Comparison of three surgical approaches for thoracolumbar junction (T12-L1) tuberculosis: a multicentre, retrospective study

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Abstract

Background: The surgical approaches to thoracolumbar junction (T12-L1) tuberculosis were controversial. We aimed to compare the safety and efficacy of three different procedures through a multicentre retrospective study. Methods: The medical records of thoracolumbar junction tuberculosis patients (n = 177) from January 2005 to January 2015 were collected and reviewed. 45 patients underwent anterior debridement and instrumented fusion (Group A), 52 underwent anterior combined with posterior debridement and instrumented fusion (Group B) and 80 underwent posterior-only debridement and instrumented fusion (Group C). Patients with neurological deficit were 10 in Group A, 23 in Group B, 36 in Group C. All patients had a standard preoperative and postoperative anti-tuberculous therapy regimen. Clinical outcomes, laboratory indexes and radiological evaluation of the three groups were compared. Operations at each centre were performed by the respective senior medical teams of the six different hospitals.

Results: All three surgical approaches achieved bone fusion and pain relief. Cases with neurological deficits had different degrees of improvement after surgery. The operative time was 330.2±45.4min, 408.0±54.3min, 227.9±58.5min, and the blood loss was 744.0±193.8ml, 1134.6±328.2ml, 349.8±289.4ml in groups A, B and C respectively. The average loss of correction was 5.5±3.7° in group A, 1.6±1.9° in group B, 1.7±2.2° in group C, and the difference between groups except B vs C were of statistically significant (P < 0.05). Conclusions: For patients with thoracolumbar junction (T12-L1) tuberculosis, the posterior-only procedure is the better than the anterior-only procedure in the correction of kyphosis and maintenance of spinal stability. The posterior-only procedure is recommended because it achieves the same efficacy as combined procedure with shorter operation time, less blood loss and trauma.
Introduction

Tuberculosis (TB) has an important influence on human health, especially in non-rich states(1–3). China has the second largest TB infected population affecting an estimated 2 million people (4,5). Spinal TB may lead to spinal instability, kyphotic deformities, and compression of the spinal nerve, and the thoracolumbar junction (T12-L1) is one of the main metastatic site of musculoskeletal system(6,7). Though most spinal TB can achieve satisfactory outcome through standard chemotherapy alone, surgical intervention is still recommended for cases with large paraspinal abscess, spinal instability, neurological injury and severe kyphosis(8,9). However, the surgical approaches are still controversial among spinal surgeons. Some surgeons prefer the anterior approach for its direct access to the infection foci, that is of benefit to debride and reconstruct(10,11). However, persistent maintenance of spinal stability is outside the scope of such procedure(12,13).

So, some experts recommend anterior debridement combined with posterior instrumentation which achieve excellent clinical results except for some inconvenient complications(14). In recent years, posterior-only surgery has gained popularity because of its valid debridement, ensure decompression and kyphosis correction with limited trauma, few complications, low cost and short recovery time(15,16). To our knowledge, no study was done to compare the therapeutic efficacy between anterior-only, posterior-only and anterior-posterior procedures for mono-segmental spinal TB focusing on the thoracolumbar junction (T12-L1). Furthermore, there is no study comparing the three surgical methods in multiple centres and on large samples. Therefore, we conducted a multicentre retrospective research to observe the safety and efficacy of three procedures of treating thoracolumbar junction(T12-L1) TB and to provide a reference for its surgical treatment.
Methods

General information

Between January 2005 and January 2015, 302 cases with thoracolumbar junction (T12-L1) TB from six hospitals across China were hospitalized; 125 were excluded because of chemotherapy lonely, poor compliance or tolerance, complicated with active lung TB or spinal tumours, HIV co-infection and lost to follow-up (Figure 1). The remaining 177 cases were included, comprising 88 males and 89 females with a mean age of 35.2 ± 10.0 years (range 14–62). 45 patients were treated by the anterior-only procedure (Group A), 52 by the combined anterior and posterior procedure (Group B) and 80 by the posterior-only procedure (Group C) (Table 1).

Patients were diagnosed as spinal TB by clinical symptoms, signs, laboratory test, radiological examination and histopathology. Neurological function of the cases was evaluated by American Spinal Injury Association (ASIA) score. 6 cases were grade A, 14 were grade C, 47 were grade D and 108 were grade E. The back pain was evaluated by visual analogue scale (VAS) for all patients, and the local kyphotic angle was assessed by Cobb technique.

Preoperative management

All cases underwent chemotherapy regimens HREZ (rifampicin 450 mg/day, isoniazid 300 mg/day, pyrazinamide 750 mg/day and ethambutol 750 mg/day) for more than 2 weeks preoperatively.

Operation technique

Operations at each centre were performed by senior surgeons. All cases were treated by general endotracheal anaesthesia, then placed in the appropriate position. (1) In the anterior-only approach, thoracoabdominal procedure was adopted. After the lesion site was completely debrided, the defect area of vertebrae was inserted with a suitable cage
or autologous or allograft iliac bone. Then the screw-rods were inserted in lateral anterior of the vertebrae. (2) In the anterior-posterior approach, the prone position was used initially. Dorsal midline incision was performed. The lamina and articular process were exposed, then pedicle screws were implanted in the right places. After correction of the kyphosis angle, bone grafting was performed, and the incision was closed. Then, patients were transferred to the lateral position, and a correctly placed incision was made. The thoracoabdominal approach was used to debride the lesion, decompress spinal cord and graft cage or iliac bone. (3) In the posterior-only approach, the prone position was used. Dorsal midline incision was performed and the lamina and articular process were exposed. After the screws were placed in the right places, the transpedicular space was used to debride lesion tissues, such as abscesses, necrotic discs and endplates. Then, suitable size autograft iliac bone or titanium cage containing cancellous bone was inserted into intervertebral body. At last, installed the rods and rectified the kyphosis and/or scoliosis. Before the surgery of each group was over, isoniazid (0.3 g) and streptomycin (1.0 g) were administered locally, and tubes were placed routinely near the incision.

**Postoperative care**

Preventive antibiotic treatment was used within 48 hours postoperatively. All cases were advised to use a bracing apparatus till bony fusion. Patients were administered oral HREZ chemotherapy for 6 months after the surgery, then received HRE chemotherapy for 9-12 months. When the drug sensitivity test indicated drug-resistant TB, sensitive drugs would be adjusted. Patients’ ESR rates, liver and kidney function were re-examined regularly. Follow-up was performed at 1, 3, 6, 12 and 18 months, then conducted once each year.

**Statistical analysis**

Continuous data were expressed as $\bar{X} \pm S.D.$ The LSD or Dunnett T3 test was used to evaluate differences in operation time, blood loss, kyphosis angle, ESR, VAS score. SPSS
version 22 (SPSS, Inc., Chicago, USA) was used for statistical analysis. Values of less than 0.05 were considered to indicate significant differences.

Results

**General patient characteristics**

In group A, the mean patient age, operation time, bleeding and duration of follow-up were 34.3 ± 10.1 years (range 18–62 years), 330.2 ± 45.4 minutes (range 200–400 min), 744.0 ± 193.8 ml (range 500–1500 mL) and 30.0±7.3 months (range 24–50 months), respectively. In group B, these were 34.4 ± 10.4 years (range 14–61 years), 408.0 ± 54.3 minutes (range 295–540 min), 1134.6 ± 328.2 ml (range 400–2000 mL) and 29.7 ± 6.6 months (range 24–50 months), respectively. In group C, they were 35.6 ± 9.9 years (range 14–62 years), 227.9 ± 58.5 minutes (range 123–600 min), 349.8 ± 289.4 ml (range 200–2200 mL) and 28.9 ± 6.1 months (range 24–52 months), respectively (Table 1).

**Laboratory evaluation**

The average preoperative ESR values were 34.7 ± 27.0 mm/h (range 2–99 mm/h) in group A, 38.9 ± 30.2 mm/h (range 2 to 99 mm/h) in group B and 36.3±25.0 mm/h (range 2–99mm/h) in group C. The postoperative ESR values turned to be normal in all cases at 3-month (Table 2).

**Function scores**

Neurologic function scores were tabulated in Table 3. All cases with neurological injury had different degrees of improvement postoperatively. The postoperative VAS of the three groups were decreased significantly at the last follow-up.

**Radiological evaluation**

The preoperative mean Cobb angle was 22.7 ± 7.9° in group A (Figure 2), 18.1 ± 6.8° in group B (Figure 3) and 20.8 ± 8.3° in group C (Figure 4). The postoperative Cobb angle decreased significantly to 11.2 ± 5.4° in group A, 8.4 ± 4.2° in group B and 8.7 ± 3.8° in
group C. At the last follow-up, the kyphosis angle was $16.7 \pm 7.0^\circ$, $10.1 \pm 4.4^\circ$, $10.3 \pm 4.0^\circ$, in groups A, B and C respectively. Compared with the preoperative Cobb angle, the postoperative and last follow-up Cobb angle in three groups had improved significantly (Table 2). By comparison of kyphosis angle loss, the results showed that the anterior–posterior and posterior-only procedure were superior to the anterior-only procedure in maintaining a corrective effect.

**Complications**

In group A, there was 1 case of superficial wound infection, 1 case of cerebrospinal fluid leakage and 1 case of electrolyte imbalance. In group B, there were 1 case of pectoralgia, 1 case of urinary infection, 3 cases of cerebrospinal fluid leakage and 5 cases of electrolyte imbalance. In group C, there were 1 case of superficial wound infection, 5 cases of cerebrospinal fluid leakage, 1 case of electrolyte imbalance and 1 case of refractory intercostal neuralgia. All of these complications were treated successfully or relieved after symptomatic treatment.

**Discussion**

The thoracolumbar junction (T12-L1) is one of the main sites of metastatic musculoskeletal TB(6,7). Although standard anti-TB chemotherapy is the fundamental method of treating spinal TB, suitable and timely surgical intervention for thoracolumbar spinal TB patients can improve spinal stability, decompress the spinal cord and prevent further development of spinal deformity and paralysis or death(17).

The thoracolumbar junction (T12-L1) is sandwiched between the peritoneum and pleura, and various surgical procedures have been used to access the area: anterior-only, anterior-posterior and posterior-only. The most common lesion area is major in anterior column of the spine involving only one motion segment(18). Therefore, early scholars thought the anterior approach(9), which can allow direct access to the focus, complete
debridement and valid decompression, would be the first choice for decompression and
debridement in spinal TB. However, it can’t prevent or correct kyphosis deformity to any
appreciable extent(19). In our study, the degree of kyphosis correction after surgery was
similar in group A to that in groups B and C, yet Cobb angle losses were larger in group A
than in groups B and C. Anterior instrumentation in spinal TB is becoming increasingly
popular, because a bone grafting alone does not provide reliable stability. It can be very
effective at correcting a deformity and maintaining the correction(20). The use of
biomaterials in lesion area is still in debate as it may undermine efforts to eradicate the
infection(21). However, some experts concluded that the usage of implants are safe
because the M. tuberculosis are dividing too slowly to produce strong adhesion or thick
biofilm in most cases(22).
The anterior-posterior procedure is an advanced surgical technique that not only achieves
radical debridement of the abscess and adequate decompression of spinal cord,
satisfactory correction of kyphosis deformity and long-term maintenance spinal stability,
but also separates the debridement area from the instrumentation area that can decrease
the spread of TB(20). Disadvantages of the combined approach are longer operation time,
higher complication rate, more blood loss and serious trauma. In our study, the operation
time, bleeding, and complication rate were much greater with this approach than with
other approaches.
Advantages of posterior-only procedure include less blood loss and shorter hospitalization
and operative time. Other advantages are adequate decompression of spinal cord,
correction of spinal deformity, reconstruction of spinal stability and improvement of
patients’ quality of life. Posterior-only procedure may be better in cases with less involved
anterior column, which is almost always achieving spontaneous fusion(23,24). However,
there is a possible risk of TB spreading to posterior healthy area, resulting in infection
diffusion and/or fistulas(25). In this research, the operation time, bleeding and complication rate were less than other groups, and group C achieved the same satisfactory kyphosis correction as group B during the follow-up period.

Our research has some limitations. First, this study was a retrospective rather than a prospective cohort study. Second, operations at each centre were performed by the respective senior medical teams of the 6 different centres, that may result in a certain degree of bias because of differences in their surgical proficiency.

Conclusions

This multicentre retrospective study showed that the posterior-only approach can be an effective treatment method for thoracolumbar junction (T12-L1) TB patients, with good neurologic recovery, avoidance of kyphosis progression and few complications.

Abbreviations

TB: Tuberculosis;
HREZ: Isoniazid, rifampicin, ethambutol, pyrazinamide;
ESR: Erythrocyte sedimentation rate;
ASIA: American Spinal Injury Association;
VAS: Visual analogue score.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the First Affiliated Hospital of the Third Military Medical University. All participants have been informed and gave written consent prior to data collection.

Consent for publication

Written informed consent was obtained from the patients for publication of their clinical
details and clinical images.

Availability of data and materials

The datasets used and analysed in this study are available from the corresponding author on reasonable request.

Competing interests

All the authors declare that they have no competing interests.

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Authors' Contributions

ZHZ and JZX designed this research. YC, JLT, LTL and ZLL participated in data collection. YPZ, PC and ZHZ participated in analysis and interpretation of data. YHZ, PC and GJW revised the draft. YPZ and PC were the main contributors in writing this manuscript.

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References

1. Ding P, Li X, Jia Z, Lu Z. Multidrug-resistant tuberculosis (MDR-TB) disease burden in China: a systematic review and spatio-temporal analysis. BMC Infect Dis [Internet]. 2017/01/12. 2017;17(1):57. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28073344

2. Zumla A, George A, Sharma V, Herbert N, Baroness Masham of I. WHO’s 2013 global report on tuberculosis: successes, threats, and opportunities. Lancet [Internet]. 2013/11/26. 2013;382(9907):1765–7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24269294
3. Zhao Y, Xu S, Wang L, Chin DP, Wang S, Jiang G, Xia H, Zhou Y, Li Q, Qu X, Pang Y, Song Y, Zhao B, Zhang H, He G, Guo J, Wang Y. National survey of drug-resistant tuberculosis in China. N Engl J Med [Internet]. 2012/06/08. 2012;366(23):2161-70. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22670902

4. Yao Y, Song W, Wang K, Ma B, Liu H, Zheng W, Tang Y, Zhou Y. Features of 921 Patients With Spinal Tuberculosis: A 16-Year Investigation of a General Hospital in Southwest China. Orthopedics [Internet]. 2017/10/24. 2017;40(6):e1017–23. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29058758

5. Boachie-Adjei O, Papadopoulos EC, Pellise F, Cunningham ME, Perez-Grueso FS, Gupta M, Lonner B, Paonessa K, King A, Sacramento C, Kim HJ, Mendelow M, Yazici M. Late treatment of tuberculosis-associated kyphosis: literature review and experience from a SRS-GOP site. Eur Spine J [Internet]. 2012/05/26. 2013;22 Suppl 4:641–6. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22627623

6. Nagashima H, Yamane K, Nishi T, Nanjo Y, Teshima R. Recent trends in spinal infections: retrospective analysis of patients treated during the past 50 years. Int Orthop [Internet]. 2009/03/12. 2010;34(3):395–9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/19277654

7. Jain AK, Dhammi IK, Jain S, Kumar J. Simultaneously anterior decompression and posterior instrumentation by extrapleural retroperitoneal approach in thoracolumbar lesions. Indian J Orthop [Internet]. 2010/10/07. 2010;44(4):409–16. Available from: https://www.ncbi.nlm.nih.gov/pubmed/20924482

8. Zhang Z, Luo F, Zhou Q, Dai F, Sun D, Xu J. The outcomes of chemotherapy only treatment on mild spinal tuberculosis. J Orthop Surg Res [Internet]. 2016/05/15. 2016;11(1):49. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27177692

9. Tuli SM. Tuberculosis of the spine: a historical review. Clin Orthop Relat Res
10. Jain AK, Dhammi IK, Prashad B, Sinha S, Mishra P. Simultaneous anterior decompression and posterior instrumentation of the tuberculous spine using an anterolateral extrapleural approach. J Bone Joint Surg Br [Internet]. 2008/11/04. 2008;90(11):1477–81. Available from: https://www.ncbi.nlm.nih.gov/pubmed/18978269

11. Benli IT, Kaya A, Acaroglu E. Anterior instrumentation in tuberculous spondylitis: is it effective and safe? Clin Orthop Relat Res [Internet]. 2007/04/25. 2007;460:108–16. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17452918

12. Soultanis K, Mantelos G, Pagiatakis A, Soucacos PN. Late infection in patients with scoliosis treated with spinal instrumentation. Clin Orthop Relat Res [Internet]. 2003/06/05. 2003;(411):116–23. Available from: https://www.ncbi.nlm.nih.gov/pubmed/12782866

13. Cui X, Li LT, Ma YZ. Anterior and Posterior Instrumentation with Different Debridement and Grafting Procedures for Multi-Level Contiguous Thoracic Spinal Tuberculosis. Orthopaedic Surgery. 2016;

14. Zhang HQ, Guo CF, Xiao XG, Long WR, Deng ZS, Chen J. One-stage surgical management for multilevel tuberculous spondylitis of the upper thoracic region by anterior decompression, strut autografting, posterior instrumentation, and fusion. J Spinal Disord Tech [Internet]. 2007/06/01. 2007;20(4):263–7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17538348

15. D’Souza A R, Mohapatra B, Bansal ML, Das K. Role of Posterior Stabilization and Transpedicular Decompression in the Treatment of Thoracic and Thoracolumbar TB: A Retrospective Evaluation. Clin Spine Surg [Internet]. 2017/02/09. 2017;30(10):E1426–
16. Hu X, Zhang H, Yin X, Chen Y, Yu H, Zhou Z. One-stage posterior focus debridement, fusion, and instrumentation in the surgical treatment of lumbar spinal tuberculosis with kyphosis in children. Childs Nerv Syst [Internet]. 2015/11/04. 2016;32(3):535–9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26527476

17. He Z, Tang K, Gui F, Zhang Y, Zhong W, Quan Z. Comparative analysis of the efficacy of a transverse process bone graft with other bone grafts in the treatment of single-segment thoracic spinal tuberculosis. 2019;9:1–8.

18. Varatharajah S, Charles YP, Buy X, Walter A, Steib JP. Update on the surgical management of Pott’s disease. Orthopaedics and Traumatology: Surgery and Research. 2014.

19. Lu G, Wang B, Li J, Liu W, Cheng I. Anterior debridement and reconstruction via thoracoscopy-assisted mini-open approach for the treatment of thoracic spinal tuberculosis: minimum 5-year follow-up. Eur Spine J [Internet]. 2011/10/15. 2012;21(3):463–9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/21997276

20. Chen WJ, Wu CC, Jung CH, Chen LH, Niu CC, Lai PL. Combined anterior and posterior surgeries in the treatment of spinal tuberculous spondylitis. Clin Orthop Relat Res [Internet]. 2002/04/20. 2002;(398):50–9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11964631

21. Faraj AA, Webb JK. Spinal instrumentation for primary pyogenic infection report of 31 patients. Acta Orthop Belg [Internet]. 2000/10/18. 2000;66(3):242–7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11033912

22. Singh K, Vaccaro AR, Kim J, Lorenz EP, Lim TH, An HS. Biomechanical comparison of cervical spine reconstructive techniques after a multilevel corpectomy of the cervical spine. Spine (Phila Pa 1976) [Internet]. 2003/10/16. 2003;28(20):2352–8; discussion
2358. Available from: https://www.ncbi.nlm.nih.gov/pubmed/14560082

23. Hee HT, Majd ME, Holt RT, Pienkowski D. Better treatment of vertebral osteomyelitis using posterior stabilization and titanium mesh cages. J Spinal Disord Tech [Internet]. 2002/04/03. 2002;15(2):149–56; discussion 156. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11927825

24. Qian J, Rijiepu A, Zhu B, Tian D, Chen L, Jing J. Outcomes of radical debridement versus no debridement for the treatment of thoracic and lumbar spinal tuberculosis. International Orthopaedics. 2016;

25. Zhang H, Sheng B, Tang M, Guo C, Liu S, Huang S, Gao Q, Liu J, Wu J. One-stage surgical treatment for upper thoracic spinal tuberculosis by internal fixation, debridement, and combined interbody and posterior fusion via posterior-only approach. European Spine Journal. 2013;22(3):616–23.

Tables

| TABLE 1. Patients’ Clinical Data | Group A | Group B | Group C | Statistical \ \ | \\
|-------------------------------|---------|---------|---------|----------------|
| Sex (male/female)             | 21/24   | 29/23   | 38/42   | P1>0.05/ P \ |
| Average age (years)           | 34.3±10.1 | 34.4±10.4 | 35.6±9.9 | P3>0.05/ P \ |
| Preoperative VAS score        | 5.7±1.6 | 6.0±1.9 | 6.1±1.6 | P3>0.05/ P \ |
| Operation time (min)          | 330.2±45.4 | 408.0±54.3 | 227.9±58.5 | P3<0.05/ P \ |
| Blood loss (mL)               | 744.0±193.8 | 1134.6±328.2 | 349.8±289.4 | P3<0.05/ P \ |
| Final follow-up VAS score     | 0.6±0.7 | 0.5±0.6 | 0.6±0.7 | P3>0.05/ P \ |
| Follow-up duration (months)   | 30.0±7.3 | 29.7±6.6 | 28.9±6.1 | P3>0.05/ P \ |

P1A vs B  P2: A vs C  P3B vs C
## TABLE 2. Cobb Angle and ESR in Three Groups

|       | Preoperative Cobb Angle (°) | Postoperative | Final Follow-Up | ESR (mm/h) |
|-------|-----------------------------|-------------|-----------------|------------|
|       |                             |             |                 |            |
|       | Preoperative Cobb Angle (°) |             | Angle Lost (°)  |            |
| A     | 22.7±7.9                    | 11.2±5.4    | 16.7±7.0        | 34.7±27.0  |
| B     | 18.1±6.8                    | 8.4±4.2     | 10.1±4.4        | 38.9±30.2  |
| C     | 20.8±8.3                    | 8.7±3.8     | 10.3±4.0        | 36.3±25.0  |
| P1    | <0.05                       | <0.05       | <0.05           | >0.05      |
| P2    | >0.05                       | <0.05       | <0.05           | >0.05      |
| P3    | <0.05                       | >0.05       | >0.05           | >0.05      |

P1A vs B: P2: A vs C: P3B vs C

## TABLE 3. ASIA Classification in Three Groups

| ASIA Classification | Group A (n) | Group B (n) |
|---------------------|-------------|-------------|
|                     | Pre-operative | Post-operative | Final Follow-up | Improvement | Pre-operative | Post-operative | Final Follow-up |
| A                   | 0            | 0            | 0               | 0           | 0            | 0               | 0 |
| B                   | 0            | 0            | 0               | 0           | 3            | 0               | 0 |
| C                   | 2            | 0            | 0               | 0           | 6            | 3               | 3 |
| D                   | 8            | 3            | 0               | 6           | 14           | 3               | 1 |
| E                   | 35           | 43           | 45              |             | 29           | 46              | 48 |

Spinal cord function improvement rate: Group A was 80%, Group B was 82.6% and Group C was 83.3%.

## TABLE 4. Complications related to surgery

| Complications                    | Group A | Group B |
|----------------------------------|---------|---------|
| Superficial wound infection      | 1       | 0       |
| Cerebrospinal fluid leakage      | 1       | 3       |
| Electrolyte imbalance            | 0       | 5       |
| Urinary infection                | 0       | 1       |
| Pectoralgia                      | 0       | 1       |
| Refractory intercostal neuralgia | 0       | 0       |

Figures
Figure 1

Clinical study design flow diagram.
The graph showed a case underwent anterior debridement, bone grafting and screw-rods internal fixation. 25-year-old man with thoracolumbar junction (T12-L1) TB (a, b) preoperative anteroposterior and lateral X-rays; (c, d) preoperative computed tomography (CT); (e) preoperative 3D reconstruction of CT; (f) preoperative MRI; (g, h) X-ray at 18-month postoperative; (i) CT at 24-month postoperative; (j) 3D reconstruction of CT at 24-month postoperative; (k, l) MRI at 18-month postoperative.
The graph showed a case underwent one-stage anterior debridement, decompression, bone grafting and posterior instrumentation. 38-year-old woman with thoracolumbar junction (T12-L1) TB (a, b) preoperative anteroposterior and lateral X-rays; (c, d) preoperative CT; (e) preoperative 3D reconstruction of CT; (f) preoperative MRI; (g, h) X-ray at 1-month postoperative; (i) CT at 6-month postoperative; (j) 3D reconstruction of CT at 6-month postoperative; (k) MRI at 13-month postoperative; (l) lateral X-rays at 56-month postoperative.
The graph showed a case underwent posterior debridement, decompression, bone grafting and internal fixation instrumentation. 18-year-old man with thoracolumbar junction (T12-L1) TB (a, b) preoperative anteroposterior and lateral X-rays; (c, d) CT preoperative; (e) 3D reconstruction of CT preoperative; (f) preoperative MRI; (g, h) X-ray at 1-month postoperative; (i, j) CT at 3-month postoperative; (k) 3D reconstruction of CT at 12-month postoperative; (l) MRI at 12-month postoperative.