

Original Article

One-stage combined posterior and anterior approaches for active tuberculosis of the subaxial cervical spine complicated with kyphosis in children: a preliminary study

Ang Deng, Hong-Qi Zhang, Ming-Xing Tang, Shao-Hua Liu, Qi-Le Gao, Yu-Xiang Wang, Chao-Feng Guo, Xi-Yang Wang

Department of Spine Surgery, Xiangya Hospital of Central South University, Xiangya Road 87, Changsha 410008, China

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Abstract: Background: Among children, the tuberculous lesions usually involved with more segments which cause severe kyphotic deformity and neurologic injury. During its growing period, growth imbalance of anterior and posterior columns in children will aggravate the kyphosis after destruction of anterior column. However, there are rare clinical trials of the approaches for active subaxial cervical tuberculosis complicated with kyphosis in children during growth period. The indication, timing, methods, and long-term efficacy of operation were controversial. The purpose of this study was to evaluate the clinical efficacy of one-stage combined posterior and anterior approaches for the case series. Methods: From 2008 to 2013, 13 children (mean age, 8.7 years) suffered from active subaxial cervical tuberculosis complicated with kyphosis. The mean preoperative Cobb angle of cervical kyphosis was 24.2°; Frankel's grade B was in one case, grade C in three cases, grade D in six cases and grade E in three cases preoperatively. All cases underwent one-stage combined posterior and anterior approaches. Results: All cases were followed up for 30 months on average. Wounds were healed without chronic infection or sinus formation. The mean Cobb angle of cervical kyphosis was -5° (range, -1° to -9°) at postoperative stage, and -4.8° (range, -1° to -8°) at final follow up. All cases showed significant improvement after surgery. Of 10 cases complicated with neural dysfunction preoperatively, 8 cases showed complete neurological recovery, and 2 cases recovered to Frankel's grade D at final follow up. During follow-up period, all cases achieved bone fusion, and no complications related to instrumentation and recurrence of tuberculosis occurred. Conclusions: One-stage combined posterior and anterior approaches for active subaxial cervical tuberculosis complicated with kyphosis in children could yield satisfactory clinical efficacy.

Keywords: Children, subaxial cervical tuberculosis, kyphosis, combined posterior and anterior, one-stage

Introduction

There is an increasing incidence of tuberculosis in developing countries. Tuberculosis of cervical spine is rare, and it accounts for about 4.2%-12% of all spinal tuberculosis [1]. The anatomic structure for the cervical spine is complex. Tuberculosis of cervical spine is easy to cause destruction and collapse of vertebral bodies, which could lead to cervical kyphosis and compression of cervical cord with high disability rate. During the period of growth and development, the spinal anatomical characteristics for children are different from adults. Among children, the tuberculous lesions usual-

ly involved with more segments which cause severe kyphotic deformity and neurologic injury. Furthermore, during its growing period, growth imbalance of anterior and posterior columns in children will aggravate the kyphosis after destruction of anterior column [2]. However, there are rare clinical trials of the approaches for active subaxial cervical tuberculosis complicated with kyphosis in children during growth period. The indication, timing, methods, and long-term efficacy of operation were controversial. Therefore, we retrospectively evaluate the clinical efficacy of one-stage combined posterior and anterior approaches for the case series.

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Materials and methods

General data

From 2008 to 2013, 13 children (7 boys and 6 girls; age, 6-11 years; average age, 8.7 years), who suffered from the active tuberculosis of the subaxial cervical spine complicated with kyphosis (course of disease, 1-11 months; average course of disease, 4.6 months) were treated by one-stage combined posterior and anterior approaches. These children suffered with different symptoms, such as neck pain, low-grade fever, weakness, malaise, night sweat, stiffness and weight loss. The erythrocyte sedimentation rate (ESR) of these children upon admission ranged from 29 to 107 mm/h, with an average rate of 51 mm/h. 10 cases were complicated with neural dysfunction. The Frankel scoring system was used to assess the neurological function. Frankel's grade B was in one case, grade C in three cases, grade D in six cases and grade E in three cases. The preoperative X-ray films, computed tomography (CT), and magnetic resonance imaging (MRI) examinations revealed that all 13 cases presented with severe destruction or collapse of vertebral bodies, narrowing of intervertebral-disc space, sequestration, epidural and paravertebral abscess, compression of cervical cord, cervical kyphosis or progressive kyphosis. Tuberculous lesions involved with two vertebral bodies in 11 cases (two cases at C3-4, three at C4-5, four at C5-6, two at C6-7), and three vertebral bodies in 2 cases (one case at C3-5, one at C4-6). The mean preoperative Cobb angle of cervical kyphosis was 24.2° (range, 13° to 37°).

The indications for the combined approaches were based on (1) severe or progressive cervical kyphosis; (2) severe destruction or collapse of vertebral bodies and intervertebral discs leading to cervical instability; and no significant efficacy by conservative therapy; (3) compression of cervical cord causing neural dysfunction; (4) massive sequestrum formation.

Exclusion criteria were based on (1) early-stage tuberculosis with limited lesions, no significant instability, and no compression of cervical cord; (2) no severe or progressive kyphosis; (3) skeletal maturation; (4) paravertebral abscess alone; (5) tuberculosis of spinous process and lamina alone; (6) active pulmonary tuberculosis, and incomplete clinical or radiologic docu-

mentation at follow up. The Ethics Committee in Xiangya Hospital of Central South University approved the study.

Preoperative procedure

Chest X-ray films and sputum smear examination upon admission were used to exclude active pulmonary tuberculosis in all 13 cases. Usually 2-4 weeks prior to the operation, the cases were administered antituberculosis drug with isoniazid (5-10 mg/kg/day with no more than 300 mg/day), rifampicin (5-10 mg/kg/day with no more than 300 mg/day), and ethambutol (15 mg/kg/day with no more than 500 mg/day). Surgery should be carried out when ESR and temperature significantly decreased, and when anemia and hypoproteinemia were rectified. However, when complicated with severe compression of cervical cord and neural dysfunction, surgery should be carried out as early as possible, so as not to delay the best time for treatment, without waiting for 2 weeks of regular anti-tuberculosis treatment or the significant decrease of ESR. Because the kyphosis angle was more than 30°, 3 cases underwent preoperative halo traction, which played important roles in partial correction of kyphosis and observation of neurological function, so as to provide a basis for intraoperative orthopaedic procedures. After preoperative halo traction the mean Cobb angle of cervical kyphosis improved to 14.7° (range, 11° to 17°).

Operative procedure

In the first procedure, posterior instrumentation and fusion were performed under general endotracheal anesthesia in the prone position. During the operation, halo traction was maintained, and somatosensory evoked potential (SEP) and motor evoked potential (MEP) were thoroughly utilized to monitor the spinal cord function, therefore to prevent neural complications. Through a midline incision, the posterior spinal elements including lamina, facet joint, and lateral mass were exposed (extraperiosteal dissection), extending one vertebrae above and below the involved segments. Then posterior instrumentation (pedicle screws or lateral mass screws) was placed. Pre-bent rods of appropriate lordosis were rotated to achieve correction of kyphosis. The cortexes of lamina and articular surfaces of facet joints were removed,

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Table 1. Preoperative, postoperative and final follow-up Frankel's grade

| Preoperative Frankel's grade | Case | Postoperative Frankel's grade | | | | | Final follow-up Frankel's grade | | | | |
|------------------------------|------|-------------------------------|---|---|---|---|---------------------------------|---|---|---|---|
| | | A | B | C | D | E | A | B | C | D | E |
| A | 0 | - | - | - | - | - | - | - | - | - | - |
| B | 1 | - | - | 1 | - | - | - | - | - | 1 | - |
| C | 3 | - | - | 1 | 2 | - | - | - | - | 1 | 2 |
| D | 6 | - | - | - | 2 | 4 | - | - | - | - | 6 |
| E | 3 | - | - | - | - | 3 | - | - | - | - | 3 |

where autogenous or allogeneous bone grafts were implanted for fusion.

In the second procedure, the anterior debridement, fusion (and instrumentation if possible) were performed in the supine position with neck slightly extension. According to the location of abscess and vertebral destruction, anterior incision from left or right side was applied. After the routine exposure, the paravertebral abscess was identified. If necessary, exploratory puncture using empty needle or X-ray positioning was utilized. The tuberculous lesions, including paravertebral abscess, collapsed intervertebral disc, and other necrotic tissues were completely removed near the midline until healthy bone was bleeding and spinal cord was decompressed. The gradual distraction was then carried out to correct the prior kyphosis by using an intervertebral spreader between adjacent normal vertebrae. Anterior column defect was reconstructed by titanium mesh filled with autogenous bone, or autogenous (or allogeneous) bone block graft. When the cervical vertebral bodies were matched in some children, titanium plate of appropriate width was placed to achieve anterior cervical fixation. Finally, treatment with 1.0 g streptomycin and 0.2 g isoniazid was locally administered.

Postoperative procedure

The drainage tube was pulled out when volume was < 50 ml/24 h. After surgery, all cases received aforementioned 3-drug chemotherapy for 12-18 months that included isoniazid, rifampicin and ethambutol. The liver and renal functions were reviewed on a regular basis. The children were allowed to turn in bed on the first postoperative day, sit on the second, and encouraged to stand or walk with braces on the third postoperative day. Active rehabilitation

was started immediately for children who had neural dysfunction. The braces were worn for at least 3 months postoperatively. All cases were examined clinically and radiologically at 3, 6, and 12 months postoperatively, and then once per 6 months. The X-ray films, CT, MRI, and ESR were recorded for assessment.

Evaluation of index and statistical analysis

The following indexes were obtained at the preoperative, postoperative, and final follow-up stages: (1) Cobb angle of cervical kyphosis (angle between the superior endplate of one vertebrae above the involved segments and the inferior endplate of one vertebrae below the involved segments); (2) Neurological function (Frankel scoring system was used to assess the neurological function). The data was presented as means \pm SD and analyzed using SPSS 17.0. Paired t tests were used to compare parameters at the preoperative, postoperative, and final follow-up stages. $P < 0.05$ indicates statistically significant difference.

Results

All surgeries were successfully completed in one stage. The mean duration of surgery was 140 min (range, 130 to 180 min) and the mean blood loss was 165 ml (range, 110 to 240 ml). Wounds were healed without chronic infection or sinus formation. Two cases, presented with pharyngeal pain after the surgery, were successfully resolved by symptomatic treatment without sequelae. All cases were followed for 30 months on average (range, 18 to 48 months) without dysphagia, bucking, esophageal fistula, and cerebrospinal fluid leakage. The mean value of ESR was 8.2 mm/h (range, 5 to 12 mm/h) at the final follow up. All cases achieved bone fusion within 3-6 months after surgery. No complications related to instrumentation and recurrence of tuberculosis occurred. Of 10 cases complicated with neural dysfunction preoperatively, 8 cases showed complete neurological recovery, and 2 cases recovered to Frankel's grade D at final follow up (**Table 1**). The mean postoperative Cobb angle of cervical kyphosis was -5° (range, -1° to -9°), which showed significant improvement ($P < 0.05$). At final follow up, the mean Cobb angle of cervical kyphosis was -4.8° (range, -1° to -8°). There was no statistically significant difference in Cobb angle of cervical kyphosis between post-

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Table 2. Preoperative, postoperative and final follow-up Cobb angle of cervical kyphosis

| | Preoperative | Postoperative | Final follow-up |
|-------------------------------------|--------------|---------------|-----------------|
| Cobb angle of cervical kyphosis (°) | 24.2±7.9 | -5±2.3 | -4.8±2.0 |

Values are mean ± SD. The postoperative and preoperative data as well as the postoperative and final follow-up data were analyzed using paired t tests. $P < 0.05$ implies statistically significant difference.

operative and final follow-up stages ($P > 0.05$) (Table 2; Figure 1).

Discussion

In children, early-stage spinal tuberculosis should be treated by conservative therapy primarily, including regular chemotherapy and spinal immobilization. However, because their symptoms were not typical and chief complaints were unclear, it led to late discovery and difficult control of spinal tuberculosis by conservative therapy. Many children already presented with obvious spinal activity limitation, kyphotic deformity and neural dysfunction during their first visit to the doctor. During the period of children's growth and development, spinal tuberculosis destroys anterior column leading to disability of anterior growth, and as posterior column continues to grow excessively, it causes the growth imbalance of anterior and posterior columns. Even if spinal tuberculosis is quiescent, spinal growth imbalance would still lead to progressive kyphosis [3-5]. Furthermore, the range of cervical motion is larger, and cervical vertebra is adjacent to important nerves and blood vessels; children are usually overly active and are less willing to cooperate with doctors for the long-term spinal immobilization and regular chemotherapy. Therefore, it is difficult to maintain efficacy, and progression of disease could cause paralysis or even life-threatening symptoms. By reviewing of the literature [6-9], the situations below were considered to perform the combined posterior and anterior approaches, including debridement, decompression, instrumentation and fusion for active subaxial cervical tuberculosis in children during growth period: (1) severe or progressive cervical kyphosis; (2) severe destruction or collapse of vertebral bodies and intervertebral discs leading to cervical instability, and no significant efficacy by conservative therapy; (3) compression of cervical cord causing neural dysfunction; (4) massive sequestrum formation. However, children suffering from early-stage tuber-

culosis (including limited lesions, paravertebral abscess alone, tuberculosis of spinous process and lamina alone, no severe or progressive kyphosis, no significant instability, and no compression of

cervical cord) are not appropriate for the combined approaches.

Regarding active subaxial cervical tuberculosis in children during growth period, the aim of surgery is to remove tuberculous lesions, shorten the course of disease, relieve cervical cord compression, reconstruct cervical stability, correct the prior kyphosis, and prevent long-term postoperative recurrence and aggravation of deformity [10]. Accordingly it's very important to choose appropriate timing of surgery. Ramani [11] believed that the best clinical efficacy required decompressing spinal cord early and positively, and it was necessary for the good recovery of neurological function without fear of instrumentation failure. In this study, 10 cases complicated with severe compression of cervical cord and neural dysfunction underwent early and positive definitive operation. Their wounds were healed without chronic infection or sinus formation, and neurological function showed obvious improvement at final follow up. Therefore, the situations below were considered to be the timing of surgery for active subaxial cervical tuberculosis in children during growth period: (1) The cases were administered antituberculosis drug for 2-4 weeks prior to the operation; when ESR and temperature were significantly decreased, and anemia and hypoproteinemia rectified, surgery should be carried out. (2) Complicated with severe compression of cervical cord and neural dysfunction, surgery should be carried out as early as possible, without waiting for 2 weeks of regular anti-tuberculosis treatment or the significant decrease of ESR, so as to prevent irreversible nerve injury.

The anterior debridement, fusion and instrumentation were widely recognized as the best operative methods currently for active subaxial cervical tuberculosis complicated with kyphosis in adult [12, 13]. However, compared with adult, the children presented with some particularities in spinal anatomy and growth. Even if the reconstruction of anterior column restored

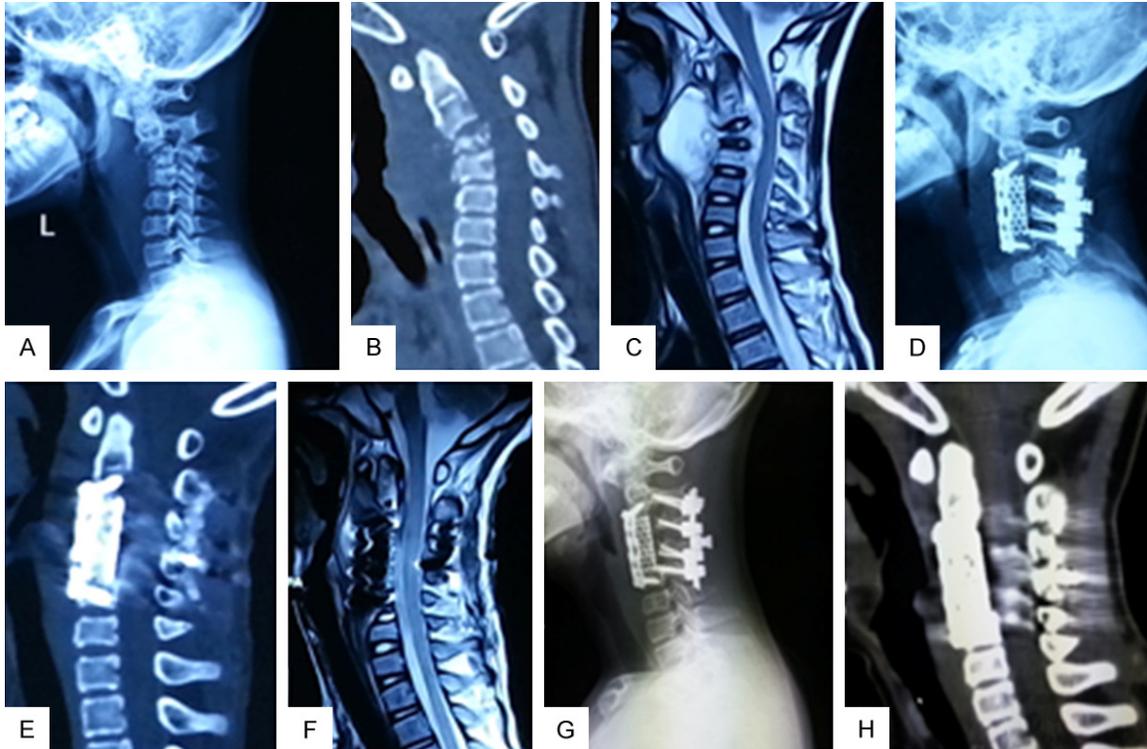


Figure 1. A 10-year-old male child, suffering from tuberculosis of C3-4 complicated with kyphosis. A-C. Preoperative X-ray films, CT and MRI revealed destruction and collapse of vertebral bodies, narrowing of intervertebral-disc space, kyphotic angle of 29° , epidural and paravertebral abscess, compression of cervical cord, and Frankel's grade D. D-F. Postoperative X-ray films, CT and MRI revealed thorough debridement, decompression and recovery of spinal canal volume, kyphotic angle of -7° , and Frankel's grade E. G, H. At 36 months after surgery, X-ray films and CT revealed bone graft fusion, kyphotic angle of -6° , Frankel's grade E, and no complications related to instrumentation and recurrence of tuberculosis.

normal physiological spinal curvature after destruction of anterior column, growth imbalance of anterior and posterior columns in children during growth period would still cause secondary kyphosis; because of very small cervical vertebral bodies, titanium plates for anterior cervical fixation in most children were rarely appropriate. Some authors [6] advocated one-stage anterior debridement and fusion to treat cervical tuberculosis in children, but the other results were inconsistent. Moon [4] reported that the preoperative cervical kyphosis of 14° progressed to 18° at final follow up using the anterior approach for the case series.

In addition, Schultz [14] analyzed and quantified the changes of kyphotic angle and the growth ratio of the fusion bloc during the growth period, with regard to different fusion techniques (anterior fusion, posterior fusion, combined anterior and posterior fusion, and anterior debridement without fusion) for thoracic and lumbar tuberculosis in children. All children

treated by anterior spinal fusion (ASF) showed an increase of the kyphotic angle by an average of 12° throughout 10 years, whereas the children treated by a combined fusion showed a decrease in the kyphotic angle of -7° . They believed that ASF was the worst operative treatment regarding the spontaneous correction of the solidly fused kyphotic bone bloc, especially involving several segments, because ASF for spinal tuberculosis in children destroyed the anterior growth and limited the capacity for spinal remodeling, and posterior overgrowth could aggravate kyphosis during the growth period. However, regarding the growth ratio of the fusion bloc, the combined fusion guaranteed better correction of kyphosis and an equal growth of the anterior and posterior height, preventing long-term postoperative recurrence and aggravation of deformity [14-16].

So far we have reported that combined posterior and anterior approaches could be the long-term safe and effective surgery for lumbar and

lumbosacral tuberculosis complicated with kyphosis in children [17, 18]. Therefore, we believed that the combined approaches should also be used for the treatment of severe active subaxial cervical tuberculosis complicated with kyphosis in children during growth period. In this study, the mean Cobb angle of cervical kyphosis was 24.2° (range, 13° to 37°) at pre-operative stage, -5° (range, -1° to -9°) at post-operative stage, and -4.8° (range, -1° to -8°) at final follow up. After surgery all cases showed significant improvement ($P < 0.05$); and there was no statistically significant difference between postoperative and final follow-up stages ($P > 0.05$).

We deduced the following characteristics from our findings: (1) Complicated with severe compression of cervical cord and neural dysfunction, surgery should be carried out as early as possible, without waiting for 2 weeks of regular anti-tuberculosis treatment or the significant decrease of ESR to prevent irreversible nerve injury. (2) When Cobb angle of cervical kyphosis was more than 30°, preoperative halo traction should be performed, as it plays an important role in the partial correction of kyphosis and observation of neurological function in providing a basis for intraoperative orthopaedic procedures. (3) For children during their growth period, a single anterior approach destroys the anterior growth, and posterior overgrowth can aggravate kyphosis, even if spinal tuberculosis is quiescent; whereas the combined approaches guarantee better correction of kyphosis and prevent growth imbalance of anterior and posterior columns. (4) Posterior subperiosteal dissection should be performed in proposed fused segments, whereas extraperiosteal dissection should be performed in non-fusion segments; and the epiphysis should be preserved as far as possible during anterior debridement. (5) In this study, destroyed anterior and middle columns severely affected cervical stability; and all cases were complicated with epidural abscess, compression of cervical cord and kyphosis; therefore, anterior column defect was reconstructed by titanium mesh filled with autogenous bone (if autogenous bone was insufficient, autogenous bone could be filled in the both ends of titanium mesh, with allogeneous bone mixed in the middle), or bone block graft after anterior debridement and decompression. (6) After posterior instrumentation

and deformity correction, the anterior column was elongated and the height of collapsed vertebrae restored; and the combined approaches could guarantee cervical stability, induce earlier anterior fusion, and prevent displacement, subsidence and prolapse of bone block graft or titanium mesh during follow up. (7) In this study, the combined approaches were successfully completed in one stage according to plan, because the procedures were carried out smoothly in short time with less blood loss, and the volume of cervical spinal canal might be changed after posterior correction when complicated with compression of cervical cord.

In general, one-stage combined posterior and anterior approaches for severe active subaxial cervical tuberculosis complicated with kyphosis in children during growth period could yield satisfactory correction, recovery of neurological function, and growth balance of anterior and posterior columns. Regular antituberculosis therapy is the basis of all treatment postoperatively, and it prevents the recurrence of tuberculosis. However, all of the children in our study had preserved significant growth, and there were preliminary results in a small group with relatively short follow up for some cases. Therefore, further study with a large sample and longer follow up will be necessary.

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Disclosure of conflict of interest

None.

Address correspondence to: Dr. Hong-Qi Zhang, Department of Spine Surgery, Xiangya Hospital of Central South University, Xiangya Road 87, Changsha 410008, China. Tel: +86 0731-89753001; E-mail: zhq9996@163.com

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