at the neurosurgical department of	34	We identified 34 patients with spinal tuberculosis who underwent surgical treatment. In the cervical spinal tuberculosis group, there were 15 cases (46.9%) In most cases treatment consisted of spinal

		Goethe-University Frankfurt. Patients with spinal tuberculosis between 2014 and 2022 were retrospectively analyzed.		instrumentation. In the thoracic group, 10 cases (29.4%) were observed. The treatment was performed by dorsolateral spinal instrumentation. For the thoracolumbar group, 9 cases (26.4%) were observed. In most cases dorsolateral spinal instrumentation was performed. One patient in the first group and one patient in the third group relapsed after operation. A second surgery was necessary. Patients with chronic back pain, immigration background and/or neurological deficit spinal TB should be considered as a differential diagnosis. Combined surgical intervention and medical treatment is associated with a favorable outcome.
Agradi, P et al., 2020(Agradi et al., 2020)	Indonesia	This study used retrospective method by analyzing medical record data of TB spondylitis patients operated at RSHS, January 2014–May 2018.	58	The 58 patients consisted of 25 males and 33 females, Kolmogorov-Smirnov test showed a significant difference (p
Xu, Z et al., 2015(Xu et al., 2015)	China	A total of 73 patients with monosegmental thoracic or lumbar spinal tuberculosis were enrolled from January 2006 to April 2011.	73	Clinical and radiographic results were analyzed and compared between the groups. Patients were followed for a mean 31.3 months (range, 21-42 months). Fusion occurred at 4-12 months (mean, 7.7 months). Surgical complications affected one and five patients in groups A and B, respectively. There was extraction of internal fixation in two group B patients. Postoperatively, there was significant Cobb angle correction in the two groups. By the last follow-up, the Cobb angle and correction loss in group A were significantly better than that in group B; the group A Oswestry Disability Index and Frankel grade were better than that in group B.
Liu, H et al., 2020(Liu et al., 2020)	China	Seventy-eight patients with thoracic TB undergoing surgical treatment were divided into two groups on the basis of the surgical methods employed: Group A (single anterior debridement + bone graft fusion and internal fixation) and Group B (single posterior debridement + bone graft fusion and internal fixation).	78	The surgical duration and mean hospital stay were significantly longer and the perioperative bleeding volume was significantly higher in Group A than B. At the last follow-up, changes in the American Spinal Injury Association grade showed no obvious differences between the two groups. Before and after the surgery and at the last follow-up, no significant differences were detected in the Cobb angle change or correction rate between the two groups.
Rava, A et al., 2023(Rava	Italy	Consecutive enrolled adult patients were	132	A total of 132 patients (59 women and 73 men) suffering from spinal TB with a mean age at presentation of 49 years (range, 32–68 years) were

et al., 2023)		conservatively treated from January 2000 to January 2020 for spinal TB in a tertiary care Orthopedic and Trauma Center—Spine Surgery Unit in Turin.		treated. The mean follow-up was 43 months (range, 12–82 months). In 80 cases, there was a single vertebra involvement while multiple levels were involved in 52 cases. Sixty-nine (52%) patients presented spondylitis without involvement of the disk and 63 (48%) patients presented a spondylitis with disk involvement. Conservative treatment was effective in 113 patients (86%) which showed inter-somatic fusion with stability of the spine. The mean period of antibiotic therapy was 12 months (range, 8–15 months). Patients wear spinal orthosis for at least 12 weeks. The physical component summary (PCS)-36 (48.9±10.0) and mental component summary (MCS) (46.5±7.0) summary scores at follow-up were comparable to the normative values (P=0.652 and P=0.862, respectively). Painful deformity occurred in 25 patients (19%).
Alam, MS et al., 2015(Alam et al., 2015)	Bangladesh	A total of 582 patients with TB of the cervical, thoracic and lumbar spine with moderate to severe cord compression were studied. Variable degrees of neurological deficit with deformity were treated from January, 2003 to July, 2014.	582	The average age was 32.5 years. All patients survived surgery. There were 7 cases of superficial infections (1.2%) whilst there were 4 cases (0.7%) of deep infections. Revision surgery was performed in 6 patients (1.0%). Implant failure occurred in 4 cases (0.7%) whilst malposition of screws occurred in 12 cases (2.1%). Perioperative bleeding complications were reported for 4 patients (0.7%). Neurological improvement occurred in all patients except for 2 cases (0.3%). Preoperatively, the majority of patients (n=221, 38%) were classified with Class A on the American Spinal Injury Association (ASIS) neurological impairment scale. This was significantly reduced postoperatively to 0.4%.
Chen, L & Zhang, J., 2023(Chen & Zhang, 2023)	China	In this retrospective analysis, we examined the clinical data from 123 patients with surgically treated thoracolumbar spinal tuberculosis. Patients were categorized into two groups based on the duration of preoperative chemotherapy: the short-course intensive chemotherapy group (n=53, 1–7 days) and the traditional quadruple chemotherapy group (n=70, 2–4 weeks).	123	All 123 patients underwent follow-up for a duration averaging 2.8±0.7 years. Five patients experienced postoperative recurrence. Patients reported significant pain alleviation and overall good clinical outcomes. Among patients with neurological dysfunction, neurological symptoms were ameliorated, and the implanted devices were found to be effective. Bony fusion was observed in all the bone grafting regions.

Outcome of Neurogical

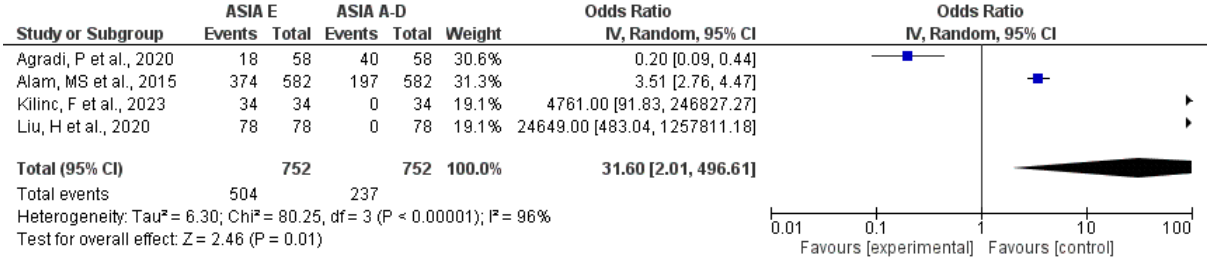

Figure 2. Forest Plot of Outcome of Neurogical

Based on the Z value of 2.46 and p value 0.01, there is effect of surgical therapy in the management of tuberculosis spondylitis.

Complications

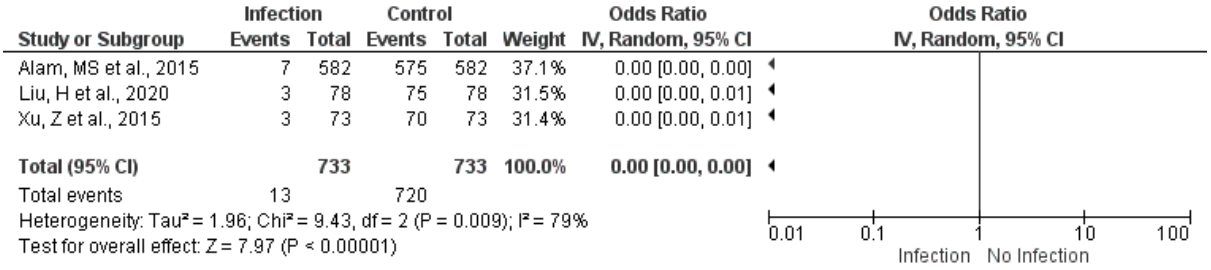

Figure 3. Forest Plot of Complications

Based on the Z value of 7.97 and p value <0.00001, there is complications of surgical therapy in the management of tuberculosis spondylitis.

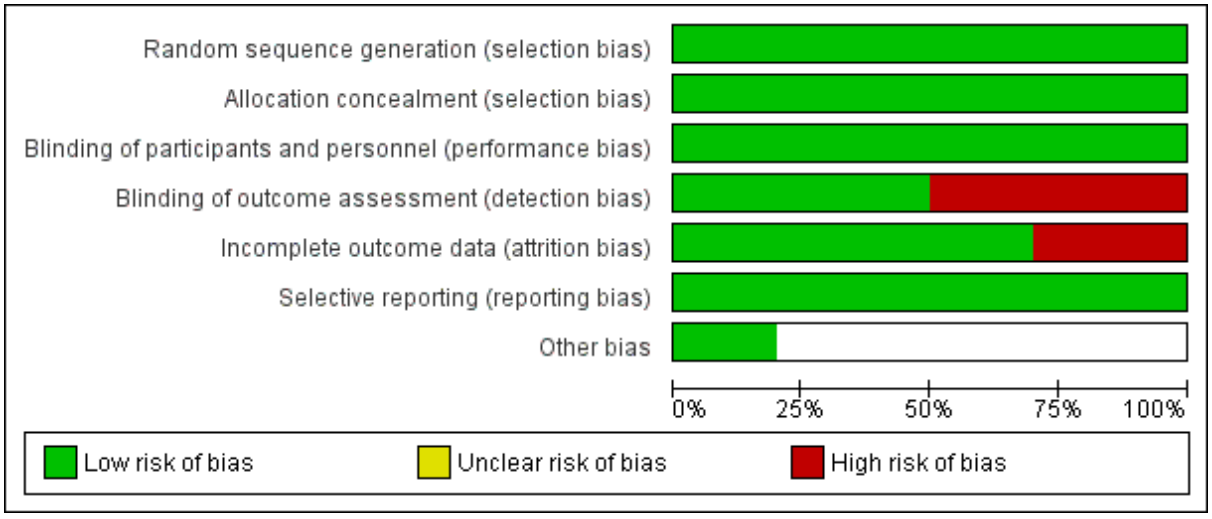

Figure 4. Risk of Bias

Based on the risk of bias, there is a 50% of low risk and 50% high risk in the blinding of outcome assessment and incomplete outcome data of the 10 studies concerned.

Discussion

Extrapulmonary tuberculosis represents 10% of all tuberculosis cases, with half involving the musculoskeletal system. The spine is the most common musculoskeletal site, accounting for between 1% and 2% of all tuberculosis cases, with the thoracolumbar junction being the most affected region of the spinal column, followed by the lumbar and cervical spine. Extrapulmonary tuberculosis often presents as a diagnostic challenge due to nonspecific clinical findings and non-

pathognomonic radiological features. It poses therapeutic challenges due to difficulties associated with accessing the site of involvement and assessing therapeutic response. Additionally, the impact of prolonged antituberculosis treatment is significant. Furthermore, extrapulmonary tuberculosis has significant health implications, leading to disability secondary to instability, pain, deformity, and neurological complications.(Norisyam et al., 2024; Shetty et al., 2021)

Tuberculosis (TB) spondylitis, also known as spinal TB or Pott disease, is a form of skeletal TB a subclassification of extrapulmonary TB. TB spondylitis is considered to be especially dangerous as it is strongly correlated to various neurologic complaints. Although there is a reduction in the number of new TB incidences worldwide, the incidence of extrapulmonary TB, including skeletal TB, remains stagnant. Estimates show that skeletal TB contributes to around 10% of all extrapulmonary TB cases. Of that 10%, TB spondylitis contributes to almost 50% of the cases, making it the most common manifestation of all skeletal TB cases. Additionally, TB spondylitis has a high rate of complications, reaching around 10-43%.(Ipang & Ramang, 2023; Pandita et al., 2020)

Alternative based on basic treatment (anti-tuberculous drugs, supportive treatment, plaster body jacket/spica or brace, bed rest, abscess drainage). This came about due to some patients in early cases with limited problems, refusing any type of surgery, or outright declining invasive procedures of being contraindicated from receiving such procedures. The basic treatment is not only in the first alternative but also for supportive treatment of others. Alternative involved surgical procedures using anterior instrumentation, debridement, and fusion – this is typically reserved for cases of anterior thoracolumbar infection with minimal kyphosis and little to no pain.(Ipang & Ramang, 2023)

Antitubercular drugs have good penetration into vertebrae affected by TB. The effectiveness of three ATT drugs, isoniazid (INH), rifampicin, and pyrazinamide has been evaluated in tuberculous vertebral lesions. It has been determined that in patients who do not have a sclerotic wall around the tuberculous lesion, INH reaches bactericidal concentrations and rifampicin and pyrazinamide reach minimal inhibitory concentration. However, in patients who have a sclerotic rim around the tuberculous focus, drugs do not penetrate within four mm of the osseous sclerotic rim, which hence necessitates surgical removal. The success of ATT alone in the absence of surgery is high, ranging from 82 to 95%. Even in patients with paraplegia, recovery (pain, neurological deficits as well as spinal deformity) may occur in 40% of the cases with medical management alone.(Garg & Goyal, 2020; Shanmuganathan et al., 2023)

Indications for surgery in a patient with spinal TB who has associated neurological deficits include: worsening of existent deficits or development of new deficits while on therapy for 3–4 weeks, spinal tumor syndrome, rapidly developing paraplegia, severe paraplegia, defined in the INDEX-TB guidelines as 'flaccid paraplegia, paraplegia in flexion, complete sensory or motor loss for greater than 6 months, presence of painful paraplegia in elderly patients, neural arch disease. This is similar to Tuli's “middle path” approach which balanced medical and surgical management and came about in the 1970–80s. Surgery is also necessary to prevent severe kyphosis.(Garg & Goyal, 2020; Jia et al., 2019)

Conventional surgical strategies for thoracic tuberculosis include the anterior, posterior, and combined anterior–posterior approaches. In 1960, Hodgson et al. reported a method involving anterior decompression and autologous bone grafting to treat thoracic tuberculosis.

Subsequently, anterior surgery has been considered the gold standard method for the surgical management of spinal tuberculosis and is widely applied in clinical practice owing to its capacity for complete exposure of the lesion and thorough debridement. However, anterior surgery has inherent limitations, including failed correction due to the low fixation strength of the internal fixator, severe trauma and vascular damage due to complex thoracic anatomical structures, and surgical intolerance in patients with poor pulmonary function due to significant pulmonary impact. With the development of thoracic surgical techniques, video-assisted thoracic surgery (VATS) has been used to treat spinal diseases. Compared with traditional open surgery, VATS offers notable advantages including fewer associated injuries, shorter postoperative recovery time, lower postoperative pain levels, and relatively smaller surgical scars.(Xiu et al., 2023)

Conclusion

In conclusion, conservative anti-TB drug therapy and surgical treatment are both safe and effective approaches for managing lumbosacral spinal tuberculosis, particularly in patients diagnosed early and with a limited number of affected vertebrae. Conservative treatment with anti-TB drugs yields favorable clinical and radiological outcomes, while surgical intervention offers additional benefits, including thorough debridement, effective spinal cord decompression, and enhanced spinal stabilization. The combination of these methods can significantly improve patient prognosis and functional recovery.

For future research, studies should focus on long-term comparative analyses between conservative and surgical treatments to assess their efficacy in preventing recurrence and preserving spinal function. Additionally, research into minimally invasive surgical techniques and biodegradable spinal implants could enhance treatment outcomes with reduced postoperative complications. Further investigations into biomechanical modeling and patient-specific treatment plans using AI-based predictive analytics may optimize surgical decision-making. Moreover, exploring early diagnostic biomarkers for spinal TB could improve detection rates and allow for earlier, more targeted interventions.

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