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ABOUT COVER

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ORIGINAL ARTICLE

Retrospective Study

Multitrack and multianchor point screw technique combined with the Wiltse approach for lesion debridement for lumbar tuberculosis

Yu-Fei Yuan, Zhi-Xin Ren, Cun Zhang, Guan-Jun Li, Bing-Zhi Liu, Xiao-Dong Li, Jie Miao, Jian-Fei Li

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Abstract

BACKGROUND

The incidence of lumbar tuberculosis is high worldwide, and effective treatment is a continuing problem.

AIM

To study the safety and efficacy of the multitrack and multianchor point screw technique combined with the contralateral Wiltse approach for lesion debridement to treat lumbar tuberculosis.

METHODS

The C-reactive protein (CRP) level, erythrocyte sedimentation rate (ESR), visual analogue scale (VAS) score, oswestry disability index (ODI) and American Spinal Injury Association (ASIA) grade were recorded and analysed pre- and postoperatively.

RESULTS

The CRP level and ESR returned to normal, and the VAS score and ODI were decreased at 3 mo postoperatively, with significant differences compared with the preoperative values ($P < 0.01$). Neurological dysfunction was relieved, and the ASIA grade increased, with no adverse events.

CONCLUSION

The multitrack, multianchor point screw fixation technique combined with the contralateral Wiltse approach for debridement is an effective and safe method for the treatment of lumbar tuberculosis.

Key Words: Lumbar spine; Tuberculosis; Debridement; Pedicle screw; Cortical bone trajectory screw; Wiltse approach

Core Tip: Pedicle screw combined with cortical bone trajectory screw+ contralateral Wiltse approach is safe and effective in the treatment of lumbar tuberculosis and suitable for the case of heavier lesion on one side and no large or flow abscesses in front of the lumbar spine.

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INTRODUCTION

2020 Global Tuberculosis Report stated that tuber-culosis remains the most common cause of death as a single infectious agent[1,2]. Spinal tuberculosis was first reported by Pott in 1782, and spinal tuber-culosis accounts for approximately 50% of cases of bone and joint tuberculosis[3], with lumbar tuberculosis accounting for 42.36% of spinal tuberculosis cases[4]. Spinal tuberculosis lesions often involve the vertebrae and intervertebral discs, leading to vertebral destruction and intervertebral space collapse, in turn resulting in intervertebral space abscesses, paravertebral abscesses[5], and angular kyphosis of the spine in severe cases[6]. Patients with lumbar spine tuberculosis may have clinical symptoms such as low back pain and neurological dysfunction, with or without symptoms of tuber-culosis toxicity[7]. In cases where medicine fails, surgery should be performed to relieve pain, correct deformity, and improve neurological function[8].

At present, the choice of surgical approach for lumbar tuberculosis remains controversial[9]. The surgical app-roaches can be divided into anterior, posterior, and combined anterior-posterior approaches, each with advantages and disadvantages. The anterior approach allows the removal of tuberculosis lesions and reconstruction of collapsed vertebrae under direct vision, but the risk of complications is high due to the complex anatomical structure of vessels and nerves in the anterior lumbar spine[9]. The combined anterior-posterior approach results in a long operation time and substantial intraoperative trauma. The conventional posterior approach requires the stripping of the paraspinal muscles, removal of normal posterior structures such as the lamina to expose and clear tuberculosis lesions, and use of screw-rod internal fixation to reconstruct lumbar lordosis[10,11].

Tuberculosis patients generally suffer from anaemia, hypoalbuminemia, and nutritional depletion [12], so surgical treatment should be as minimally invasive as possible to remove tuberculosis lesions while reducing damage to normal structures and reconstructing the spinal sequence[13]. Based on the above considerations, the author's team applied the posterior unilateral multitrack, multianchor screw technique combined with the contralateral Wiltse approach for lesion debridement in the treatment of lumbar tuberculosis.

An article in 2021 cited the pedicle screw as one of the top 10 inventions that shaped modern orthopaedics[14]. Pedicle screws were first used in vertebral fusion in 1959[15], and Roy-Camille first used pedicle screws for spinal fixation in 1963. Through the anterior column, pedicle screw placement can achieve three-column fixation of the spine, with excellent holding force and orthopaedic strength. In this study, the screw trajectory refers to the cortical bone trajectory (CBT) of the pedicle fixation technique, not the traditional technique. The CBT screw technique was first proposed by Santoni *et al* [16] in 2009; in this technique, the screw point is more inwards than the pedicle screw point, as it needs to be exposed to the isthmus of the lamina. The screw track runs from the medial-caudal to the lateral-cephalic direction. The screw is driven from the medial side of the lateral edge of the lamina into the posterior part of the superior endplate, and the screw path runs in the cortical bone. There are four cortical bone contact points to hold the screw, which results in a stronger screw holding force; thus, this technique is especially suitable for patients with osteoporosis and can be used for in revision surgery for adjacent segment disease[17] and in spinal orthopaedics[18].

MATERIALS AND METHODS

Patient population

Our research project was approved by the Ethics Committee of Handan Central Hospital. All patients signed informed consent forms. All methods were performed in accordance with the relevant guidelines and regulations.

The clinical data of patients with lumbar tuberculosis treated by unilateral pedicle screw combined with CBT screw fixation + the contralateral Wiltse approach for lumbar tuberculosis debridement from October 2014 to January 2021 were retrospectively analysed.

Inclusion criteria: X-ray, computed tomography (CT), magnetic resonance imaging (MRI), and other imaging examinations of patients showed vertebral and intervertebral space destruction, sequestrum formation, intervertebral and paravertebral cold abscess formation, spinal instability/deformity, *etc.*, which were consistent with the characteristics of spinal tuberculosis; a caseous substance was present, consistent with the diagnosis of spinal tuberculosis by histopathology; the patient had symptoms such as night sweats, low fever in the afternoon, and fatigue; and the patient had intractable low back pain, progressive neurological impairment, and other symptoms. Exclusion criteria: huge abscess anterior to the lumbosacral spine; lumbar infusion abscess.

Preoperative preparation

All patients were absolutely bedridden; high-energy and high-protein diets were given to improve the nutritional status, and anaemia and hypoproteinaemia were corrected before surgery. Low-molecular-weight heparin (4100 units 1/d) was injected subcutaneously to prevent deep vein thrombosis. All patients received standard combinations of 4 drugs for 2–4 wk (H, isoniazid: 300 mg/d, R, rifampicin: 450 mg/d, E, ethambutol: 750 mg/d, Z, pyrazinamide: 750 mg/d).

Surgical strategy

Two advanced surgeons performed the operations. The patient underwent general anaesthesia and tracheal intubation in the prone position. The target segment was positioned, a midline incision was made in the posterior lumbar spine, and the paraspinal muscle on the opposite side of the lesion was stripped. The spinous process, lamina, and facet joints were exposed, and the pedicle screws and CBT screws were inserted according to the preoperative plan. A prebent titanium rod was fixed and locked, and then the incision was closed. A wound incision was made on the opposite side, the original muscle space was separated to reach the intervertebral space, the channel was expanded step by step, a quadrant dilator was placed, the facet joint was exposed, and electrocautery was used to stop bleeding and peel the surface soft tissue. Osteotomy was used to remove part of the inferior and superior articular processes, and limited cleavage of the lamina was used to expose the spinal canal. Exposure and protection were performed under direct vision, and the dural sac and nerve root were retracted. Then, the intervertebral space was exposed, suction was performed to remove pus, and curettage of the infected vertebral body and intervertebral space abscess, sequestrum and caseous necrosis was performed with different angled spatulas until the surface of the healthy bone showed slight bleeding. After the lesions were completely removed, the dural sac was carefully checked to ensure that there was no damage, and a large amount of iodophor hydrogen peroxide and normal saline were injected through a syringe to flush the intervertebral space. After irrigation, 1.0 g of streptomycin was sprinkled into the wound, an indwelling negative-pressure drainage tube was placed in the deep paraspinal muscle, and the incision was closed. The culture results of samples from the removed lesions were consistent with the diagnosis of tuberculosis.

Postoperative management

The motor and sensory functions of the legs of the patients were closely observed, and the patients were encouraged to perform straight leg raising exercises. When the drainage volume was less than 50 mL in 24 h, the drain was removed. Standard H/R/E/Z combinations were administered for at least 6 mo, and a lumbar brace was worn for at least 12-16 wk after surgery. It was recommended that the patients perform their daily activities without weight bearing. Routine blood examination results, liver and kidney function indicators, the C-reactive protein (CRP) level, and the erythrocyte sedimentation rate (ESR) were reviewed monthly according to the situation during the application of anti-tuberculosis drugs. X-rays were reviewed at 1, 3, 6, 9, and 12 mo after the operation and every year thereafter, and CT findings were reviewed every 3 mo. A trabecular bone connection between vertebrae as observed on CT reconstruction was considered to indicate bone fusion.

Data acquisition and factors of interest

The CRP level and ESR were recorded and evaluated preoperatively and at the last follow-up. The Oswestry disability index (ODI), American Spinal Injury Association (ASIA) classification, and visual analogue scale (VAS) score of low back pain were documented and analysed preoperatively, 3 mo after the operation, and at the last follow-up. All patients underwent follow-up for at least one year, and the time of osseous fusion was recorded.

Statistical analysis

Statistical analysis was performed using SPSS 18.0 software (IBM, United States). The ESR and CRP level before surgery and at the last follow-up were continuous variables conforming to a normal distribution and were compared by paired *t* test. The ODI and VAS score before surgery, 3 mo after surgery, and at the last follow-up were analysed by one-way analysis of variance followed by the least significant difference test for comparisons between two groups. $P < 0.05$ was considered statistically significant.

RESULTS

General information

Among a total of 13 patients, the male/female ratio was 5:8, and the average age was 60.15 ± 10.31 years (Table 1). Four patients also had pulmonary tuberculosis; 9 patients had symptoms of tuberculosis toxicity, such as low fever, night sweats, weight loss, and fatigue; and all patients had persistent low back pain in the passive position and different degrees of lower extremity nerve dysfunction. All patients underwent laboratory tests (routine blood examination, CRP, ESR) and imaging examinations (X-ray, CT, MRI).

Surgical information

The mean operation time was 150.92 ± 37.32 min (110-210 min), the mean blood loss was 415.39 ± 151.91 mL (200-600 mL), and the mean follow-up time was 18.23 ± 4.69 mo (Table 1).

Follow-up data

At the last follow-up, the CRP level and ESR in all patients decreased to the normal physiological range, and the difference was statistically significant compared with the preoperative values (CRP: $t = 17.934$, $P < 0.001$; ESR: $t = 8.341$, $P < 0.001$, Table 1). The average preoperative ODI of 80.31% ± 3.35% (86% - 74%) decreased to 29.08% ± 1.94% (26% - 32%, $P < 0.05$ compared with preoperation) 3 mo after the operation. By the last follow-up, the ODI further decreased to 19.54% ± 2.18% (16% - 24%, $P < 0.05$ compared with preoperation and $P < 0.05$ compared with 3 mo postoperation) ($F = 2109.803$, $P < 0.001$). The preoperative VAS score of 7.54 ± 0.97 (6-9) decreased to 2.23 ± 0.73 (1-3; $P < 0.05$ compared with preoperation) 3 mo after the operation and decreased to 0.54 ± 0.66 (0-2) by the last follow-up ($P < 0.05$ compared with preoperation and $P < 0.05$ compared with 3 mo postoperation) ($F = 274.176$, $P < 0.001$) (Table 2). The ASIA grade improved from grade C to D in one patient and from grade C to E in another patient at the last follow-up, and the ASIA grade improved from grade D to E in all 8 remaining patients at the last follow-up. The mean time to osseous fusion after surgery was 8.85 ± 2.51 mo. A retrospective case is shown in Figure 1. Two patients suffered from pneumonia, which was cured by the application of sensitive antibiotics postoperatively. There were no cases of intraoperative vascular or nerve injury or implant-related complications. The incision healed well in all patients, with no cases of sinus tract formation or tuberculosis recurrence.

DISCUSSION

Benefits of the Wiltse approach in the treatment of lumbar tuberculosis

The Wiltse approach is more accurate for removing lumbar tuberculosis lesions, with less intraoperative trauma and faster postoperative recovery[19]. Biomechanical studies have shown that the posterior bone structures of the spine act as anchor points for posterior muscles and ligaments, which can share the stress of internal fixation and increase the stability of the spine. The Wiltse approach has the following advantages: (1) The target lesion is entered through the original muscle space, retaining the attachment of the paraspinal muscle to the spinous process and maintaining the integrity of the muscle structure, additionally, dead space is not easily formed, reducing the risk of infection; (2) The Quadrant channel is fixed to expose the surgical area, reducing repeated pulling on the soft tissue, which is beneficial for the recovery of the soft tissue; and (3) The operation under the channel allows a single-person operation and reduces the workload of the assistant; additionally, reducing the degree of injury to the dorsal branch of the spinal nerve root reduces the risk of paraspinal muscle neuropathic atrophy, which is conducive to enhancing the recovery of patients after surgery.

Reliability of the multitrack, multianchor screw technique

The combined use of pedicle screws and CBT screws was first performed in patients with degenerative scoliosis by Professor Ueno *et al*[20] in 2013. The purpose of surgery for lumbar tuberculosis is to remove the infection foci, protect nerve function, and stabilize the spine. For tuberculosis lesions invading the anterior column and part of the central column of the vertebral body, CBT screws can be placed to avoid lesions and fix the spine through the posterior and central columns. Biomechanical

Table 1 Baseline information and variables of patients

Case No.	Sex (M/F)	Age (year)	Bone fusion time (mo)	Operation		Follow-up (mo)	CRP (mg/L)		ESR (mm/h)	
				Time (min)	Blood loss (mL)		Preop	Final	Preop	Final
1	M	47	6	211	600	13	103.9	1.0	102	2
2	M	47	12	201	400	24	94.2	3.8	90	4
3	M	72	8	120	200	13	78.5	4.7	34	3.1
4	F	68	6	140	400	11	69	4.2	34.8	4
5	F	50	10	120	300	15	48.9	2.0	51	9
6	F	55	12	110	300	19	99	1.3	65	2.6
7	M	65	9	140	600	24	70	4.8	49	12
8	F	69	6	200	600	18	84	3.3	34	2
9	F	47	8	130	500	16	80	2.4	48	7
10	F	64	12	120	300	20	61	0.5	100	9
11	F	77	6	140	200	24	73	2.0	68	3
12	F	64	8	130	400	16	84	2.6	59	13
13	M	57	12	200	600	24	85	7	59	1.7
mean ± SD	-	60.15 ± 10.31	8.85 ± 2.51	150.92 ± 37.32	415.39 ± 151.91	18.23 ± 4.69	79.27 ± 15.23	3.05 ± 1.82[a]	61.06 ± 23.58	5.57 ± 3.70[a]

[a]$P < 0.001$. CRP: C-reactive protein; ESR: Erythrocyte sedimentation rate.

Table 2 Comparison between pre- and postoperative variables (mean ± SD)

Time	VAS	ODI (%)	ASIA				
			A	B	C	D	E
Preoperation	7.54 ± 0.97	80.31 ± 3.35	0	0	2	8	3
3 mo postoperation	2.23 ± 0.73[a]	29.08 ± 1.94[a]	0	0	1	1	11
Final follow-up	0.54 ± 0.66[a,d]	19.54 ± 2.18[a,d]	0	0	0	1	12

[a]$P < 0.05$ *vs* preoperation.
[d]$P < 0.05$ *vs* 3 mo after operation.
VAS: Visual analogue scale; ODI: Oswestry Disability Index; ASIA: American Spinal Injury Association Classification of Spine Injury.

studies have demonstrated that the insertion torque of CBT screws is 1.71 times that of pedicle screws [21], the uniaxial pullout resistance is increased by 30%[16]; additionally, the sagittal flexion and extension strength of CBT screws is better than that of pedicle screws. However, pedicle screws have strong resistance to axial rotation and coronal stress under lateral flexion[22], so we placed CBT screws in the middle and pedicle screws in the head and tail according to the characteristics of the lesion to achieve fixation with multiple tracks and anchors. In 2015, a study by Matsukawa *et al*[23] showed that the biomechanical strength of the same vertebral body after fixation with the cross-track technique was better than that after fixation with CBT and pedicle screws alone. Related studies have shown that short-term stabilization can be provided by an internal fixation system, while reconstruction with long-term stability requires bone fusion[24]. In this study, all patients were able to wear a brace to participate in daily activities. At the final follow-up, all patients showed bone fusion, with no cases of screw pullout or instrumentation failure. Thus, the authors speculate that multitrack, multianchor point screw technology provides outstanding fixation strength and a stable mechanical environment. However, the biomechanical strength of the fixed structure in this study needs to be further verified by biological models. Safety and efficacy of multitrack, multianchor point fixation combined with the Wiltse approach in the treatment of lumbar tuberculosis.

In this study, none of the patients experienced internal fixation-related neurological injury, and all achieved partial neurological recovery. At the last follow-up, the neurological function improved from

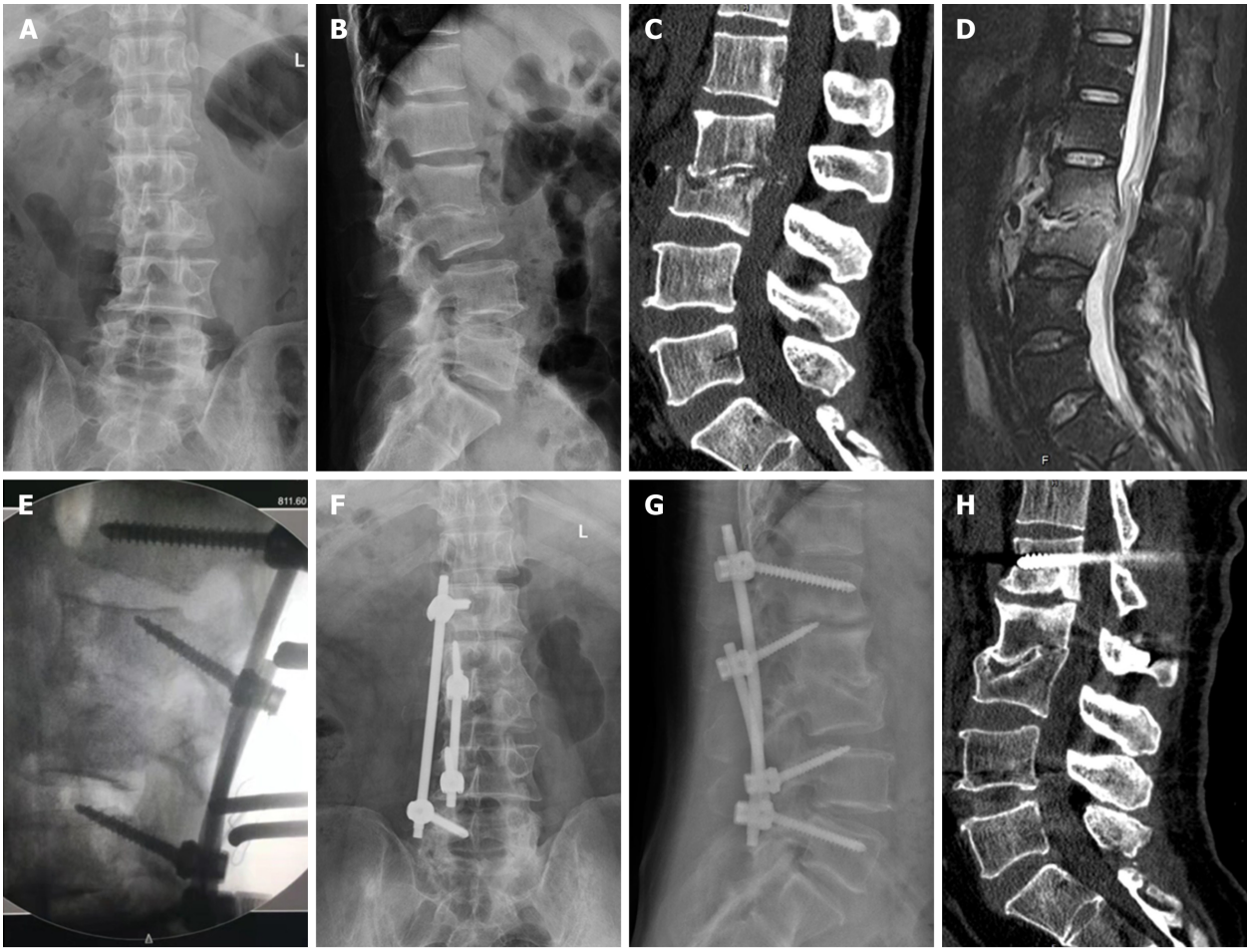

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Figure 1 A typical case with bone fusion. A 47-year-old male patient presented with low back pain and left leg numbness and weakness. A and B: The pathological diagnosis was L2/3 lumbar tuberculosis, preoperative lumbar spinal X-ray showed L2/3 intervertebral space collapse; C: Lumbar spinal CT showed L2/3 intervertebral space stenosis and vertebral body destruction, and sequestrum could be seen invading the front of the intervertebral space and protruding backwards into the spinal canal; D: Fat-suppressed magnetic resonance imaging of the lumbar vertebrae showed destruction of the L2/3 intervertebral disc, narrowing of the intervertebral space, pus formation in the intervertebral space protruding towards the front and back of the intervertebral space, and compression of the dural sac; E: C-arm fluoroscopy during the operation confirmed good positioning of the pedicle screws and cortical bone trajectory screws; F and G: X-ray of the lumbar spine 1 year after the operation showed L2/3 intervertebral space fusion, normal positioning of the internal fixation device, and the absence of broken screws and rods; and H: CT scan of the lumbar spine 1 year after the operation showed that the L2/3 vertebral bodies had fused and that tuberculosis lesions had not developed. CT: Computed tomography.

ASIA grade D to grade E in 8 patients and ASIA grade C to grade E in 1 patient. The ODI and VAS score were also significantly improved at the last follow-up.

Safety and efficacy of pneumonectomy in the treatment of multidrug-resistant tuberculosis (MDR-TB)

For MDR-TB with cavitation, adjuvant pneumonectomy is safe and effective[25]. Adjuvant therapeutic surgery can improve the quality of life of pulmonary tuberculosis patients, with more obvious benefits in women, those aged < 40 years, those with a body mass index ≥ 20 kg·m^{-2}, and nonsmokers[26]. Pneumonectomy has been reported to have a 90% cure rate for MDR-TB, but the choice of surgical strategy requires the participation of both pulmonologists and cardiothoracic surgeons[27].

Research limitations

This was a retrospective study with a small sample size, no control group, and a short follow-up period, and a multicentre prospective randomized controlled trial with rich clinical data and a long follow-up period is needed. Due to the narrow operative field of the Wiltse approach under the channel, it is not suitable in cases where extensive debridement should be performed under direct anterior vision, such as in cases of large abscesses and infusion abscesses in front of the vertebra. Recurrence due to incomplete posterior debridement may occur in such cases. Due to the limitation of the surgical field, the surgeon needs to have sufficient patience to remove the lesion and repeatedly flush the intervertebral space.

CONCLUSION

Compared with other internal fixation techniques, fixation with pedicle screws combined with CBT screws and the contralateral Wiltse approach can be used to both effectively stabilize the spine and remove lesions with less trauma and is suitable in cases of larger lesions on one side and no large or only small abscesses in front of the lumbar spine.

ARTICLE HIGHLIGHTS

Research background

The incidence of lumbar tuberculosis is high worldwide, and effective treatment is a continuing problem.

Research motivation

There are different methods for internal fixation in the treatment of lumbar tuberculosis, but method with less trauma are more beneficial for patients.

Research objectives

The objective of this study was to examine the efficacy of multitrajectory, multianchor fixation techniques combined with the contralateral Wiltse approach in the treatment of lumbar tuberculosis.

Research methods

This retrospective analysis of patients diagnosed with lumbar tuberculosis compared the C-reactive protein (CRP) level, erythrocyte sedimentation rate (ESR), visual analogue scale (VAS) score of low back pain, Oswestry disability index (ODI) and American Spinal Injury Association (ASIA) grade as well as neurological recovery before and after surgery.

Research results

The CRP level, ESR, VAS score and ODI were decreased after surgery. Neurological dysfunction was relieved, and the ASIA grade was increased.

Research conclusions

We propose that the multitrajectory, multianchor screw technique combined with the contralateral Wiltse approach for lesion removal is beneficial to improve the clinical symptoms and quality of life of patients with lumbar tuberculosis.

Research perspectives

The multitrajectory, multianchor screw technique combined with the contralateral Wiltse approach for lesion removal is safe and effective in the treatment of lumbar tuberculosis.

FOOTNOTES

Author contributions: Miao J contributed to the conception and design of this study; Yuan YF wrote the main manuscript text; Ren ZX and Li JF prepared Figure; Zhang C followed up the patients and collected the relevant data; Li GJ performed the statistical analysis; Li XD and Liu BZ prepared Tables; and all authors reviewed and approved the final manuscript.

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