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Original Article

The role of anterior and posterior approaches with circumferential reconstruction without any anterior instrumentation in extended multilevel cervical spinal tuberculosis

Hao Zeng[1], Yupeng Zhang[1], Zheng Liu[1], Xiyang Wang[1], Yong Cao[1], Xiongjie Shen[2]

[1]Department of Spine Surgery, The Xiangya Hospital of Central South University, High-performance Imitative Bone Bio-engineered Materials of Engineering Laboratory of Hunan Province, 87 Xiangya Road, Changsha 410008, People's Republic of China; [2]Department of Spine Surgery, Hunan Provincial People's Hospital, Changsha 410005, People's Republic of China

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Abstract: To evaluate the clinical efficacy and feasibility of 11 patients with extended multilevel (≥3 levels) cervical spinal tuberculosis treated by combined anterior debridement, decompression and long allograft bone and posterior instrumentation and posterior-lateral fusion. Retrospective review of data on eleven patients who suffered from extended (≥3 levels) multilevel cervical spinal tuberculosis (EMCST) admitted to our hospital between January 2006 and December 2012. All of them were treated by anterior debridement, corpectomy, decompression and peg-in-hole allograft bone without anterior instrumentation combined with posterior lateral mass screw fixation and posterior-lateral fusion. Of which, 3 patients were securely added with laminectomy in consideration of anterior severe compression. Anteroposterior/lateral plain films and computed tomographic images were used to determined sagittal balance and bone fusion. The clinical efficacy was evaluated using statistical analysis based on the materials about the visual analogue scale (VAS) scores of pain, neurological status and erythrocyte sedimentation rate (ESR), which were collected at certain time. The average follow-up period was 33.9 ± 6.3 months (24-43 months). In the 11 cases, no postoperative complications related to instrumentation occurred and neurologic function was improved in various degrees. The average pretreatment ESR was 51.7 ± 14.1 mm/h (30-83 mm/h), which got normal (8.1 ± 1.6 mm/h) within 3 months in all patients. The average preoperative VAS was 6.6 ± 1.1, which decreased to 0.5 ± 0.69 postoperatively. All patients got bony fusion within 6-9 months after surgery. In conclusions, anterior debridement, corpectomy, decompression and peg-in-hole allograft fusion combined with posterior instrumentation and posterior-lateral fusion with or without laminectomy can be an effective treatment method for the treatment of extended multilevel cervical spine tuberculosis.

Keywords: Cervical spinal tuberculosis, multilevel, anterior, posterior approaches, allograft fusion, circumferential reconstruction

Introduction

The incidence of tuberculosis has been increased through the world. Spinal tuberculosis (ST), which is a common extra-pulmonary, is the most frequent and serious form of skeletal tuberculosis [1, 2]. TB of cervical spine is a rare disease, of all the patients suffering from spine TB, only 4.2% to 12% has involvement of the cervical spine [3]. However, the treatment of extended multilevel cervical spinal tuberculosis is described as atypical and case reports are published as rarities in the mainstream academic journals. In its most common forms, ST involves the anterior column of a single motion segment i.e. two adjoining vertebral bodies and their intervening disc (peri-discal). But when ST involves more than single motion segment or multilevel (three or more vertebrae), this may be multilevel or long-segment [4]. Although the ant-TB chemotherapy and external immobilization still play an irreplaceable role in treatment of cervical spinal tuberculosis (CST) in most cases, EMCST is characterized by involved multiple vertebrae, severe kyphosis deformity, large abscess and spinal cord compression,

Table 1. Data of 11 Patients with EMCST underwent surgery

Patient No	Age/Sex	Affected level	ASF Level	Surgery procedures	Follow-up (mon)	Post. complication	Kyphosis angle (°)			VAS			ESR	
							Pre	Post#	FFU*	Pre	Post#	FFU*	Pre	Post #3 mon
1	24/F	C4-C6	C3-C7	ACF+DEB+ADE+PIPF	38	None	18	-7	-7	8	2	0	43	8
2	37/M	C3-C6	C2-C5	ACF+DEB+ADE+PIPF	43	None	12	-6	-4	6	3	0	83	11
3	40/F	C3-C5	C2-C6	ACF+DEB+ADE+PIPF	24	CFL	26	-10	-9	6	2	1	66	7
4	58/M	C3-C5	C2-C6	ACF+DEB+ADE+PILPF	36	None	15	-5	-5	6	2	1	48	9
5	39/M	C4-C6	C3-C7	ACF+DEB+ADE+PIPF	26	None	21	-10	-9	6	4	0	48	8
6	44/M	C3-C6	C2-T1	ACF+DEB+ADE+PILPF	30	DYS+AXP	3	-9	-9	7	2	0	56	8
7	38/F	C3-C5	C2-C6	ACF+DEB+ADE+PIPF	33	None	11	-8	-7	6	1	1	40	8
8	40/M	C4-C6	C4-C6	ACF+DEB+ADE+PIPF	38	DYS	19	0	-1	7	4	1	55	10
9	57/M	C3-C6	C2-C7	ACF+DEB+ADE+PILPF	27	CFL+AXP	30	-4	-4	5	3	2	45	9
10	60/F	C3-C5	C3-C6	ACF+DEB+ADE+PIPF	40	WDH	33	-1	0	7	1	0	30	5
11	19/M	C4-C6	C3-C6	ACF+DEB+ADE+PIPF	38	None	3	-13	-10	9	2	0	55	9
Mean values	41.4±13.1				33.9±6.3		17.4±9.9	-6.6±4.0	-5.9±3.4	6.6±1.1	2.3±1.0	0.5±0.69	51.7±14.1	8.4±1.6

F: female; M: male; ASF: anterior spinal fusion; DEB: debridement; ADE: anterior decompression; ACF: anterior corpectomy and fusion; PIPF: posterior instrumentation and posterior-lateral fusion; PILPF: posterior instrumentation, laminectomy and posterior-lateral fusion; CFL: cerebrospinal fluid leakage DYS: dysphagia; AXP: axial pain; WDH: wound delay healing; Pre, Post, FFU: preoperative, postoperative, final follow-up; Mon: months. #indicates a statistically significant difference between preoperation and postoperation ($P<0.05$); *Indicates that there is no significant difference comparing postoperative and at final visit values ($P>0.05$).

Table 2. Neurologic recovery according to Frankel grade

Preoperative Frankel grade	No. of patents	Frankel grade at final follow-up				
		A	B	C	D	E
A	0	0	0	0	0	0
B	2	0	0	0	2	0
C	5	0	0	0	1	4
D	4	0	0	0	0	4
E	0	0	0	0	0	0

Wilcoxon signed rank test, compare final follow-up with pre-operation in ASIA, $P<0.05$.

which usually beyond the medical disease. Therefore, surgical invention will be necessary in this case. To our knowledge, surgical treatment of EMCST has rarely been reported. He et al. [5] reported 25 patients (only 4 cases with 3 levels lesion) with lower CST underwent stand-alone anterior corpectomy, debridement, decompression, bone grafting and instrumentation. But they laid more emphasis on the effectiveness of a single anterior approach mainly on short-segment CST without any further discussion about EMCST. In fact, multilevel cervical corpectomy has traditionally been associated with increased fixation and/or graft-related complications and worse clinical outcomes compared with single-level procedure, in spite of the advantages of stand-alone anterior surgery for multilevel cervical discords including improved visualization, radical debridement, directly addressing the clinically relevant pathology and more extensive decompression, theoretically leading to improved rates of arthrodesis and perfect clinical outcome. Vaccaro et al. [6] described the graft/plate construct dislodged in 3 of 33 patients with a two-level corpectomy and fusion (9%) compared with 6 of 12 patients with a three-level corpecromy and fusion (50%) during the early postoperative period. They persisted that anterior cervical plating and bone grafting alone after a three-level cervical corpectomy for various disorders appears to afford inadequate stability in the early postoperative period. Graft and plate dislodgement or even fracture has been reported in 5% to 50% of patients after a stand-alone anterior fixation procedure in the processing of a multilevel cervical corpectomy [7-11]. Clinically and biomechanically, unfortunate complication frequently encountered with stand-alone long-segment (≥3 levels) anterior plating including screw and/or plate migration or displacement as well as breakage caused by the large cantilever forces generated at the caudal screw-plate junction [6, 12-14].

In present study, we would evaluate the clinical efficacy and feasibility of eleven patients with extended multilevel (≥3 levels) cervical spinal tuberculosis treated by combined anterior debridement, decompression and long allograft bone and posterior instrumentation and posterior-lateral fusion.

Materials and methods

Basic information

From January 2006 and December 2012, 60 patients with diagnosis of CST underwent surgery at our spinal center, including 11 patients who suffered from EMCST: seven of them were males, and four were females, aged from 19 to 60 years (with an average age of 41.4 ± 13.1 years). Clinical details of surgical group are presented in "**Tables 1** and **2**". All patients were presented with general symptoms including weakness, night sweats, neck pain and stiffness, local tenderness and spasm of the posterior muscles of the neck, and lower fever with weight loss and variable degree of local deformity angle. Although retropharyngeal abscesses of different size were present in all patients, symptomatic dysphagia occurred in none. All patients were complicated with incomplete paraplegia. The diagnosis of tuberculosis of the EMCST guided by non-specific laboratory findings such as anemia, hypoproteinemia, and elevation of erythrocyte sedimentation rate (ESR) and by radiological findings including spinal x-ray films, computed tomography, and magnetic resonance imaging (**Figure 1**). The classification of the American Spinal Injury Association (ASIA) (**Table 2**) was used to assess the neurological compromise function, 2 cases in grade B, 5 cases in C, and 4 cases in D. The ESR of patients upon admission ranged from 30 to 83 mm/h, with an average of 51 ± 14 mm/h. Eight patients had spondylitic changes in 3 vertebrae and three patients had affection of 4 vertebrae. Written informed consent was obtained from all patients, and the study protocol was approved by the Xiangya Hospital Ethics Committee.

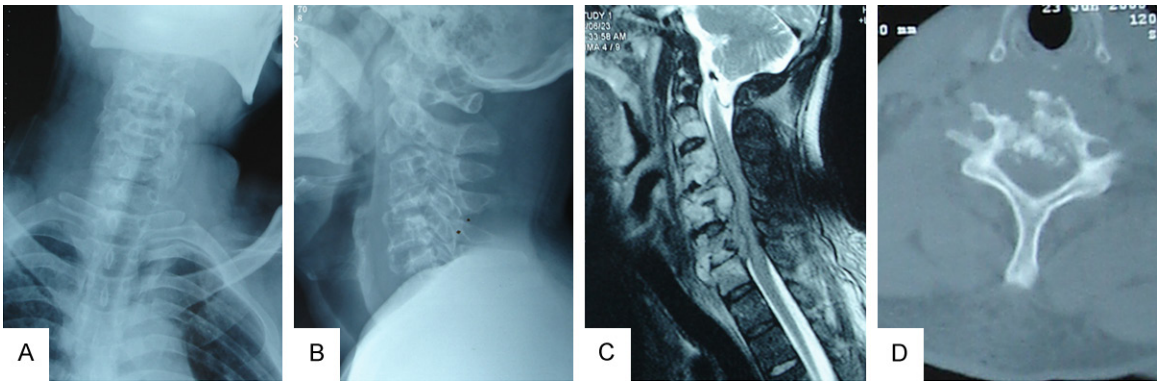

Figure 1. Pre-operative images of the no. 4 patient. (A, B) Antero-posterior and lateral X-ray of a 58 years-old male demonstrated vertebral body damage and sagittal instability. A pre-operative sagittal MRI (C) and coronal CT (D) showed significant vertebral body destruction with kyphosis associated with epidural and paravertebral abscess formation, and the cervical spinal cord was severe compressed surrounding the C3-C5.

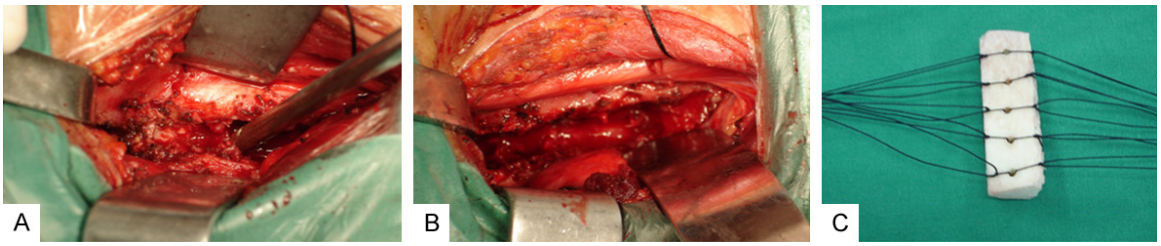

Figure 2. Anterior surgical process. A, B. Anterior debridement, corpectomy, decompression and allograft fusion without any anterior fixation. C. A peg-in-hole style allograft, we had preprocessed some surgical silk across the holes of allograft.

Preoperative procedure

Patients in this study had a clinical diagnosis of EMCST and were administrated anti-TB drugs with the HREZ (isoniazid, rifampin, ethambutol and pyrazinamide) chemotherapy regimen, consisting of isoniazid (300 mg/day), rifampicin (450 mg/day), ethambutol (750 mg/day) and pyrazinamide (750 mg/day) 2-4 weeks before surgery. Prudently, three patients with relatively severe kyphosis deformity were treated by halo traction with a weight of 1-3 kg preoperatively. When the ESR and temperature returned to normal or had significantly decreased, and anemia and hypoproteinemia were rectified completely, it was time to carry out the procedure.

Operative procedure

Surgery was performed under general endotracheal anesthesia. Anterior approach: The patients in supine position were performed using a standard Smith-Robinson approach for anterior exposure to the cervical spine through the right-sided transverse skin incision. After routine exposure, the necrotic tissue in the disc and the vertebral bodies were cleaned up by curettes and pituitary forceps. The paravertebral abscess was then identified and drained. All infected material was performed as much as possible for radical debridement (**Figure 2A**, **2B**). After excision of the necrotic disc and collapsed vertebrae, a suitable flush tube was inserted into the paravertebral space to flush with appropriate pressure until no pus was retrieved. After corpectomy and decompression, the cartilage endplates of the upper and lower vertebrae were excised with a cutting-burr and curette and the bony endplates were preserved. Gradual distraction was carried out using an intervertebral body spreader between adjacent normal vertebrae to correct the existing kyphosis. The operating table was gradually extended to assist the deformity correction. The pre-finished peg-in-hole style allograft was cut to an appropriate length and the 2 ends were shaped to fit the bony endplates of the upper and lower vertebrae. More specifically,

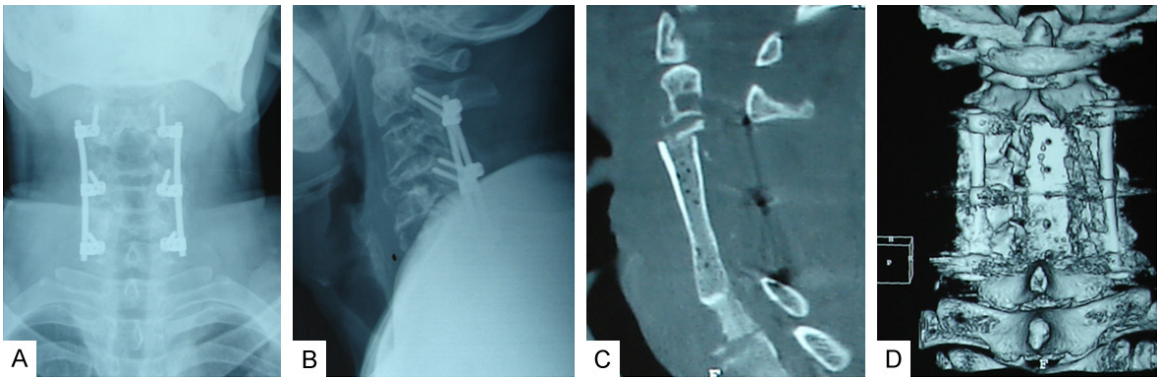

Figure 3. Postoperative and follow-up images of the no. 4 patient. (A, B) A postoperative Antero-posterior and lateral X-ray indicated that the stability got improved after laminectomy, lateral mass screws and posterolateral fusion on the first stage; Sagittal CT (C) and three-dimensional CT scans (D) showed screws and rods did not notice loose fixation and was in good shape, with perfect bone fusion without signs of tuberculosis recurrence, at 24-month follow-up.

the graft must be recessed with an adequate anterior and posterior cortical lip at the caudal and cephalad vertebral endplates. The peg-in-role graft is placed with slight distraction of the cervical spine followed by the release of distraction, allowing compression across the strut graft. The host bone cortical lips act as a buttress preventing graft displacement until the application of the rigid posterior instrumentation. In the pre-finished peg-in-hole style allograft, we had preprocessed some surgical silk across the holes of allograft (**Figure 2C**). Following allograft placement, the peg-in-hole allograft was fastened by surgical silk across with the musculus longus colli. Local application of tuberculostatic agents with 1.0 g streptomycin and 0.2 g isoniazid was locally administered; closed drainage and incision sutures were performed postoperatively. The material debrided was sent for culture and histopathologic examination. No anterior plate or other supplement device was used in any patients in our study. Posterior approach: The patients were placed in a prone position with halo traction with a weight of 3 kg during the operation. After routine exposure, a posterior fixation with bilateral lateral mass plates and screws was performed in all patients. The lateral mass screws were placed conventionally. The instrumented fusion should span over 3 or 4 levels, at least reaching the upper and lower fusion vertebrae. When there was a potential instability, the extension of the posterior instrumentation should increase. In addition to instrumented fixation, a posterolateral fusion was performed in all cases by using a high-speed burr to decorticate the bilateral facet joints. Allograft particles were then packed into the decorticated facet joints. Finally, removal of halo traction, closed drainage and incision sutures were performed postoperatively.

It is worth mentioning that when cervical spinal cord was compressed by massive anterior impingement of epidural abscess, destructed vertebrae and/or necrotic material, the posterior laminectomy after posterior fixation should be given priority before anterior direct decompression in consideration of security of spinal cord. In our study, 3 patients were underwent posterior laminectomy, instrumentation and posterolateral fusion on the first stage. One or two weeks later, the anterior approach was performed on the second stage.

Postoperative procedure

The drainage tube was pulled out when the volume of drainage was less 30 ml/24 hours. Patients continued with the oral HREZ chemotherapy postoperatively. Six months later, pyrazinamide was discontinued. Patients then received nine- to twelve-month regimens of the HRE chemotherapy (6HREZ/9-12HRE). All of the patients were examined clinically and plain X-ray and/or CT at 3, 6 and 12 months after surgery and then once a year. After surgery, patients were allowed to ambulate with a hard cervical collar for at least 6 months in average after remaining supine for 5-7 days postoperatively. The routine postoperative medical treatments were carried out, including the mannitol

for dehydration treatment, gangliosides for conventional nerve nutrition and prophylactic antibiotic administration. In addition, functional rehabilitation exercise was advised to all patients during the early stage of recovery.

Follow-up index and statistical analysis

For all cases, the average follow-up period was 33.9 ± 6.3 months (24-43 months). The following indexes were recorded pre-, postoperatively, and during the follow-up: (1) kyphosis angle; (2) visual analogue scale (VAS) scores of pain; (3) erythrocyte sedimentation rate (ESR). Using SPSS 19.0 software, kyphosis angle, VAS scores and ESR were statistically analyzed by paired *t* test pre-, postoperatively and during the follow-up and neurological function was statistically analyzed by Wilcoxon signed rank test pre-, and during the follow-up. Discrepancy of the normal distribution was analyzed by a rank-sum test with a significance level of 0.05 (**Tables 1**, **2**).

Results

Basic condition and complications

The operation time was 190-300 min, with mean operation time of 225 ± 39 min; the blood loss was 190-600 ml, with mean blood loss of 365 ± 128 ml; the hospitalization time was 9-24 days, with mean hospitalization time of 15.2 ± 4.5 days. Wounds were healed without chronic infection or sinus formation except one case presented with wound delayed healing attributed to fat liquefaction. Treated by negative pressure drainage and frequent dressing change, the patient got healed well. Also, two patients showed symptoms of mild dysphagia postoperatively, the symptoms disappeared after the patient was advised to have liquid diet. In addition, two patients suffered from cerebrospinal fluid leakage at the ventral of C4-5 level. Performed by operative suture, the reverse Trendelenburg position, administration of enough concentrated sodium salt solution, closed drainage, preventative anti-inflammatory and symptomatic supportive treatment for 2 weeks, the patients got a good outcome after removing drainage-tube and suture of wound. Unfortunately, there are two patients with posterior laminectomy presented with harvested axial pain postoperatively. Treated with physical therapy and acupuncture and moxibustion of traditional Chinese medicine, both of them got moderate improvement and turned to some pain killer if necessary. No complication related to instrumentation and bone grafted occurred (**Tables 1**, **2**).

Neurologic function and pain

Neurologic deficits in all patients were improved at final follow-up examination. The results were evaluated by ASIA classification: At the last follow-up, the neurological status of the two patients with grade B preoperative neurological deficits had returned to grade D. Of the 5 patients with preoperative grade C deficits, one had recovered to grade D and four had returned to normal. All four patients with preoperative grade D deficits recovered to grade E (**Table 2**). And three patients showed incomplete neurological function postoperatively attributed to delayed diagnosis because of economic issue. All patients had pain relief: The average preoperative VAS was 6.6 ± 1.1, which decreased to 0.5 ± 0.69 postoperatively (**Table 1**).

Kyphosis deformity

The kyphosis angle was 3-33°, with mean kyphosis angle of 17.4 ± 9.9°, preoperatively; it significantly decreased to -13-0° with mean kyphosis angle of -6.6 ± 4.0°, postoperatively ($P<0.05$). The kyphosis angle was -10-0° with mean kyphosis angle of 5.9 ± 3.4° at final follow-up, whose loss of correction was only 0.9 ± 0.9° (0-3°). It still significantly improved in comparison to the preoperative measurements ($P<0.05$) (**Table 1**).

Bone graft fusion

Anterior long-segment allograft fusion and posterolateral fusion was performed in all patients. Lateral and flexion-extension X-ray and CT-scans showed neither settling, expulsion nor migration of any inserted allograft or loosening of the lateral mass screws. The presence of continuous, bridging and bone trabeculae at the graft-host vertebral endplate junction was identified by CT-scans (**Figure 3**). Pseudoarthrosis was determined by the absence of osseous trabecular bridging between the graft and host vertebra endplates and the presence of a lucent line at the graft-vertebral junctions in the sagittal reconstruction CT scans [15]. In our study, all patients achieved bone

fusion within 6-9 months after surgery, which were confirmed by two different surgeons based on the above criteria of radiological fusion.

Erythrocyte sedimentation rate

The average pretreatment ESR was 51.7 ± 14.1 mm/h (30 to 83 mm/h), which got normal within 3 months in all patients. There was a statistical difference between preoperative ESR and 3 months follow-up ESR ($P<0.05$) (**Table 1**).

Discussion

Cervical spine tuberculosis with low incidence, accounted for only 4.2% to 12% of all spinal tuberculosis [3]. Various surgical approaches have been introduced in treatment of spinal tuberculosis. However, multilevel spinal tuberculosis is often described as rarities in the mainstream academic journals, not to mention extended (≥3 levels) cervical spine tuberculosis. Although potent anti-TB drugs have made uncomplicated tuberculosis a medical disease, when presented with neurologic compromise, significant vertebral body destruction with kyphosis associated with segmental instability, failure of medical treatment, and/or epidural/paravertebral abscess formation, surgical invention will be given priority.

However, Emery et al. [16] discovered that poor sagittal spinal correction has been documented after anterior debridement and fusion without fixation with 3° loss of segmental kyphosis correction. On the contrary, lots of researchers had noted that the correction of sagittal alignment improved by anterior strut grafting and adjunctive posterior instrumentation [5, 17-21]. A simultaneous or delayed posterior fixation and fusion has been increasingly recommended to support anterior allografts following debridement, corpectomy and decompression of three or more levels. Jones [13] even suggested that if posterior fusion occurs, the anterior strut graft should be protected by posterior load-sharing, which is supported by their patients' improvement in clinical symptoms and continued maintenance of alignment, despite incomplete radiographic healing of the anterior graft fracture. In addition, from the biomechanical perspective, many researchers analyzed that the anterior internal fixation should be applied in one or two segment cervical spine lesion, the posterior approach had better to be used for three or more segments combined with articular process fusion [7, 22, 23]. In our study, all patients were performed by anterior debridement, corpectomy, decompression and peg-in-hole allograft fusion combined with posterolateral lateral mass screws and fusion. Fortunately, all patients achieved bone fusion within 6-9 months without any complications related to instrumentation and bone grafted.

Can the improvement of internal fixation devices replace surgery skills? Interestingly, some clinical reports appeared that the anterior plate does not prevented graft-related complication in multilevel corpectomy reconstruction. In fact, on the contrary, it seems that the use of internal fixation has increased the complication rate in several studies [24-26]. Biomechanically, DiAngelo et al. and Olsewski et al. [27] analyzed that as the strut height increased, the level of load borne by the facets decreased, suggesting that excessive distraction of the vertebral segments changed the load-sharing between the posterior elements and the strut, increasing the chances for collapse and potential pseudarthrosis. Singh et al. [12] strongly oppose against the application of anterior instrumentation after a multilevel corpectomy using a peg-in-hole technique for stability and confirmed that it actually hinder the sagittal correction obtained by posterior fixation. We should also keep in mind that the addition of anterior plate placement is not without risk. Anterior screw misplacement may result in nerve root or spinal cord decompression and plate dislodgement may result in soft tissue irritation or esophageal erosion, not to mention added cost and operation time [6, 28, 29]. In our study, no anterior plate or other supplement device was used in any patients, but we got satisfied clinical outcomes without any allograft-related complications.

The anterior column is prone to infection with *M. Tuberculosis*. Moreover, the adjacent, or upper and lower reserved vertebras were soaked in the para-spinal vertebrae abscess and/or necrotic tissue for so long that they were in a sub-health status with osteoporosis or even cortical destruction. Therefore, selecting an appropriate manner for anterior column reconstruction is particularly important in the treatment of EMCST. Is titanium mesh cage (TMC) or

tricortical strut graft? Unfortunately, the literature rarely reported in the treatment of EMCST. Nevertheless, TMC does offer several advantages over strut grafts, including improved biomechanical stability, better endplate purchase, better correction of sagittal alignment (with precontoured lordotic cages), variable height and diameter options, and the ability to be packed with autograft or allograft bone to provide a larger surface area available for fusion. Obviously, complications related to TMC were subsidence and kyphotic deformity of the involved segment. Nakase et al. [30] followed up the results in TMC reconstruction after cervical corpectomy and they found that multilevel subtotal corpectomy was one of the risk factors in TMC technique attributed to that the TMC is very hard and it sinks into the vertebral body without the cortex (severe cage subsidence). Some researchers [31] even reported that the primary disadvantage of using TMC was the difficulty in assessing fusion status because of sagittal reconstructions of axial images of CT-scans unable to identify fully the TMC and vertebra interface with adequate clarity. We believed at least theoretically, that the use of TMC may contribute to the increased incidence of displacement in treatment of EMCST. The adjacent sub-health vertebras with osteoporosis or even cortical destruction will yield to the very hard TMC, unable to support its reconstruction. In our study, all of 11 patients were performed with peg-in-hole allograft and got good clinical outcomes without any graft-related complications. Nevertheless, the migration or dislodgement of these long allograft struts may be associated with invading vital anatomic structures, resulting in pseudoarthrosis; compression of the spinal cord, leading to paralysis or neural injury; compression of the esophagus and tracheal impingement, resulting in dysphagia and dyspnea [32-35]. We thought that the peg-in-hole allograft was feasible for EMCST. The first, it avoided the significant donor site complications and morbidity: postoperative donor-site pain, paresthesias in the distribution of the related peripheral nerves, vascular injury, adjacent bone fracture (pelvic crest), and wound infection; the second, it got achievement of uniformly strong cortical and cancellous bone in a wide range of shapes and size and a shortened operating time; the third, the combined use of anterior long allograft struts with posterior rigid instrumentation and posterolateral fusion escaped the graft-related complications in the short or long-term follow-up in our study; the fourth, the peg-in-hole allograft was fastened by surgical silk with the musculus longus colli during surgery, which benefited its temporary stability during early period of postoperation.

In our study, 3 patients were underwent posterior laminectomy, instrumentation and posterolateral fusion on the first stage and one or two weeks later, was performed from the anterior approach on the second stage. The cervical spinal cord of each one case was compressed by massive anterior impingement of epidural abscess, destructed vertebrae and/or necrotic material. Direct anterior decompression may result in iatrogenic spinal cord injury because when the spinal cord is overwhelmed on the threshold point by the anterior compression, any minor injury may breed incalculable disaster. Sodeyama et al. [36] found that posterior shifts of the spinal cord of more than 3 mm, which is closely implicated with anterior safe decompression even in neurological recovery after laminaplasty or laminectomy. Of the three patients, two with preoperative grade B had recovered to grade D and one with preoperative grade B had returned to normal. There was no case suffered from any further spinal cord injury. And the two patients showing incomplete neurological function postoperatively were attributed to delayed diagnosis. Unfortunately, two patients were harvested axial pain after laminectomy postoperatively, which may be a symptom from surgical damage or disuse atrophy of the nuchal muscles and ischemia of the shoulder muscles [37-39].

Conclusions

The present study showed that radical debridement of spinal tuberculosis and anterior insertion of allograft bone without any anterior fixation, secured with rigid lateral mass screw fixation with posterior-lateral fusion should have had a beneficial influence on the extended multilevel cervical spine tuberculosis, segment and global spinal reconstruction, balance and fusion. Our experience lends credit to the idea that if the anterior severe compression of spinal cord by the epidural abscess, destructed vertebrae and/or necrotic material, laminectomy after posterior fixation should be given priority before anterior direct decompression in

consideration of security of spinal cord. However, the complication, or axial pain after laminectomy should be taken into account. Only when individual surgery is integrated with useful supportive care and standard chemotherapy can we obtain better outcomes in the treatment of EMCST. The most significant limitations of this study are its retrospective nature and small sample size without comparison with simple chemotherapy and/or anterior-only approach. Therefore, prospective and larger randomly compared studies with longer follow-up times are needed.

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Disclosure of conflict of interest

None.

Address correspondence to: Dr. Xiyang Wang and Yong Cao, Department of Spine Surgery, The Xiangya Hospital of Central South University, High-performance Imitative Bone Bio-engineered Materials of Engineering Laboratory of Hunan Province, 87 Xiangya Road, Changsha 410008, People's Republic of China. E-mail: 2621132371@qq.com (XYW); 562883970@qq.com (YC); Dr. Xiongjie Shen, Department of Spine Surgery, Hunan Provincial People's Hospital, Changsha 410005, People's Republic of China. E-mail: 15211032998@163.com

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