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Severe Spinal Tuberculosis Challenges in Surgical Management

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Aziz ur Rehman[1,] Sajjad ullah[1,] Muhammad idris khan[1], Moath Ahmed Abdullah Abdullah[2], Sulaiman Khan[3]

[1] Khyber Teaching Hospital Peshawar
[2] Institute of Public Health and Social Sciences KMU Peshawar
[3] Hayatabad Medical Complex Peshawar

CORRESPONDING AUTHOR: DR Aziz ur Rehman, FCPS Neurosurgery, KHYBER TEACHING HOSPITAL

Abstract

Background: Spinal tuberculosis can cause vertebral collapse, kyphosis, and neurological deficit. Chemotherapy remains the base treatment. Surgery is indicated when neurological compromise, instability, deformity, or abscess-related compression risk persists despite medical therapy. Surgical outcomes are reported for a cohort with severe spinal tuberculosis.

Methods: Retrospective observational study of 200 patients operated between July 2022 and October 2025 at the Department of Neurosurgery, Khyber Teaching Hospital, Peshawar. Surgical approaches included anterior, posterior, and combined procedures. Variables recorded included age, sex, residence, tuberculosis history, symptom duration, spinal level, lesion type, vertebrae involved, ASIA grade, VAS, ESR, CRP, Cobb angle, operative time, blood loss, hospital stay, mobilization time, complications, and recurrence.

Results: Mean age was 41.9 ± 23.7 years. Females were 108 (54.0%) and males were 92 (46.0%). Mean symptom duration was 27.5 ± 14.9 weeks. Cervical involvement was 60 (30.0%), thoracic 46 (23.0%), lumbar 48 (24.0%), and lumbosacral 46 (23.0%). Approaches were posterior 68 (34.0%), combined 67 (33.5%), and anterior 65 (32.5%). Instrumentation was used in 89 (44.5%). Neurological outcome was improved in 63 (31.5%), unchanged in 74 (37.0%), and worsened in 63 (31.5%). Wound infection occurred in 102 (51.0%) and recurrence in 90 (45.0%). Recurrence differed by approach ($p = 0.047$), and in adjusted analysis the combined approach showed lower odds of recurrence (Odds Ratio [OR] 0.40, 95% Confidence Interval [CI] 0.19 to 0.85, $p = 0.016$). Wound infection was independently associated with male sex (OR 2.31, 95% CI 1.20 to 4.44, $p = 0.012$) and instrumentation (OR 2.30, 95% CI 1.22 to 4.32, $p = 0.010$).

Conclusion: Surgical management produced variable neurological recovery in a severe cohort. High rates of wound infection and recurrence were the main barriers to durable benefit. Combined approaches showed lower recurrence odds after adjustment. Surgical treatment improved clinical status for a substantial proportion of patients.

Keywords: spinal tuberculosis; surgical approach; neurological outcome; wound infection; recurrence; kyphosis.

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Introduction

Spinal tuberculosis (TB) remains an important cause of disability in endemic settings. It is a frequent osteoarticular manifestation and can progress to vertebral body destruction, kyphotic deformity, and neurological deficit, including paraplegia.[1]

The clinical problem centers on deformity and neurological deficit. Surgical approach selection remains debated, including posterior surgery with or without corpectomy, and reported outcomes vary by disease pattern and operative extent.[2] Disease distribution concentrates in the thoracic and lumbar spine. In a cohort of 893 patients, thoracic and lumbar involvement accounted for 86.6 percent of cases.[3]

Surgery aims to address neurological compromise, instability, and progressive deformity, but the optimal approach remains debated. Spinal TB primarily affects the anterior column. The anterior approach provides direct exposure for debridement and reconstruction, yet reports link it with respiratory failure, death, and graft-related complications in some series.[4] Posterior strategies have expanded because pedicle screw fixation provides three-column stability and allows circumferential decompression through posterior corridors, with extrapleural access that can reduce pulmonary complications.[5]

Current work has described indications, operative components, and outcome measures, but variability persists across disease patterns and levels. Anti-tuberculosis chemotherapy remains the cornerstone, while surgery is often required in severe kyphosis, impaired neurological function, or spinal instability. Debridement, bone grafting, and internal fixation remain core operative steps.[6] Neurological recovery relates to the nature of compression and MRI appearance. Better recovery is reported with preserved cord volume and edema or myelitis, compared with myelomalacia and reduced cord volume, and outcomes differ by compressive tissue type.[7]

A clear gap remains in pragmatic outcome evidence that reflects real-world case-mix, timing, and postoperative pathways in high-burden centers. Laminectomy alone for anterior disease has been described as inappropriate because it removes healthy posterior elements and can worsen instability and deformity.[8] Approach selection also varies by anatomy. Upper thoracic anterior access can be difficult because of the sternum, clavicle, ribs, and mediastinal structures, which increases the relevance of posterior-only strategies in this region.[9] Posterior approaches also differ in extent. Posterior corpectomy can improve deformity correction but increases operative time, while decompression and stabilization without corpectomy is described as less invasive in selected cases.[10]

Challenges persist in multi-segment disease and in preventing postoperative complications in patients with poor bone quality or suspected drug resistance.[11] Postoperative pathway measures, including local lesion continuous irrigation protocols after posterior surgery, have been evaluated with early inflammatory and pain outcomes.[12]

This study evaluates surgical outcomes for spinal tuberculosis in a high-burden tertiary center, including anterior, posterior, and combined approaches. Outcomes were assessed using Cobb angle, VAS, and ASIA grade, with complications and recurrence documented during follow-up.[13] The research question is pragmatic: in routine practice, what clinical, radiological, and functional outcomes follow surgical treatment of spinal tuberculosis, and which adverse outcomes dominate the postoperative course.

The expected insight is practical. It describes baseline deformity and pain burden in a high-burden setting and it defines the complication profile that limits durable success.

Materials and Methods

Study Design

This study used a retrospective observational design. The study protocol underwent rigorous review and was approved by the Institutional Ethical Review Board (IERB) of Khyber Teaching Hospital. Given the retrospective design, which involved the analysis of archived medical records and radiological images, the requirement for individual informed consent was waived by the ethics committee. Personal identifiers were removed. Data were anonymized before analysis.

Study Setting and Duration

The study was conducted in the Department of Neurosurgery, Khyber Teaching Hospital, Peshawar, a tertiary care referral center that manages a high volume of complex spinal tuberculosis cases. Data were collected over 3.5 years and included all eligible patients operated on between July 2022 and October 2025.

Sample Size

The sample size was estimated using OpenEpi (Version 3.01) with a 95% confidence level and a 5% margin of error. The final cohort included 200 patients and exceeded the minimum required sample size.[14]

Sampling Technique

A consecutive non-probability sampling technique was used. Admission and operative registries were reviewed to identify all patients who underwent surgery for spinal tuberculosis during the study period. All eligible cases were included consecutively to reduce selection bias and reflect the routine case mix presenting to the center.

Sample Selection

Strict eligibility criteria were applied to ensure the homogeneity of the study population.

Inclusion Criteria:

1. Age 1 to 80 years, both sexes.
2. Spinal tuberculosis confirmed microbiologically or histopathologically, including intraoperative culture or histopathology and or PCR-based testing.
3. Operated during the study period for at least one surgical indication:
    - Neurological deficit (ASIA A to D)
    - Spinal instability
    - Progressive or significant kyphotic deformity
    - Paraspinal or epidural abscess with neural compression
    - Failure of conservative treatment
4. Baseline and follow-up neurological status documented using ASIA grades A to E.

Exclusion Criteria:

1. Alternative diagnosis not excluded when tuberculosis could not be confirmed.
2. Incomplete records or insufficient follow-up.
3. Active severe pulmonary tuberculosis precluding general anesthesia or surgery.
4. Prior spinal surgery at the same level.

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5. Lost to follow-up.

Definition of Terms

To ensure consistency and reproducibility in data interpretation, the following operational definitions were applied:

Neurological Status

- Neurological function was recorded using the American Spinal Injury Association impairment scale. Grades were documented from A to E.[15]
- Neurological deficit was defined as ASIA grade A, B, C, or D.
- Neurological improvement was defined as an increase in ASIA classification by one or more levels.

Pain intensity

- Back pain severity was assessed using the Visual Analog Scale (VAS) and recorded from 0 to 10.[16]

Pain relief score

- Pain relief was recorded as an ordinal pain relief score documented during follow-up.

Kyphotic deformity

- Kyphosis was measured using the Cobb angle. Cobb angle was defined as the angle between the extension line of the upper endplate of the normal vertebra adjacent to the diseased vertebra and the lower endplate of the next normal vertebra.[18]

Data Collection Procedure

Data were extracted using a standardized proforma from physical files and electronic records. Variables recorded included age, sex, residence, tuberculosis history, symptom duration, spinal level, lesion type, vertebrae involved, American Spinal Injury Association (ASIA) grade, Visual Analog Scale (VAS) score, Erythrocyte Sedimentation Rate (ESR), C-reactive Protein (CRP), Cobb angle, operative time, blood loss, hospital stay, mobilization time, complications, and recurrence. Follow-up data included neurological outcome category, wound infection status, pain relief score distribution, anti-tuberculosis treatment duration, and follow-up duration. Wound infection was coded as a binary outcome. Other postoperative complications were coded as one primary complication category per patient.[17] Radiological evaluation relied on preoperative imaging. Kyphotic deformity was recorded as present or absent, and deformity magnitude was measured using the Cobb angle on baseline lateral radiographs.[18] ESR and CRP were recorded at admission as inflammatory markers.[9]

Data Analysis Plan

Data were entered into SPSS version 27 and checked for completeness, internal consistency, implausible values, and outliers. Categorical variables were standardized to uniform labels. Continuous variables were summarized as mean and standard deviation when approximately normal and as median with interquartile range when skewed. Categorical variables were summarized as frequencies and percentages. Baseline reporting covered demographics, disease profile, imaging and laboratory markers, and operative and perioperative variables recorded in the dataset.

Outcomes were analyzed using available fields. Neurological outcome was reported as improved, unchanged, or worsened. Pain outcome was reported using baseline VAS and the pain relief score distribution. Complication and recurrence rates were reported as proportions, including wound infection, postoperative complication categories, intraoperative complications, and recurrence.

Bivariable associations used chi-square or Fisher exact tests for categorical predictors and independent t test or Mann–Whitney U tests for continuous predictors in binary outcomes, and chi-square with one-way ANOVA or Kruskal–

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Wallis tests for the three-level neurological outcome. Pain relief score analyses used non-parametric group testing and Spearman correlation for continuous predictors. Multivariable analysis used binary logistic regression for recurrence and wound infection with covariates selected a priori from clinically relevant variables available in the dataset, with missing data quantified and complete-case analysis applied where missingness was limited. Two-sided p values were used with significance set at $p < 0.05$.

Results

Patient characteristics and follow-up

Mean age was 41.9 ± 23.7 years. Females were 108 (54.0%) and males were 92 (46.0%). Urban residence was 109 (54.5%) and rural residence was 91 (45.5%). Previous tuberculosis history was present in 94 (47.0%). Mean symptom duration was 27.5 ± 14.9 weeks. Mean follow-up was 12.3 ± 6.6 months. Mean anti-tuberculosis treatment duration was 10.6 ± 4.8 months.

Table 1: Demographic and Clinical Characteristics of the Study Cohort (N=200)

Variable	Value
Age (years)	41.9 ± 23.7
Female	108 (54.0%)
Male	92 (46.0%)
Urban residence	109 (54.5%)
Rural residence	91 (45.5%)
Previous TB history (yes)	94 (47.0%)
Previous TB history (no)	106 (53.0%)
Symptom duration (weeks)	27.5 ± 14.9
Follow-up (months)	12.3 ± 6.6
ATT duration (months)	10.6 ± 4.8

*ATT = Anti-tuberculosis treatment

Baseline disease characteristics

Cervical involvement was 60 (30.0%), thoracic 46 (23.0%), lumbar 48 (24.0%), and lumbosacral 46 (23.0%). Kyphotic deformity was recorded in 87 (43.5%). Mean Cobb angle was 40.2 ± 22.8 degrees. Mean baseline VAS was 5.1 ± 3.1. Mean ESR was 65.3 ± 31.5 mm/h and mean CRP was 25.2 ± 15.0 mg/L. Baseline ASIA grades were A 55 (27.5%), B 37 (18.5%), C 39 (19.5%), D 34 (17.0%), and E 35 (17.5%). Neurological deficit (ASIA A to D) was present in 165 (82.5%), while 35 (17.5%) were neurologically intact (ASIA E) and underwent surgery for instability, deformity, abscess-related compression risk, or failure of conservative management.

Table 2: Baseline Disease Characteristics and Imaging Findings

Variable	Value

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Spinal level involved	
Cervical	60 (30.0%)
Thoracic	46 (23.0%)
Lumbar	48 (24.0%)
Lumbosacral	46 (23.0%)
Kyphotic deformity (yes)	87 (43.5%)
Kyphotic deformity (no)	113 (56.5%)
Lesion type	
Lytic	66 (33.0%)
Mixed	66 (33.0%)
Sclerotic	68 (34.0%)
Number of vertebrae involved	
1	35 (17.5%)
2	33 (16.5%)
3	33 (16.5%)
4	29 (14.5%)
5	43 (21.5%)
6	27 (13.5%)
Baseline ASIA grade	
A	55 (27.5%)
B	37 (18.5%)
C	39 (19.5%)
D	34 (17.0%)
E	35 (17.5%)
Cobb angle (degrees)	40.2 ± 22.8
VAS score	5.1 ± 3.1
ESR (mm/h)	65.3 ± 31.5
CRP (mg/L)	25.2 ± 15.0

*VAS = Visual Analog Scale; ESR = Erythrocyte Sedimentation Rate; CRP = C-reactive Protein

Operative and perioperative parameters

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Surgical approach was posterior in 68 (34.0%), combined in 67 (33.5%), and anterior in 65 (32.5%). Instrumentation was used in 89 (44.5%). Mean operative time was 3.50 ± 1.43 hours. Mean blood loss was 775.8 ± 445.3 mL. Mean hospital stay was 16.2 ± 8.1 days. Mean time to mobilization was 7.3 ± 4.1 days.

Table 3: Operative and Perioperative Parameters

Variable	Value
Surgical approach	
Posterior	68 (34.0%)
Combined	67 (33.5%)
Anterior	65 (32.5%)
Instrumentation used (yes)	89 (44.5%)
Instrumentation used (no)	111 (55.5%)
Operative time (hours)	3.50 ± 1.43
Blood loss (mL)	775.8 ± 445.3
Hospital stay (days)	16.2 ± 8.1
Time to mobilization (days)	7.3 ± 4.1

Clinical outcomes and complications

Neurological outcome was improved in 63 (31.5%), unchanged in 74 (37.0%), and worsened in 63 (31.5%). Wound infection was recorded in 102 (51.0%). Recurrence was recorded in 90 (45.0%). Postoperative complications were also recorded as a single primary category per patient. The primary recorded complication was hardware failure in 57 (28.5%), infection in 50 (25.0%), and CSF leak in 49 (24.5%). Pain relief score distribution is shown in Table 5.

Table 4: Clinical Outcomes and Postoperative Complications

Outcome Category	Result (n, %)
Neurological outcome	
Improved	63 (31.5%)
Unchanged	74 (37.0%)
Worsened	63 (31.5%)
Wound infection (yes)	102 (51.0%)
Wound infection (no)	98 (49.0%)
Recurrence (yes)	90 (45.0%)
Recurrence (no)	110 (55.0%)
Primary postoperative complication*	

Hardware failure	57 (28.5%)
Infection	50 (25.0%)
CSF leak	49 (24.5%)
None recorded	44 (22.0%)

Table 5: Pain Relief Score Distribution at Follow-up

Pain Relief Score	Number of Patients (n, %)
0 (No relief)	38 (19.0%)
1	35 (17.5%)
2	39 (19.5%)
3	36 (18.0%)
4	28 (14.0%)
5 (Complete relief)	24 (12.0%)

*Pain relief score: 0 = no relief, 5 = complete relief

Bivariable association testing

Recurrence differed by surgical approach (p = 0.047). Recurrence occurred in 34 of 65 (52.3%) after anterior surgery, 22 of 67 (32.8%) after combined surgery, and 34 of 68 (50.0%) after posterior surgery. ESR differed by recurrence status. Mean ESR was 60.0 ± 32.0 mm/h in the recurrence group and 69.6 ± 30.7 mm/h in the non-recurrence group (p = 0.034).

Wound infection differed by age (p = 0.014). Mean age was 37.9 ± 24.5 years in infected cases and 46.1 ± 22.1 years in non-infected cases. Wound infection also differed by instrumentation (p = 0.021) and lesion type (p = 0.045). Infection occurred in 54 of 89 (60.7%) with instrumentation and 48 of 111 (43.2%) without instrumentation. Infection occurred in 43 of 68 (63.2%) with sclerotic lesions, 30 of 66 (45.5%) with lytic lesions, and 29 of 66 (43.9%) with mixed lesions.

Neurological outcome differed by lesion type (p = 0.026). Improvement occurred in 29 of 66 (43.9%) lytic lesions, 18 of 66 (27.3%) mixed lesions, and 16 of 68 (23.5%) sclerotic lesions.

Table 6: Bivariable Association Testing Summary

Outcome	Predictor	Key Comparison	p-value
Recurrence	Surgical approach	Anterior vs Combined vs Posterior	0.047
Recurrence	ESR	Mean ESR: recurrence vs no recurrence	0.034
Wound infection	Age	Mean age: infected vs non-infected	0.014
Wound infection	Instrumentation	Yes, vs No	0.021

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Wound infection	Lesion type	Lytic vs Mixed vs Sclerotic	0.045
Neurological outcome	Lesion type	Lytic vs Mixed vs Sclerotic	0.026

Multivariable analysis

Multivariable logistic regression models were fitted for recurrence and wound infection using clinically relevant covariates available in the dataset.

Table 7A: Multivariable Logistic Regression for Recurrence

Term	**Odds Ratio (OR)**	**95% Confidence Interval**	**p-value**
Combined approach (vs Anterior)	0.40	0.19 to 0.85	0.016
Posterior approach (vs Anterior)	0.89	0.44 to 1.82	0.751
Age (per year increase)	1.01	1.00 to 1.02	0.155
Male sex (vs Female)	0.62	0.33 to 1.15	0.131
Symptom duration (per week)	0.99	0.97 to 1.01	0.323
ASIA score (per grade increase)	1.05	0.86 to 1.29	0.642
Instrumentation (yes vs no)	1.04	0.57 to 1.90	0.889
ATT duration (per month)	0.98	0.92 to 1.04	0.429
Follow-up duration (per month)	1.00	0.95 to 1.04	0.906

*Reference categories: Surgical approach = Anterior; Sex = Female; Instrumentation = No

Table 7B: Multivariable Logistic Regression for Wound Infection

Term	**Odds Ratio (OR)**	**95% Confidence Interval**	**p-value**
Age (per year increase)	0.98	0.97 to 1.00	0.012
Male sex (vs Female)	2.31	1.20 to 4.44	0.012
Instrumentation (yes vs no)	2.30	1.22 to 4.32	0.010
Combined approach (vs Anterior)	1.60	0.75 to 3.41	0.225

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Posterior approach (vs Anterior)	0.75	0.35 to 1.58	0.445
Symptom duration (per week)	1.00	0.98 to 1.02	0.765
ASIA score (per grade increase)	1.21	0.98 to 1.50	0.075
ATT duration (per month)	1.03	0.97 to 1.10	0.362
Follow-up duration (per month)	0.96	0.92 to 1.01	0.131

*Reference categories: Surgical approach = Anterior; Sex = Female; Instrumentation = No

Spinal level reference category cervical. Surgical approach reference category anterior. Instrumentation reference category no. Sex reference category female. ASIA modeled per one-grade increase from A to E

Discussion

This study shows a late-presenting surgical spinal tuberculosis cohort with high baseline severity and high downstream morbidity. Mean symptom duration was 27.5 weeks. Prior tuberculosis history was present in 47.0%. Baseline inflammation was high. Baseline deformity was substantial with a mean Cobb angle of 40.2 degrees. Neurological status spanned the full ASIA range A to E. This profile aligns with established patterns where prolonged illness and systemic factors influence neurological recovery and relapse risk in spinal TB-related cord injury.[19] The operative mix included anterior, posterior, and combined approaches, with instrumentation used in 44.5%. Outcomes were mixed. Neurological improvement occurred in 31.5% while 31.5% worsened. Recurrence occurred in 45.0%. Wound infection occurred in 51.0%. Hardware failure, infection, and CSF leak were the dominant postoperative complication categories. The association signals were coherent with the clinical picture. Recurrence differed by approach and ESR differed by recurrence status. Infection differed by age, instrumentation, and lesion type. Neurological improvement differed by lesion type. In multivariable models, combined surgery was associated with lower recurrence odds and instrumentation remained a major infection driver. These results point toward two linked mechanisms. Residual disease control and systemic infection-control capacity likely dominated long-term outcomes more than decompression mechanics alone, consistent with the emphasis in spine TB reviews on disease clearance, chemotherapy adherence, and risk environments that increase relapse.[20]

Published surgical literature helps contextualize both the direction of benefit and the complication gap. In multisegment cohorts, authors describe higher instability, kyphosis burden, abscess load, and neurological dysfunction, with greater operative complexity as the number of involved levels increases. This aligns with the vertebrae-involved distribution in this dataset and with the observed operative time, blood loss, and prolonged hospital stay.[21] Technique-focused posterior papers also note that posterior strategy variants create different trade-offs. Posterior corpectomy can improve deformity correction in selected patterns but at the cost of longer operative time and higher operative burden, while posterior decompression and stabilization without corpectomy is positioned as less invasive for selected cases.[22]

In contrast, the prospective observational study of posterior decompression and stabilization in thoracic and lumbar disease reports marked pain improvement with comparatively low complication burden and earlier functional recovery metrics than the present dataset suggests.[23] Upper thoracic posterior-only debridement and fixation series also report

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sustained VAS improvement, normalization of ESR and CRP over follow-up, and low relapse rates under structured pathways, which diverges from the high infection and recurrence signals here.[24] Similarly, the one-stage posterior series for posterior-element tuberculosis with incomplete paralysis reports postoperative improvement in pain and disability indices with normalization of inflammatory markers and reliable fusion, again contrasting with the present complication profile.[25]

Comparative approach work that includes anterior, posterior, and combined groups reports complication rates far below the present levels and lists wound infection, sinus or fistula formation, and fixation loosening or fracture as expected but usually less frequent events, which frames the current findings as a setting and case-mix signal rather than a typical benchmark.[26] Within this dataset, the protective association of the combined approach against recurrence is clinically plausible in the same direction as literature that emphasizes more complete lesion clearance and anterior column reconstruction for selected patterns, while reviews still caution that approach choice must match morphology and level constraints.[27] The lesion-type associations in this dataset also fit established biological reasoning. Reviews emphasize that drug penetration and tissue characteristics vary across lesion composition, and this can influence persistence or relapse risk and the inflammatory trajectory, which matches the ESR recurrence signal and the lesion-type signals in bivariable testing.[28]

Taken together, the findings support a clear interpretation aligned with the study focus on surgical outcomes in spinal tuberculosis with neurological deficit. Symptom and deformity burden at baseline were high. Surgical intervention occurred late in the disease course for many patients, and the dataset shows that late, complex disease can still yield neurological improvement and pain relief for a subset, as seen across posterior-only series that use functional indices and neurological grading to demonstrate postoperative gains.[29] The dominant limitation to durable success in this cohort was the adverse-event burden, especially infection, recurrence, and mechanical failure. The regression results sharpen priorities. Combined approach association with lower recurrence supports disciplined selection for patients where anterior clearance and reconstruction are required, while the infection model underscores instrumentation-specific risk that demands stronger perioperative infection control and wound-care pathways in instrumented cases. Postoperative local lesion management protocols that combine irrigation and drainage have been evaluated with measurable ESR decline and pain improvement, and the same pathway logic fits this cohort's high infection and relapse signals.[30] Epidemiologic cohorts confirm that disease burden clusters in the thoracic and lumbar spine in endemic populations, supporting level-stratified planning and follow-up in high-volume centers, including surveillance for late relapse and implant-related failure.[31]

Limitations

Retrospective single-center design, heterogeneous approach selection, and reliance on record completeness limit causal inference and may underestimate events occurring outside follow-up.

Conclusion

Surgical management produced variable neurological recovery in a severe spinal tuberculosis cohort. High rates of wound infection, recurrence, and mechanical failure limited durable benefit. Combined approaches showed lower recurrence risk in adjusted analysis, supporting morphology-based approach selection and tighter perioperative infection control and wound care.

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