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Intervertebral focal surgery for the treatment of non-contiguous multifocal spinal tuberculosis

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Abstract
Purpose The purpose of this study was to assess the clinical efficacy of intervertebral focal surgery by complete debridement, deformity correction, graft fusion, and internal fixation for patients with non-contiguous multifocal spinal tuberculosis.
Methods A total of 29 cases with non-contiguous multifocal spinal tuberculosis admitted to the hospital from January 2000 to January 2007 were treated by intervertebral focal surgery. There were 63 foci in 29 cases, averaging 2.2 foci per case, and 146 affected vertebral bodies, averaging 2.3 vertebral bodies per focus. Three cases had one normal intervertebral disc between two foci, and the other 26 cases had two or more normal intervertebral discs between two foci.
Results All cases were followed-up for an average of five years. The kyphosis showed a mean correction rate of 67.7% after surgery. A mean loss rate of correction of 8.2% was observed at the final follow-up. The levels of erythrocyte sedimentation rate and C-reactive protein returned to normal in 27 cases on average at 5.8 months and bone union could be observed at five months after surgery. Eleven cases with nerve damage recovered to E grade at the final follow-up.
Conclusions Intervertebral focal surgery by complete debridement, deformity correction, graft fusion, and internal fixation for patients with non-contiguous multifocal spinal tuberculosis was feasible and effective.

Both Jian-Dang Shi and Zi-Li Wang contributed equally to this paper.

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Introduction

Non-contiguous multifocal spinal tuberculosis has two or more foci separated by at least one normal intervertebral disc [1, 2]. This is rare in clinical practice and difficult to treat. The surgical methods for patients with surgical indications are not uniform. Lee et al. used a long-segment debridement combined with graft fusion and internal fixation to treat these lesions [3, 4]. Ibn et al. adopted segment fixation comprising one or multiple normal spinal motion segments above and below the lesion(s). While this type of fixation provides strong support, it sacrifices too much spinal motor function [2, 5, 6]. Recently, we performed many clinical and basic studies using intervertebral focal surgery to treat mono-segmental spinal tuberculosis and have obtained primary success [7, 8]. Intervertebral focal surgery means that all of the procedures involving debridement, deformity correction, graft fusion, and internal fixation were performed within the pathological vertebral body rather than on neighbouring segments [9]. We report here a group of 29 cases with non-contiguous multifocal spinal tuberculosis treated by intervertebral focal surgery. The aim of this clinical study was to evaluate the results of this method.

Clinical data and methods

General data

From January 2000 to January 2007, a total of 29 cases with non-contiguous multifocal spinal tuberculosis were enrolled in the study. The cohort comprised 17 males and 12 females, aged 16–64 years, with an average age of 40 years. The course of disease ranged from six to 48 months, with an average of

28 months. All cases were confirmed as non-contiguous multifocal spinal tuberculosis by clinical manifestations, imaging and histopathology. The clinical data for the distribution of patients with non-contiguous multifocal spinal tuberculosis was recorded (Table 1). In total, 146 affected vertebrae were involved in the study, with an average of 2.3 affected vertebral bodies per focus. There were 63 foci in 29 cases, with a mean of 2.2 foci for each case. Laboratory examinations included X-ray, CT and MRI. The results showed that the erythrocyte sedimentation rate (ESR) was 29–146 mm/H (mean 56 mm/H); and the C-reactive protein (CRP) was 0.9–23.4 mg/L (mean 10.7 mg/L) (the normal ESR level in males is 0–15 mm/h, and 0–20 mm/h in females; the normal CRP is 0–2.87 mg/L). Quadruple therapy, including 300 mg/d Isoniazide, 450 mg/d Rifampicin, 750 mg/d Pyrazinamide and 750 mg/d streptomycin was given preoperatively for two to four weeks, with an average duration of three weeks. All therapy was continued six months after surgery.

Surgical strategy

The indications for surgery were as follows: cases with spinal cord or cauda equina nerve or root compression causing neurological dysfunction; cases where the stability of the spine had been destroyed; cases with serious or progressive kyphosis deformities; and cases accompanied by large abscess formation, bone sequestration, cavitation or sinus tract formation.

Table 1 The clinical general data of patients with non-contiguous multifocal spinal tuberculosis

General data	Cases (*n*)
Number of males/females (*n*=29)	17/12
Lesion location (*n*=29)	
Thoracic vertebrae	3
Thoracolumbar segment	4
Lumbar vertebrae	3
Thoracic vertebrae and Lumbar vertebrae	19
Vertebral involvement (*n*=29)	
4 vertebrae	13
5 vertebrae	6
6 vertebrae	6
7 or 7+ vertebrae	4
Distribution of multifocal of spinal TB (*n*=29)	
2 foci	24
3 foci	5
Number of normal intervertebral disc between affected bodies	
1	3
2 or 2+	26
Frankl grade (*n*=29)	
B	2
C	4
D	5
E (normal neurological status)	18

The surgery was performed under general anaesthesia. The following two surgical strategies were used. The same group of experienced surgeons was involved in this study.

First, 20 cases underwent posterior fixation, combined with anterior debridement and strut graft. This strategy was used for any cases with damage of the vertebral body. All cases were operated upon in the forced prone position, and a posterior mid-line incision was made centred on the affected vertebral body. Eighteen of 20 cases required with two or more sets of mono-segment fixation and two needed long-segment fixation. All cases underwent intervertebral focal surgery. In cases where the residual height of the body was one-third to two-thirds of normal, normal screws were used via a posterior approach at the level of affected body (Fig. 1e, f; L2 body); in cases where the residual height of the body was less than one-third of normal, a 25–35-mm short screw was used and a connecting rod was added to increase stability (Fig. 1e, f; T9, T11, L4 and L5 fixation). Two cases underwent continuous fixation due to the one normal intervertebral disc between two foci (Fig. 1e, f; T10-11). All incisions were closed after fixation. The cases were then placed in the lateral position with the infected focus uppermost. After that, focal debridement and graft implantation were undertaken via thoracic, thoracolumbar, or peritoneal approaches for different affected segments; 18 cases underwent implantation of autologous iliac bone graft and two cases implantation of a titanium mesh cage and autologous iliac bone. Posterior fixation, including CD, GSS, M8 and SINO, were selected. The incision was closed after repeated washing with saline, and a negative pressure drainage was used. A tube for thoracic closed drainage was used if the chest had been opened. Third, a one-stage posterior deformity correction, internal fixation, and two-stage debridement were performed in five cases, and used with two or more sets of mono-segment fixation. Five cases of two-stage surgery were performed. One-stage posterior deformity correction, internal fixation, and two-stage debridement were performed. Usually, the second operation was performed one to two weeks after the first surgery. The technique is mainly reserved for patients with poor general condition or poor nutritional status, who may not be able to tolerate a long operation.

Second, anterior debridement, deformity correction, graft fusion, and internal fixation were performed in nine cases. Those cases had damage to less than one-third of the vertebral bodies, still leaving enough space for a screw. Two sets of instruments were selected for the eight cases and one set for one case. All cases were performed in the lateral position, with the deteriorated body uppermost. The foci were exposed via thoracic, thoracolumbar, or peritoneal approaches according

Fig. 1 A 21-year-old male was diagnosed with T9-11, T12-L1, and L4-5 non-contiguous multifocal spinal tuberculosis. **a**, **b** Preoperative X-ray film shows narrowing at T9-11, T12-L1, and L2-5 segments. **c** Preoperative sagittal CT shows tuberculosis cavities and sequesters at the T9-10, T10-11, and T12-L1 segments. **d** Preoperative T2-weighted MRI shows foci at the T9-11, T12-L1 and L4-5, with one normal interval between the T9-11 and T12-L1 foci. **e**, **f** X-ray film of case after treatment with T9-L1, L4-5 posterior fixation, anterior debridement and graft fusion. The residual height of T12 was one-third to two-thirds normal and full size screws were used; the L4-L5 segment was fixed by short screws and a connecting rod was added. The residual height of the T9, T11, L4 and L5 was less than one-third normal and a 20–35-mm short segment screw was used. **g** CT shows graft union and the fixation was removed two years after surgery

to the different affected segments. Anterior debridement and strut graft were performed in a similar way, followed by deformity correction and internal fixation. Anterior fixation with the Z-Plate and Ventrofix were used. The details of the cases are shown in Table 2.

Postoperative treatment and follow-up

The drainage tube was removed when the drainage volume was less than 50 mL per day, but antibiotics were continued for one to three days. Following four weeks of bed rest,

Table 2 Intervertebral focal surgery in 29 cases (*n*)

Surgery	Intervertebral complete focal debridement	Intervertebral graft fusion	Intervertebral internal fixation
Posterior + anterior	20	20	18
Anterior	9	9	6

patients were permitted to move about using a brace. Examinations with X-ray, CT, MRI, B ultrasound, ESR, CRP, liver and renal functions were performed at follow-up, along with assessment of recovery of neurological functions, correction of deformity, and success of bone graft fusion. The Cobb's angle was measured using a lateral projection X-ray. The graft union was assessed by the Moon standard [10]. There were no obvious findings of loss of correction or bone absorption. There was bone moulding. Reappearance of bone trabeculae between the graft bed and graft were observed, along with substantial graft thickness.

Results

All cases had a mean follow-up time of five years, ranging from four to nine years. The mean Cobb's angle prior to and after surgery, including the final follow-up, was 36.5±7.6°, 9.8±8.1°, and 10.3±6.3°, respectively, with a mean correction of 25.3±4.5° after surgery, and a correction rate of 67.7%. However, a mean of 2.5±1.4° was lost at the final follow-up, with loss rate of 8.2%. ESR and CRP levels returned to normal after a mean of 5.8 months in 27 cases. Graft union was identified within four to six months after surgery, with an average of five months. Eleven patients with nerve lesions recovered to a grade of E. The incision healed by first intention in all but two patients who had second intention healing due to fat liquefaction. No case suffered from spinal cord, nerve, great vessel or organ damage during surgery. No breakage or cut-out was found.

Discussion

The incidence of non-contiguous multifocal spinal tuberculosis is rare in clinical practice [1, 10], but is characterised by severe symptoms and poor nutritional status [11]. The mean ESR was high but recovered slowly. The damage to affected areas causes poor stability of the spine. Multifocal spinal tuberculosis is easily misdiagnosed [12, 13]. It is difficult to treat these cases. The surgical methods for patients with surgical indications are not uniform. To date, for treatment within a fixed range, the majority of surgeons usually employ the short-segment or even long-segment fusion/fixation approaches, wherein the fixed or fused range includes the damaged mono-segmental with one or more adjacent normal motion segments [14, 15]. The short- and long-segment approaches provide a strong correction and fixation. However, these approaches limit the activity of more than two normal motion segments, affecting the mobility of the spine in the long term. In the lumbar spine, for example, a normal range of motion of spinal motion segment is flexion and extension movement of ~10–15°, lateral flexion of ~6–8°, and 2° for the axial torsion [16]. The studies of Sudo et al. [17] and Gillet [18] have shown that longer fixed segments cause more concentrated stress and higher forces on adjacent segments; this, in turn, accelerates adjacent segment degeneration. The clinical results of intervertebral focal surgery with complete debridement, deformity correction, graft fusion, and internal fixation limited to as few normal spinal segments as possible are satisfactory in treating mono-spinal tuberculosis [7]. Those methods also meet the requirements of non-contiguous multifocal spinal tuberculosis in our study.

We performed intervertebral focal surgery for multi-segmental spinal tuberculosis by anterior complete debridement, bone grafting, posterior or anterior instrumentation. In these cases, complete debridement was performed [19]. For mono-segment spinal tuberculosis of each foci, each focus was cleared; for multi-segment spinal tuberculosis, the foci were separated into several mono-segment foci and treated separately. For complete debridement, the foci should neither undergo over excision of normal bone, nor overlook infected material that could cause the disease to recur [20]. For the procedure of intervertebral focal graft union, the best graft is autologous iliac bone followed by titanium mesh cage filled with autologous iliac bone [21]. The drawback of the former is chronic pain and cosmetic defect while the latter can undergo mesh subsidence [14]. The length of the graft is based on size of the defective areas and the graft should be cut to size according to the mono-segment bone defect, which allow close contact the normal bone and improved survival. Long segments of fibula are not recommended, as these sacrifice the more normal spinal motion segments and may lead to bone non-union. For the procedure of intervertebral focal fixation, for cases where there were two or more normal spinal motion segments between affected foci, two or more sets of apparatus were selected and the normal motion units were maintained. For cases with posterior internal fixation for a case with one normal spinal motion segment between two affected foci, a set of apparatus was used to fix the connected affected segments in order to prevent the remaining segment from undergoing early degeneration. In cases where the residual height of the affected body is greater than two-thirds of normal, routine pedicle screw or centrum screws could be used; in cases where

the residual height was one-third to two-thirds of normal, routine screws could be used via a posterior approach. However, if the residual height is less than one third, a 25–35-mm short pedicle screw can be used via a posterior approach. There is documented evidence to suggest that satisfactory mid- and short-term results can be achieved [7, 22].

Two different types of surgery were used. The first is indicated for any cases with damage of vertebral body in non-contiguous multifocal spinal tuberculosis. However, the second type of approach has a limited indication in multisegmental spinal tuberculosis with intervertebral focal surgery, which can only be used in cases that had damage to less than one-third of each vertebral body, still leaving enough space for a screw. There were no significant differences in the clinical efficacy, operative time, blood loss and other complications, which had been reported in our previous article [7]. Our study revealed that satisfactory deformity correction is achieved and that the correction angle loss is similar to that found in long-segment fixation. Cavusoglu et al. [23] reported the average correction rate was 74% in anterior fixation. Mukhtar et al. [24] reported the average postoperative correction was 35.7% in anterior fusion and posterior fixation for the treatment of spinal tuberculosis, which is similar to that in our study, indicating that single-segment fusion is fixed recoverable and can maintain spinal stability. The average bone healing time in our study was similar to that in the literature [7]. ESR, CRP and Frankel grade of neurological function returned to normal in six months after surgery. It is similar in efficacy to conventional surgery [25].

In conclusion, for patients with non-contiguous multifocal spinal tuberculosis, the intervertebral focal surgery with complete debridement, deformity correction, graft fusion, and internal fixation was feasible and effective. It not only maintains spinal stability but retains the normal motor function of spinal segments, to some extent, and may slow the degeneration. It also creates a relatively small surgical invasion and saves on fixation materials and therefore less health care costs.

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