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Single-Stage Anterior Debridement, Autogenous Bone Grafting and Anterior or Posterior Instrumentation for Spinal Tuberculosis

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Abstract

The goal of this study was to discuss the indications for anterior or posterior instrumentation following radical debridement and autogenous bone grafting in patients with spinal tuberculosis over a 4-year period (2011–2015). In the current study, 71 patients (38 male and 33 female; average age, 42.4 years) were treated with single-stage anterior radical debridement, autogenous bone grafting, and anterior or posterior instrumentation. The average follow-up period was 43.8 months (range, 24–76 months). All cases had bony fusion. The average preoperative erythrocyte sedimentation rate (ESR) was 41.2 mm/h (range, 11–96 mm/h), improved to 29.0 mm/h (range, 9–57 mm/h) 1-week postoperatively, and became normal within 3 months for all patients. The average preoperative kyphosis was 16.7° (range, -19–70°), corrected to 0.7° (range, -26–22°) postoperatively, and fully improved to 3.8°(range -23–26°) at the final follow-up. The average neurological recovery in the patients was a 1.2 using the scale of Frankel et al. No severe complications occurred. Therefore, we believe that single-stage surgical management for spinal tuberculosis by anterior debridement, autogenous bone grafting, anterior or posterior instrumentation, and fusion was effective as a treatment. However, single-stage anterior or posterior instrumentation should be based on a comprehensive evaluation of the lesion segment, effectiveness of the antituberculous treatment, and imaging examination of the abscess size, scope, and degree of vertebral damage.

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Introduction

With the spread of AIDS and an increased application of immunosuppressants, the incidence of tuberculosis has increased in recent years [1]. The spine is the most frequent site of osseous involvement in tuberculosis [2,3] with it occurring here in approximately 50% of patients with skeletal tuberculosis [4]. Although antituberculous chemotherapy is fundamental in the management of spinal tuberculosis, it cannot prevent the associated deformity nor decrease the paraparesis rate [5,6]. Authors are beginning to further emphasize the important role of surgery in treating spinal tuberculosis [7,8].

A major development in the surgical treatment of spinal tuberculosis was the combined application of instrumentation based on debridement and grafting for bone fusion [9,10]. The application of instrumentation can help the lesion segment obtain sufficient stability following surgery, improving bone fusion efficiency and reducing relapse rate. However, the application and selection of instrumentation currently remains controversial as a surgical strategy.

The current study discusses current surgical strategies and instrumentation for spinal tuberculosis.

Materials and Methods

We retrospectively studied 71 cases of spinal tuberculosis patients who had surgical treatment at our institution between January 2011 and April 2015. Patient information is summarized in Table 1. There were 38 males and 33 females, and their average age was 42.4 (range, 19-74) years. There were 6 cases of cervical lesions, 27 cases of thoracic tuberculosis, 12 cases of thoracolumbar tuberculosis, and 26 cases of lower lumbar spine tuberculosis.

T**able 1:** Summary of clinical data obtained in 71 patients with spinal tuberculosis.

Case No.	Age(y)/Sex	Level	Kyphosis(°)			Surgical Type	Neurologic Status (Frankel)		Follow-up (m)	ESR		
			Pre	Post	LV		Pre	Post (6 m)		Pre	Post (1 w)	Post (3 m)
1	50/M	T3-T4	28	5	9	A	D	E	60	61	38	10
2	63/M	T11-L2	60	22	26	A+P	C	E	24	34	28	7
3	74/M	L3-L4	-10	-16	-13	A	D	E	44	46	32	12
4	70/M	T7-T8	30	6	8	A	E	E	61	41	32	9
5	64/F	T12-L1	24	10	14	A	C	E	45	44	31	11
6	48/M	T6-T7	32	12	15	A	C	D	72	32	24	9
7	55/M	L1-L2	12	3	7	A+P	D	E	53	48	29	9
8	32/F	T8-T10	55	9	12	A+P	B	E	45	26	15	10
9	30/M	T3-T4	32	8	11	A	C	D	32	36	25	7
10	44/F	L2-L3	2	-9	-6	A+P	D	E	34	35	22	6
11	40/M	T12-L1	26	8	12	A	C	D	55	26	18	8
12	38/M	C6-C7	8	0	3	A	E	E	51	18	12	8
13	24/F	L3-L4	-8	-15	-12	A+P	D	E	42	40	29	10
14	39/M	T7-T9	68	20	25	A+P	B	D	29	51	39	13
15	45/M	T3-T4	26	8	12	A	D	E	45	42	29	10
16	71/M	T10-T11	38	12	16	A	E	E	63	31	24	6
17	38/F	T12-L1	22	7	11	A	D	E	47	27	16	11
18	23/M	T5-T6	30	14	17	A	D	E	59	41	32	12
19	50/F	L2-L3	0	-10	-7	A+P	C	E	37	30	20	5
20	23/F	T5-T6	28	15	18	A	C	D	24	42	34	13
21	38/F	T10-T11	14	7	10	A	C	E	54	26	19	7
22	38/F	T5-T6	28	14	16	A	D	E	38	53	37	11
23	52/M	L4-S1	-8	-18	-15	A+P	D	E	32	29	21	14
24	45/M	C5-C6	13	3	5	A	D	E	39	34	22	17
25	65/F	T12-L1	20	8	12	A	C	D	71	40	29	10
26	43/M	L4-L5	-10	-14	-12	A	D	E	55	63	40	11
27	44/M	T6-T7	36	16	19	A	D	E	49	28	21	6
28	27/F	T6-T7	44	20	24	A	C	E	35	46	32	12
29	37/M	L2-L3	3	-7	-2	A+P	D	E	25	38	19	9
30	41/F	L3-L4	-11	-15	-13	A	D	E	39	49	34	11
31	26/M	C6-C7	17	2	5	A	D	E	54	37	23	9
32	23/F	L4-L5	-14	-18	-15	A+P	C	E	60	50	38	10
33	42/F	T8-T10	63	17	21	A+P	C	E	34	43	35	10
34	33/M	L1-L2	-2	-10	-7	A	E	E	47	52	39	12
35	65/F	L5-S1	-18	-26	-23	A+P	E	E	68	67	37	14
36	49/M	T11-T12	14	6	9	A	E	E	46	36	19	9
37	42/F	L4-L5	-11	-16	-14	A+P	D	E	71	29	18	9
38	58/M	T7-T9	62	21	24	A+P	C	E	30	83	55	8
39	33/F	T12-L1	35	13	16	A	B	D	41	54	39	10
40	43/M	L4-L5	-9	-19	-16	A+P	B	D	35	31	22	6
41	60/F	T6-T7	29	12	15	A	E	E	31	54	43	10
42	41/M	L2-L3	-2	-6	-4	A	E	E	46	46	34	12
43	73/M	T8-T9	28	8	11	A	C	E	45	39	30	9
44	37/F	L1-L2	2	-9	-6	A	E	E	35	30	22	7

45	32/M	C5-C6	20	7	10	A	B	D	24	52	29	11
46	39/F	L2-L3	-4	-10	-7	A	C	E	34	43	28	10
47	28/F	T6-T7	25	11	14	A	E	E	50	44	28	11
48	32/M	L2-L3	3	-7	-4	A+P	B	D	74	42	27	12
49	26/F	L5-S1	-14	-25	-22	A+P	E	E	40	33	25	11
50	25/F	T3-T4	30	8	13	A	C	E	41	29	18	7
51	57/M	L4-L5	-10	-15	-13	A+P	D	E	30	54	38	12
52	49/M	T11-L1	54	9	13	A+P	C	E	24	31	24	8
53	57/M	L3-L4	-8	-15	-12	A+P	D	E	41	36	27	13
54	34/F	T6-T8	57	14	19	A+P	B	D	24	38	29	14
55	71/M	L3-L4	-7	-15	-12	A+P	D	E	39	46	34	13
56	49/F	T10-T11	14	6	9	A	D	E	35	32	24	9
57	66/F	T10-T11	15	7	11	A	D	E	42	49	35	11
58	32/M	L2-L3	5	-8	-5	A+P	D	E	71	20	16	4
59	36/M	L4-L5	-12	-17	-16	A+P	C	E	37	47	40	8
60	46/F	C5-C6	15	3	6	A	D	E	38	42	34	10
61	25/F	T7-T8	33	11	14	A	C	E	27	47	32	10
62	20/M	L3-L4	-11	-14	-13	A	E	E	37	33	24	8
63	23/M	T10-T11	20	9	13	A	D	E	25	16	11	4
64	19/M	L5-S1	-19	-25	-23	A+P	E	E	42	42	34	11
65	31/M	L2-L3	1	-8	-5	A+P	D	E	46	45	36	10
66	48/F	T9-T10	17	7	10	A	D	E	26	28	19	8
67	37/F	L3-L4	-8	-14	-12	A+P	C	D	69	45	36	11
68	25/F	C4-C5	16	-2	1	A	C	E	76	30	21	5
69	41/F	T10-L1	70	21	26	A+P	B	D	53	96	57	9
70	47/M	L2-L3	1	-6	-4	A+P	D	E	28	53	38	10
71	41/F	T5-T7	59	19	23	A+P	C	E	35	46	37	11

Abbreviations: Pre: Preoperative; Post: Postoperative; LV: Last Visit; A: Anterior Radical Debridement, Autogenous Bone Grafting and Anterior Instrumentation; A+P: Anterior Radical Debridement, Autogenous Bone Grafting And Posterior Instrumentation.
The reference value of ESR in our hospital: < 20 mm/h (male), < 15 mm/h (female).

The diagnosis of spinal tuberculosis was based on clinical manifestations, MRI, and CT scans. This diagnosis was confirmed using a pathological examination of removed tissue following surgery; any cases that could not be confirmed by histology were excluded.

All patients presented tuberculosis symptoms, such as weight loss, fever, and fatigue. MRI and/or CT were used to determine the scope of the lesion, the position and degree of spinal cord compression, and paraspinal abscesses. Erythrocyte sedimentation rate (ESR) was used to evaluate the lesion activity and if it was cured. The angle of kyphosis was measured on lateral radiographs by drawing a line from the upper surface of the first normal vertebra above the lesion to the lower surface of the first normal vertebra below the lesion [11]. For lower lumbar lesions, the angle of kyphosis was defined as the angle between the posterior border of the first normal upper vertebra and the posterior margin of the first sacrum. The average preoperative angle of kyphosis was 16.7° (range, -19° to 70°). Preoperative nerve function was graded based on the Frankel scoring system [12]. There were 8 cases with Grade B, 22 cases with Grade C, 28 cases with Grade D, and 13 cases with Grade E.

Preoperatively, all patients received routine chest X-rays and a sputum examination for the tubercle bacillus; no patients had open tuberculosis or acute miliary pulmonary tuberculosis. All patients received four first-line antitubercular drugs (i.e., isoniazid, rifampicin, ethambutol, and pyrazinamide) for 2–10 weeks prior to surgery. After the patients regained their normal appetite and any fever, anemia, and hypoproteinemia subsided, surgery was carried out. Forty-one patients underwent anterior debridement, spinal cord decompression, distraction for kyphosis correction, and an autograft with single-stage anterior plate or screw-rod systems utilized. Patients who had large paraspinal abscess had posterior instrument fixation. Thirty patients received posterior transpedicular screw fixation and distraction in the intervertebral space while in the prone position. This was followed by anterior debridement, decompression, and autografting with further distraction while in the supine position. The strut autografts consisted of the autologous ribs (21 patients), fibula (2), or iliac bone (48).

Postoperatively, all patients were given bed rest for six weeks and bracing was used within the initial three months. Regular

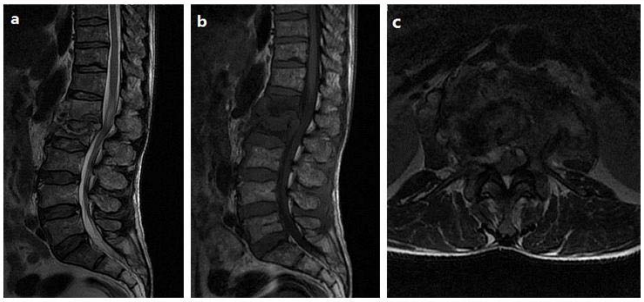

Figure 1: (a, b and c) MRI images demonstrated L1 vertebral body, L2 vertebral body, and intervertebral disc damage. Epidural and paravertebral abscesses are visible and the spinal cord was compressed and deformed.

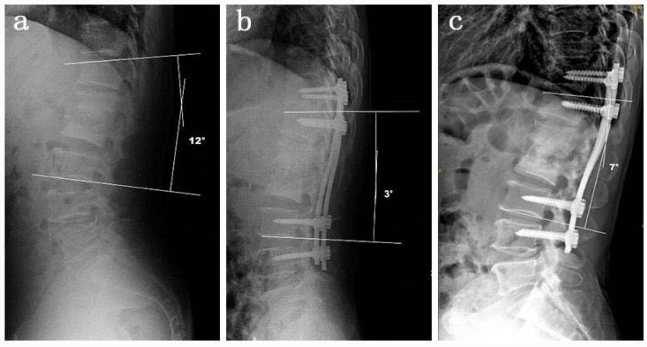

Figure 2: (a) A preoperative lateral X-Ray showing L1 and L2 vertebral damage. The kyphotic angle was 12°. (b) A postoperative lateral X-Ray showing anterior debridement, pressure release, autogenous bone grafting, and pedicle screw instrumentation. The kyphotic angle was corrected to 3°. (c) Four months after surgery, a lateral X-Ray showed good instrumentation and bone fusion. However, the kyphotic angle regressed to 7°.

antituberculous chemotherapy continued for 10–18 months after surgery. Liver function tests and ESR were monitored carefully at regular intervals. All cases were followed-up for an average of 43.8 months (range, 24-76 months). The parameters used in the follow-up were ESR, spinal bony fusion, local kyphotic angle, and neurological status.

Results

All 71 patients were cured without chronic fistula formation or relapse. Three weeks after surgery, the symptoms of all patients were alleviated. Patient average preoperative ESR was 41.2 mm/h (range, 11 to 96 mm/h). One week after surgery, this value dropped to 29.0 mm/h (range 9 to 57 mm/h), and it returned to a normal value within 3 months after surgery. Two patients had a preoperative ESR of 83 and 96 mm/h. After 8 weeks of antituberculous chemotherapy, ESR no longer significantly decreased, and the symptoms of nerve damage worsened progressively. In order to save the nerve function, surgery was performed. The surgery was successful and nerve function was recovered; 2 weeks later, ESR decreased to under 50 mm/h.

In this group 41 cases were treated with one-stage anterior instrumentation. A successful fusion was defined as the absence of movement on flexion-extension radiographs, the presence of intact hardware from instrumentation, and the appearance of a bridging bone at the diseased segment, as suggested by Vale *et al.* [13] All patients achieved full fusion by, on average, 4.1 months (range, 3-9 months).

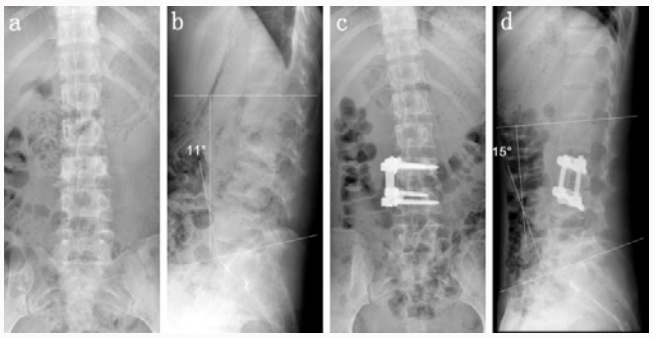

Figure 3: (a, b) A preoperative X-Ray showing L3 and L4 vertebral damage. The kyphotic angle was -11°. (c, d) A postoperative X-Ray showing anterior debridement, pressure release, autogenous bone grafting, and anterior instrumentation. The kyphotic angle was -15°.

Kyphotic angle and the extent of correction in each patient are shown in Table 1. The mean preoperative kyphosis of 16.7° (range, -19°–70°) was reduced to 0.7° (range, -26°-22°) postoperatively. At final follow-up, a minor progression of kyphosis was observed, with an average kyphosis of 3.8° (range, -23°–26°). Thus, the correction regressed by, on average, 3.1° by the final follow-up.

Neurological recovery was observed in all of the 58 patients who had presented a neurological deficit (Table 1). Specifically, 28 patients with a grade D neurological deficit recovered to normal, 7 patients with a grade B improved to a grade D, 1 with a grade B improved to a grade E, 6 with a grade C improved to a grade D, and 16 with a grade C recovered completely. The average neurological recovery in the patients was 1.2 grades on the scale of Frankel *et al.*[12] No patients deteriorated over the course of the study, including patients without a neurological deficit preoperatively.

Complications occurred in three patients. A urinary tract infection occurred in one patient, which was treated with the appropriate antibiotics. Another patient developed a superficial wound infection that was medically treated. A pleural tear occurred in 1 patient that resolved after using a prolonged intercostal drainage tube *in situ* for five days. However, no complications associated with the instrumentation occurred and there were no mortalities.

Illustrative Cases

A 55-year-old male patient was admitted to the hospital because of back pain and neuralgia of lower extremities. An examination of his nervous system showed incomplete paralysis of lower extremities. An imaging examination showed L1 and L2 vertebral damage, accompanied with epidural and paravertebral abscesses (Figure 1). His preoperative kyphotic angle was 12° (Figure 2a). After 3 weeks of antituberculous treatment, a single-stage anterior debridement, pressure release, autogenous bone grafting, and pedicle screw instrumentation was performed. The postoperative kyphotic angle was corrected to 3° (Figure 2b). His back pain symptoms were relieved significantly and lower limb muscle strength returned to normal. Four months after surgery, the bone fusion was complete and the kyphotic angle was increased to 7° (Figure 2c). Antituberculous treatment continued for a year after surgery.

A female patient aged 41 years with a L3–4 tuberculosis spondylitis. Her preoperative kyphotic angle was -11° (Figure 3b). After 4 weeks of antituberculous treatment, a single-stage anterior debridement, pressure release, autogenous bone grafting, and

anterior instrumentation was performed. The postoperative kyphotic angle was -15° (Figure 3d). Antituberculous treatment continued for a year after surgery.

Discussion

Spinal tuberculosis is a local manifestation of the Mycobacterium tuberculosis infection; thus, it is a systemic disease. Antituberculous chemotherapy is fundamental for the treatment of spinal tuberculosis, but surgical treatment is often necessary to improve function. The purpose of surgery is not only to remove the lesions and release the compression of the spinal cord or nerve roots but also to correct vertebral kyphosis and instability. Both a positive and significant importance has been attributed to surgery for shortening the treatment period, improving lesion health, and reducing any potential disabilities.

Indications that the spinal tuberculosis must be operated on are as follows: the presence of neurological deficits, spinal instability, severe and/or progressive kyphosis, a lack of response to a chemotherapy treatment, and a large paraspinal abscess [14,15]. Previously, ESR of above 80 mm/h was considered a warning against spinal tuberculosis surgery. In our study, two patients had ESR above 80 mm/h. Even after four weeks of antituberculous chemotherapy, ESR was still above 60 mm/h due to poor efficacy of the drugs. Surgeries were performed on these patients and patient ESR was significantly decreased two weeks after the operation. Therefore, we concluded that when antituberculous efficacy is poor and ESR is above 40 mm/h, surgery should still be considered after a thorough preparation and evaluation.

In 1960, Hodgson et al. used anterior debridement combined with bone fusion of a graft to treat spinal tuberculosis. This greatly improved the spinal tuberculosis success rate and confirmed the importance of a complete debridement and single-stage bone fusion [16]. However, single debridement and bone fusion cannot significantly improve kyphosis, since a fracture, displacement, and absorption of the grafted bone can happen after surgery [17]. A 10-year follow-up study conducted by Parthasarathy [18] demonstrated that after a simple anterior bone graft fusion surgery combined with chemotherapy, the kyphotic angle increased by 15°, on average. Many clinical cases [19,20] have already confirmed that the application of instrumentation can effectively increase vertebral stability, correct a kyphotic deformity, promote control of the tuberculosis, promote bone graft fusion, improve patient quality of life, and reduce recovery times. Eysel *et al.* [21] recommended anterior instrumentation even in the presence of florid vertebral discitis, and they did not find an increased risk of prolonged or recurrent infection. However, it still unclear whether to use anterior or posterior instrumentation after anterior debridement and bone grafting [9,10,22-26].

Scholars who chose anterior instrumentation argued that by using the same entrance to finish debridement, bone grafting and instrumentation can help avoid additional surgery trauma. This is in contrast with posterior instrumentation, which requires a second entrance. Thus, anterior instrumentation can shorten the operation time and reduce blood loss and hospitalization time [27,28] Yilmaz *et al.* [10] treated 38 patients with anterior instrumentation and fusion. They found that no recurrence of spinal tuberculosis had occurred at a, on average, 2.42 year follow-up. In their report, 22 patients, who had one to two level affection, had a 64% correction of kyphosis (58%±90%), and 16 patients, who had more than two levels affection, had a 81% (75%±97%) correction. There was 58% (41/71) of patients received the anterior instrumentation. This is similar to the findings by Zhao *et al.* [29]. In their study, 22 patients with cervical, thoracic, and thoracic-lumbar level involvement underwent anterior instrumentation, and 18 lumbar spine patients received posterior instrumentation. The kyphosis correction rate after the last follow-up reached 59% and not a single case of a displaced grafted bone or instrumentation infection was reported. We concluded that this surgery procedure is suitable only under the following conditions: (1) patients with a significantly damaged anterior column and due to the damage to vertebral stability after debridement, grafted bone must be used to restore the vertebral height; (2) patients who have anterior compression and must perform anterior decompression; and (3) patients who have single or adjacent vertebrae tuberculosis and their local lesions can be completely removed by surgery with an expected low recurrence rate after the surgery.

Scholars who chose posterior instrumentation combined with anterior debridement argued that the distance between the posterior instrumentation and the tuberculosis lesion is enough to greatly lower the probability of infection after the surgery [9,22,24]. Moon *et al.* [9] treated 39 patients with posterior instrumentation and anterior interbody fusion for thoraco-lumbar tuberculous kyphosis. The mean preoperative kyphosis angle (37°) improved to 16° after surgery. After, on average, 3.6 years the angle had little difference (18°), and no patient experienced a loss of correction more than 3°. Sundaraj *et al.* [24] reported that for patients undergoing anterior debridement and bone grafting combined with posterior instrumentation and fusion, only 6.5% of the patients had grafted bone-related problems and no patients had any grafted bone displacement, but rather, they all had good efficacy. In the current study, all 30 cases that were treated with single-stage posterior instrumentation combined with anterior debridement and bone grafting had good efficacy and no patients had severe systemic complications after surgery. Furthermore, no patients had any reoccurrence after surgery; the correction rate following the final follow-up reached 110%. We concluded that this surgical procedure is suitable for the following conditions: (1) patients with two or more segments that have spinal tuberculosis accompanied with severe vertebral damage and kyphosis deformity; and (2) patients with lumbosacral spinal tuberculosis and a difficult anterior instrumentation.

All cases in this group had single-stage anterior debridement and autogenous bone grafting combined with anterior or posterior instrumentation. Since immediate stability was obtained, the fusion rate after two-year follow-up reached 100%. Therefore, we believe that single-stage surgical management for spinal tuberculosis by anterior debridement, autogenous bone grafting, anterior or posterior instrumentation, and fusion was effective in treating the disease.

Conclusion

Spinal tuberculosis is part of systemic disease and a systemic antituberculous drug treatment is thus fundamental for spinal tuberculosis treatment. Apart from effective antituberculous chemotherapy, active debridement and spinal stability surgery are significant in spinal tuberculosis treatment. Single-stage anterior or posterior instrumentation must be based on a comprehensive evaluation of the lesion segment, effectiveness of the antituberculous treatment, imaging examination of the abscess size, scope of the instrumentation, and degree of vertebral damage.

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