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A 270° Retention of Spinal Structure in the Treatment of Thoracic and Lumbar Tuberculosis via Posterior-Only Approach

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Objective: The necessity of radical debridement in the treatment of thoracic and lumbar tuberculosis is increasingly challenged. We introduce the 1-stage surgical treatment with 270° retention of the spinal structure via a posterior-only approach and investigate the clinical efficacy and feasibility of this method in treating thoracic and lumbar spinal tuberculosis.

Summary of Background Data: In former research articles, many potential disadvantages are found in the treatment of thoracic and lumbar tuberculosis after radical debridement, such as prolonged operative time, increased the surgical trauma, unsatisfactory bony fusion, instability of the spine, and too much blood loss.

Methods: Twenty-one patients who had thoracic and lumbar tuberculosis were admitted to our hospital between January 2013 and September 2014. All of them were treated with 1-stage surgical treatment by internal fixation, focal debridement, and fusion via the posterior-only approach. Then, the clinical efficacy was evaluated, with the Cobb angle reflecting spinal kyphotic angles, erythrocyte sedimentation rate (ESR), Frankel Grade scores, and imaging examination preoperatively and postoperatively.

Results: Patients were followed up for 24 to 40 months (mean, 29.95 months), Fusion occurred at 4 to 9 months (mean, 5.86 months). There were significant differences between groups regarding the Cobb angle, ESR, and Frankel Grade scores. Delayed wound healing

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affected 1 patient because of diabetes. No complications regarding the internal fixation and no tuberculosis recurrence were observed during follow-up.

Conclusions: Combined with anti-tuberculosis chemotherapy, the method, characterized by 270° retention of the spinal structure, can be an effective and feasible method in treating thoracic and lumbar spinal tuberculosis.

Key words: Spinal tuberculosis – Surgical treatment – Posterior – Debridement

In recent decades, with the emergence of antibiotic-resistant strains and the increasing incidence of human inmmunodeficiency virus (HIV) infection, total tuberculosis incidence has increased all over the world, especially in developing countries.[1,2] Although spinal tuberculosis accounts for less than 1% of patients of tuberculosis, it is a destructive form of tuberculosis destroying the vertebral structure, resulting in kyphosis formation and spinal cord compression.[3,4]

Anti-tuberculosis chemotherapy remains the mainstay for treating early stage spinal tuberculosis. However, it could not avoid the spinal cord compression or sequelae of kyphosis in some cases. Therefore, surgical methods still play an important role in treating spinal tuberculosis. The reported surgical treatment methods, including anterior or posterior radical debridement, may result in consequences, such as prolonged operative time, increased surgical trauma, unsatisfactory bony fusion, and instability of the spine.[5] Thus, we introduce the 1-stage surgical treatment with 270° retention of the spinal structure via a posterior-only approach, and the aim of this study is to investigate the clinical efficacy and feasibility of this method in treating thoracic and lumbar spinal tuberculosis.

Materials and Methods

Patient information

From January 2013 to September 2014, we enrolled 21 patients with active spinal tuberculosis of the thoracic or lumbar spine with indications for surgery: (1) progressive neurological deficit; (2) persistent pain caused by instability; (3) severe kyphosis or kyphosis likely to progress; and (4) poor outcomes after conservative chemotherapy. Permission was obtained from the hospital ethics committee before starting this study, and informed consent was obtained from all patients or their legal guardians.

Medical records of clinical and operative reports, radiographic images, and pathology reports were extracted. The diagnosis of spinal tuberculosis is determined by nonspecific laboratory findings including blood routine examination, blood chemistry profile, and erythrocyte sedimentation rate (ESR) and by imaging findings such as spine X-ray, computed tomography (CT), and magnetic resonance imaging (MRI).The Cobb angle is measured on spinal X-ray. The involvement of contiguous vertebral end plates, the destruction of vertebrae, and the location of sequestrums were identified on CT. Abscess, spinal cord compression, and destruction of intervertebral discs are observed by MRI. In addition, neurologic status is also evaluated according to the Frankel grade scores.

Preoperative procedure

The patients received antituberculosis drugs after the preliminary diagnosis for at least 3 weeks, together with strict bed rest and measures to improve general condition and nutrition. Antituberculosis drugs included ethambutol (EMB) 750 mg/d, isoniazid (INH) 300 mg/d, pyrazinamide (PZA) 1500 mg/d, rifampicin (RFP) 450 mg/d, and levofloxacin 300 mg/d. Surgery was performed under the cover of chemotherapy. Generally, surgery was performed when physical condition improved obviously.

Surgical method

Given general endotracheal anesthesia in prone position, we made the posterior median longitudinal incision and continued to incise until spinous process and vertebral plate were exposed clearly. In step 1, we set the internal fixation screws through the vertebral pedicle as planned and corrected the kyphosis of certain degree by a rod at the same time. In step 2, we identified the vertebrae according to imaging findings and chose the severely involved side of vertebrae, with the opposite side filled in with gauze. We stripped the unilateral vertebral plate and zygapophyseal joints by rongeur in the

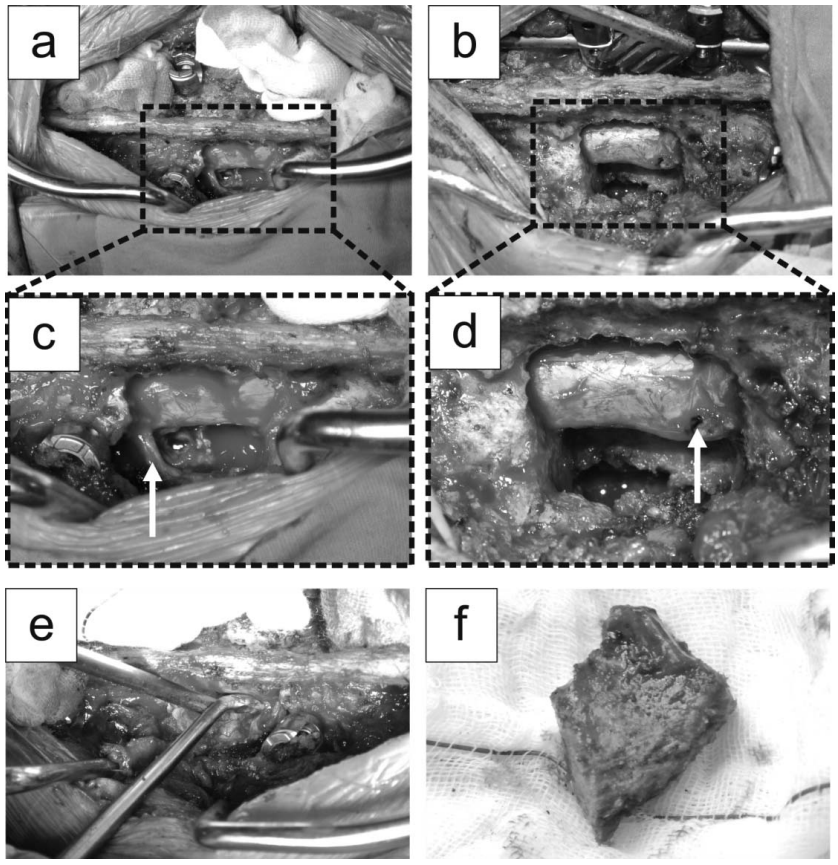

Fig. 1 During the operation, (a and c) we freed and protected the lumbar nerve (arrow) in treating lumbar tuberculosis, (b and d) but sometimes sacrificed the thoracic nerve (arrow, with the ligature presented) in treating thoracic tuberculosis. (e and f) The surgical procedures also contain curetting the central lesion and resecting the appropriate autogenous bone from the posterior superior iliac spine (c is enlargement of a, and d is enlargement of b).

chosen side, during which we freed and protected the upper and lower lumbar nerve roots (Fig. 1a and 1c), but sometimes sacrificed the thoracic nerves (Fig. 1b and 1d).Then we entered the targeted space, drained the abscess with negative pressure, and curetted the central lesion (Fig. 1e), which was the involved vertebral body and the intervertebral disc in most cases, with satellite lesions retained. The kind of lesion resection was considered focal debridement instead of radical debridement. In step 3, we resected the appropriate autogenous bone from posterior superior iliac spine (Fig. 1f). After careful disposal, we implanted the bone graft into the debrided space. As the above steps were completed, 270° of the spinal structure remained (Fig. 2). Treatment with streptomycin (1.0 g) was locally administered. A negative pressure drainage tube was routinely fixed on the operated side. The debrided tissue and bone were kept for culture and histopathologic examination.

Postoperative procedure

Antibiotics were administrated during the first week after the operation. The negative pressure drainage tube was pulled out when drainage flow was less than 30 mL/d. The stitches were normally removed 14 days after the operation. Patients were instructed to wear a brace for at least 6 months. The patients were given the antituberculosis drugs for 12 to 18 months postoperatively. ESR and liver and kidney function were examined once a month postoperatively to monitor any adverse reactions of the antituberculosis drugs, and all patients were followed up on an outpatient basis at 3-month intervals for the first 6 months and then 6-month intervals for the next 2 years, and annually for life thereafter. X-rays were performed once a month, and MRIs were taken every 3 months.

Statistical analysis

Mean and standard deviation were used to describe normal distribution data. Median and quartile percentile were used to describe skewed distribution data. Paired *t* test and Wilcoxon signed-rank test were used to analyze the comparison between 2 different times. Two-way analysis of variance (ANOVA) was used to analyze the comparison among 3 different times, and the LSD *t* test was used

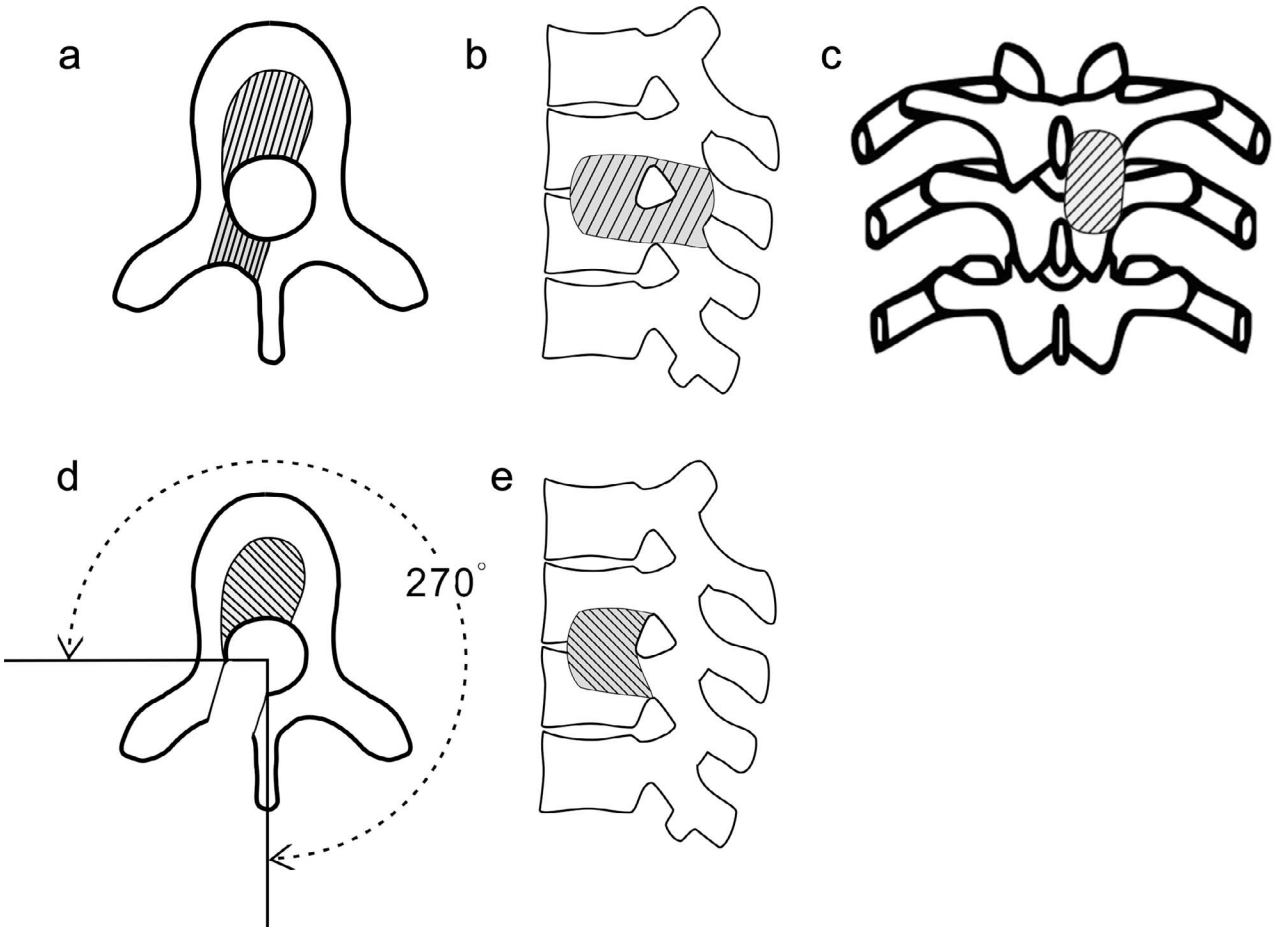

Fig. 2 During the operation, (a–c) we resected the unilateral vertebral plate and zygapophyseal joints and (e and f) implanted the bone graft and kept 270° of the spinal structure.

as the post hoc test. $P \leq 0.05$ was considered statistically significant. All statistical calculations were performed by PASW Statistics, version 21.0.

Results

Twenty-one consecutive patients with thoracic or lumbar tuberculosis were enrolled in this study, and the characteristics of the patients are described in Table 1. The population comprised 13 males and 8 females, with a mean age of 47.9 (range, 24–73) years. All patients presented with constitutional symptoms such as fatigue, weakness, night sweats, lower fever with weight loss, or other symptoms of different degrees. The most common symptom was dorsal spine pain (90.5%), followed by neurologic complaints (76.2%). Although abscesses of different size were identified in all patients, absolute paraplegia did not occur in this study. On admission, the neurologic compromise function was assessed: 4 cases of grade C, 12 cases of grade D, and 5 cases of grade E. The mean Cobb angle of the 21 cases at diagnosis was 17.24° (range, 8°–25°), and the median ESR was 28 (range, 2–113) mm/h.

All 21 patients underwent a 1-stage surgical treatment by internal fixation, focal debridement, and fusion via the posterior-only approach. The mean operation time was 230 (range, 120–300) minutes. The median of intraoperative blood loss was 500 (range, 200–1500) mL. Transfusion volume of blood or blood products ranged from 0 to 1500 mL, and 11 cases did not receive transfusions. The detailed surgery information is summarized in Table 2.

For all cases, the mean follow-up period was 29.95 months (range, 15–40 months). After the operation, anemia and hypoproteinemia were corrected in time. The pretreatment ESR ranged from 2 to 113 mm/h, and the postoperative ESR ranged from 5 to 22 mm/h at the 3-month follow-up. The

Table 1 Clinical data of all patients

Case no.	Sex	Age (yr)	Operation time (h)	Blood loss (mL)	Transfusion volume (mL)	Follow-up (mo)	Diseased segments	Fusion time (mo)	ESR		Frankel grade		Cobb's angle (°)		
									Before surgery	After 3 mo	Before surgery	Final follow-up	Before surgery	After surgery	Final follow-up
1	M	61	4	800	1000	30	L3-4	6	29	12	D	E	12	8	10
2	F	61	3.5	500	0	29	L4-5	5	70	10	D	E	15	12	14
3	F	52	4	400	600	32	L2-3	7	113	15	D	E	15	12	13
4	F	58	3	400	0	34	T11-12	7	38	21	D	E	20	6	9
5	F	72	4	1500	1000	25	L3-4	6	86	12	D	E	15	12	13
6	F	34	4	500	0	25	L1-2	4	36	8	D	E	8	5	6
7	M	67	3	400	600	26	T10-11	9	28	11	C	D	12	8	10
8	M	28	5	1000	0	26	T8-9	5	45	10	D	E	22	10	13
9	M	29	4	1000	1000	36	T2-3	5	2	5	E	E	22	12	15
10	M	24	5	1500	400	32	T9-10	6	14	14	E	E	15	6	10
11	M	61	4	800	0	24	T6-7	4	15	8	E	E	20	10	15
12	F	57	3.5	400	900	32	L3-4	7	83	22	D	E	18	12	15
13	M	53	4	500	0	32	L4-5	6	20	14	D	E	18	15	16
14	F	61	2	300	0	30	L7-8	7	22	12	D	E	16	12	15
15	F	40	3	200	0	26	L8-9	5	28	9	D	E	24	16	18
16	M	49	3.5	200	0	26	L5-6	6	16	15	E	E	15	10	12
17	M	34	4.5	1000	1200	28	L4-5	5	44	12	E	E	15	12	12
18	M	26	4	1000	1200	30	L3-4	5	17	14	C	D	10	8	9
19	M	73	4	800	0	36	T7-8	7	16	9	D	E	25	12	15
20	M	41	3.5	500	0	40	T12-L1	6	38	19	C	E	25	5	10
21	M	25	4	1000	1200	30	L2-5	5	17	12	C	E	20	15	16

F, female; M, male.

ESR of all patients had significantly decreased ($P < 0.05$; Table 3). The mean Cobb angles distinctly reduced from 17.24° (range, 8°–25°) preoperatively to 10.38° (range, 5°–16°) in the immediate postoperative period and 12.67° (range, 6°–18°) at final follow-up. The loss of correction was only 2.29° (Fig. 3). The results of post hoc analysis showed there was statistical significance of Cobb angle between each time by LSD t test ($P < 0.05$; Table 3). During follow-up, the mean bony fusion time is 5.86 (median, 4–9) months. At the last visit, in the 16 patients with preoperative neurologic deficit, 2 with grade C recovered to normal, 2 with grade C recovered to grade D, and 12 with grade D recovered to normal. They had distinct improvement in the Frankel Grade scores postoperatively ($P < 0.05$; Table 3). Delayed wound healing affected 1 patient because of diabetes, and no sinus formation was observed in the patients. No complications regarding internal fixation and no tuberculosis recurrence were observed during follow-up. All 21 patients obtained complete intervertebral bony fusion (Fig. 4) with a mean time of 5.86 months (range, 4–9 months).

Table 2 General condition and surgical results of the patients

Variable	Mean ± SD or median (Q1, Q3)
Age	47.90 ± 16.30
Operation time	3.79 ± 0.68
Follow-up time	29.95 ± 4.24
Cobb's angle (preoperatively)	17.24 ± 4.80
Cobb's angle (postoperatively)	10.38 ± 3.23
Cobb's angle (last follow-up)	12.67 ± 3.01
Blood loss	500 (400, 1000)
Transfusion volume	0 (0, 1000)

Discussion

Over the last several decades, although various methods have been introduced and applied to treat spinal tuberculosis, therapeutic strategy for spinal tuberculosis is still controversial. As to this disease, supportive therapy and potent antitubercular chemotherapy are used to stop the infectious process, improve physical condition, and accelerate the patients' recovery process. In the meantime, surgical treatment still plays an important role in treating spinal tuberculosis, with the goals of decompression, debridement, and the rebuilding stability to correct deformity of kyphosis. However, the ideal surgical approach for thoracic and lumbar tuberculosis still appears controversial.

Table 3 Comparison of variables over time

Variable	Time	Mean ± SD or median (Q1, Q3)	Statistic	*P*
ESR	Preoperatively	28 (16.5, 44.5)	−3.829[a]	<0.0001
	Postoperatively	12 (9.5, 14.5)		
Frankel grade	Preoperatively	4.05 ± 0.67	−6.852[b]	<0.0001
	Postoperatively	4.90 ± 0.30		
Cobb's angle	Preoperatively	17.24 ± 4.80	38.985[c]	<0.0001
	Postoperatively	10.38 ± 3.23		
	Last follow-up	12.67 ± 3.01		

[a]Wilcoxon signed-rank test Z.
[b]Paired *t* test.
[c]ANOVA *F* test.

In 1983, Denis first introduced the 3-column model concept to describe the instability of spinal trauma.[6] Spinal tuberculosis mostly affects the anterior and middle spinal column. Thus, the anterior approach, which was considered the gold standard for a long time, could provide direct access to involved segments and allow efficient decompression of the spinal cord.[7] However, exposure of the involved segments via an anterior approach would increase surgical trauma, because the segments are blocked by complex anatomical structures especially in thoracic cavity.[8–11] Another practical problem was that a postoperative drainage tube was not easy to install through the thoracic and abdominal cavity. Moreover, it may lead to postoperative hydrothorax and pneumonia. Meanwhile, paravertebral exudate could not be easily drained out and could possibly form encapsulations, potentially leading to relapse. The posterior approach with smaller surgical incisions and minimum surgical trauma could reduce possible postoperative complications. In this study, only 1 patient experienced delayed wound healing because of diabetes, and no severe postoperative complications, including atelectasis, lung infection, and chylothorax, happened. Moreover, postoperative drainage of residual lesions outflowed more easily in the supine position because of gravity.

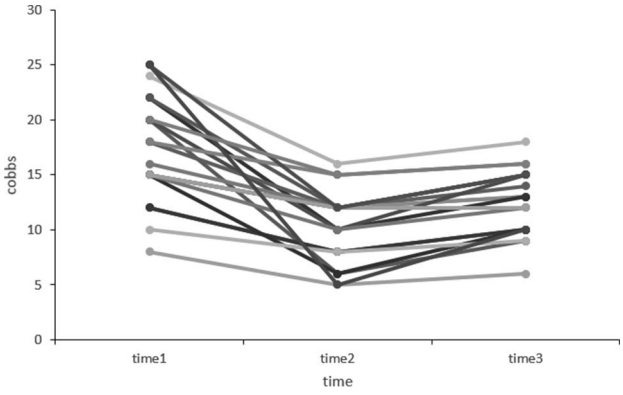

Fig. 3 Postoperative correction was successful, and loss of correction was acceptable at the final follow-up (time 1 preoperatively; time 2 postoperatively; time 3 last follow-up).

Another reason for the traditional gold standard of anterior approach is that posterior decompression in spinal tuberculosis should remove the healthy posterior vertebral structures and aggravate spinal instability. Nowadays, the modern pedicle screw could provide rigid fixation and enable adequate stability, which is much better and stronger than anterior fixation.[9] Moreover, it could also reach a potent braking effect to correct deformity and avoid the loss of corrected degrees as far as possible.[12,13] Meanwhile, fixation and bone graft are far from the lesions in the posterior approach, which could decrease disease relapse.[14] In our study, no breaking or loosening in internal fixation occurred during follow-up. The postoperative Cobb angle was significantly improved, and the loss of correction during follow-up was acceptable (2.29°).

The traditional viewpoint restricting the posterior approach comes from the uncertainty of whether the approach can achieve radical resection of the lesion. In a previous study, the posterior approach provides no advantage in radical debridement.[15] However, with the development of multiple antituberculosis drugs, tuberculous lesions could be successfully treated by means of spontaneous fusion eventually, and the attempt to radical debridement should not be overemphasized.[16,17] When patients have severe spinal tuberculosis with involvement of consecutive multisegmental vertebrae or huge prevertebral abscesses, achieving satisfactory radical debridement by posterior approach is impossible. Nowadays, many surgeons such as Jain[1] and Tuli[18] noted

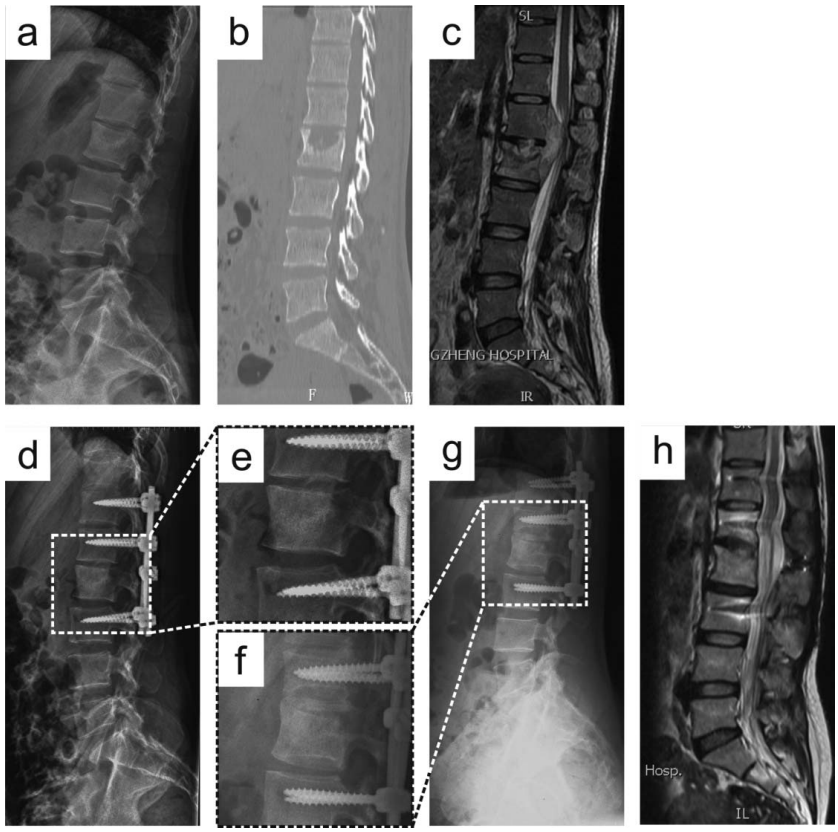

Fig. 4 A 34-year-old woman had back pain for 4 months and incomplete paralysis for 2 weeks. On admission, the neurologic deficit was assessed as grade D. (a and b) Preoperative lateral X-ray and CT scan showed involved segments located at L2. (c) Preoperative MRI showed the presence of a local abscess and compressed spinal cord. Radiography showed fixation was in good position postoperatively (d) and at 6-month follow-up (g). (e and f) The graft bone achieved bony fusion successfully. (h) Postoperative MRI showed disappearance of local abscess and no spinal cord compression. At last visit, the patient's Frankel grade recovered to E (e is enlargement of d, and f is enlargement of g).

that posterior laminectomy with extensive structure removed may cause overmuch normal posterior spinal column damaged, potentially making the spine unstable. After radical debridement, the extensive damage to the bone graft bed creates difficulty in obtaining good osseous healing. In addition, Chandler and Cappello[19] indicated that a great deal of scar tissue and abnormally proliferated fibrous connective tissue after laminectomy and radical debridement potentially adhered to nerve roots and the dural sac, causing a series of consequent compression symptoms. Focal debridement could overcome the disadvantages of extensive radical debridement by minimizing the damage to spinal integrity, retaining enough vertebral bone substance to guarantee fusion, preventing epidural adhesion, and decreasing the possibility of formation of scar tissue to protect spinal cord. In this study, the postoperative Frankel grade scores was significantly improved at the last visit, and bony fusion occurred with a mean time of 5.86 months. In contrast, autogenous bone grafting is also an important procedure to insure bony fusion. Autogenous bone would generate a satisfied effect of fusion with the minimal possibility of immunologic rejection and secondary infection, whereas 270-degree retention of the spinal structure can ensure the stability as much as possible.

Ideal spinal operations should be well tolerated and nearly minimally invasive, associated with minor postoperative complications and an almost near-normal spine. Thus, we describe the surgical method emphasizing 270° retention of the spinal structure. To the best of our knowledge, no other study has reported this kind of method previously. Thus far, the clinical outcomes and radiographic results of the patients are all satisfactory. Based on our clinical experience, we recommend the indications for the method as follows: (1) stability of the involved segment is lost, and potent internal fixation is in need; (2) patients, reluctant to tolerate or accept the immobilization of lying in bed or wearing the brace for a long time, hope to get out of bed as soon as possible; (3) patients in poor physical conditions have difficulty in accepting 1-stage surgical treatment by anterior approach or surgical treatment by anterior and posterior approach; (4) patients do not have a large abscess, serious spinal canal invasion, and spinal deformity.

Conclusion

Combined with multiple antituberculosis drugs, this method with 270° retention of the spinal structure via the posterior-only approach can maintain spinal column integrity, improve neurologic function, achieve satisfactory bony fusion, decrease postoperative complications, and lead to effective recovery in the end.

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