Observational Study

Medicine®

OPEN

Posterolateral decompression, bone graft fusion, posterior instrumentation, and local continuous chemotherapy in the surgical treatment of thoracic spinal tuberculosis

Xin Hua Yin, MD, Liang Yan, MD, Ming Yang, MD, Ke Zhang, MD, Bao Rong He, MD, Zhong Kai Liu, MD*, Ding Jun Hao, MD

Abstract

To investigate the clinical efficacy of surgical treatment for thoracic spinal tuberculosis with kyphosis deformity via posterolateral debridement, fusion, posterior instrumentation and local continuous chemotherapy. A total of 25 patients with thoracic tuberculosis received surgery by posterolateral decompression, fusion, posterior instrumentation, and postural drainage with local continuous chemotherapy between June 2009 and October 2011. The clinical outcomes was evaluated using statistical analysis about deformity correction, bone fusion, neurologic status, and the visual analog score (VAS) and erythrocyte sedimentation rate (ESR). All of 25 patients were followed up for 39.0 ± 10.7 months (range, 24–60 months) postoperatively. There was no recurrence of tuberculosis, breakage and looseness of internal fixation. Bony fusion was achieved in all cases with 6.7 ± 1.9 months. The values of ESR recovered to normal within 6 months postoperatively. All patients with neurological deficit had significant improvement at the final follow-up. The average preoperative Cobb angles were significantly decreased to 12.2 ± 2.9° (range, 8–17°) postoperatively, and at final follow-up were 12.9 ± 2.7°. Our results showed that single-stage posterolateral debridement fusion, posterior instrumentation and local continuous chemotherapy can be expected to yield satisfactory clinical and radiographic outcomes in patients with thoracic spinal tuberculosis.

Abbreviations: ASIA = American Spinal Injury Association, CT = computed tomography, ESR = erythrocyte sedimentation rate, MRI= magnetic resonance imaging, TB = tuberculosis, VAS = visual analog scale.

Keywords: local continuous chemotherapy, posterolateral approach, surgical management, thoracic spinal tuberculosis

1. Introduction

Spinal tuberculosis (STB) is one of the most prevalent infectious diseases in China.[1] Spine tuberculosis affects the thoracic spine most commonly, followed by the lumbar and, very rarely, the cervical spine. Since 1960, the management of thoracic tuberculosis has alternated between surgical and conservative treatment. Due to the anatomic characteristics and positioning of the thoracic region, *Mycobacterium tuberculosis* (*M. tuberculosis)* is more likely to affect adjacent vertebral bodies and diffuse subligamentously. It is therefore difficult to perform radical for thoracic tuberculosis and so recurrence of spinal tuberculosis recurrence postoperatively is not uncommon. Although many surgical approaches have been reported for patients with thoracic tuberculosis,[2–4] the optimal management strategy remains controversial (short operative time, minimally invasive, rapid recovery, less complications and lower recurrent rate).

The most important question when using drugs to treat spinal TB is how to maximize the amount of drug reaching lesions. Zhang et al [5] found that the local application of large doses of chemotherapy drugs, such as isoniazid, could kill pathogenic bacteria, thus preventing the development of further pathology. However, in our experience, we seldom find any utility in local continuous chemotherapy for the treatment of spinal tuberculosis. This aim of this research was to investigate the clinical efficacy of surgical treatment for thoracic spinal tuberculosis using posterolateral decompression, fusion, instrumentation, and local continuous chemotherapy.

2. Methods

This study was approved by the ethics board committee of Xian Honghui Hospital, and informed consent was obtained in writing from all participants. A total of 25 patients with thoracic spinal tuberculosis who had surgical treatment and local continuous chemotherapy in our department between June 2009 and October 2011 were enrolled in this analysis. The inclusion

Editor: Mehmet Bakir.

This work was financially supported by Postdoctoral Science Foundation in Shanxi Province, China (2016BSHYDZZ41) and Social Development Science Foundation of the Department of Science and Technology of ShanXi province (2018SF196).

The authors have no conflicts of interest to disclose.

Department of Spine Surgery, Hong Hui Hospital, Xi'an Jiaotong University College of Medicine, Xi'an, Shaanxi, China.

** Correspondence: Zhong Kai Liu, Department of Spine Surgery, Hong Hui Hospital, Xi'an Jiaotong University College of Medicine, Xi'an, Shanxi 710054, PR China (e-mail: spine2020@163.com).*

Medicine (2018) 97:51(e13822)

Received: 12 July 2018 / Received in final form: 28 November 2018 / Accepted: 1 December 2018

http://dx.doi.org/10.1097/MD.0000000000013822

criteria were: lesions confined thoracic vertebrae and a minimum follow up period of 24 months. The exclusion criteria included: active pulmonary tuberculosis, non-contiguous multifocal STB, patients lost to follow-up or death, previous thoracic spinal tuberculosis surgery, thoracic lesion induced by disease, such as metastasis or multiple myeloma.

All patients presented with constitutional back ache, fatigue, weight loss, with a mean symptom duration of 5.4 ± 2.0 (range 2–8) months. The American Spinal Injury Association (ASIA) classification system was used to assess neurological deficits (1 patient was ASIA grade A, 5 were grade B, 12 were grade C and 7 were grade D). A visual analog scale (VAS) was used to assess lower back pain. The Cobb angle was calculated by the following method: lesions involving the cephalic vertebral endplate above normal and end the vertebral endplate below the normal do 2 parallel lines. Diagnosis of TB was established by nonspecific laboratory findings such as elevation of erythrocyte sedimentation rate (ESR) and by spinal X-rays as well as magnetic resonance imaging (MRI).

We preformed subsequent histopathological examination of the biopsy sample for patients with suspected tuberculosis infection. Tuberculosis culture and sensitivity analysis performed for all patients to confirm diagnosis and characterize drug resistance. Patients were prescribed a four anti-TB drug regimen of isoniazid (5 mg/kg), rifampicin (10 mg/kg), ethambutol (15 mg/kg) and pyrazinamide (25 mg/kg), postoperatively. We provided nutritional support to patients with hypoproteinemia in order to restore premorbid nutritional status.[10] The patients with preoperative and follow-up kyphotic angle and VAS scores of back pain were compared.

2.1. Surgical procedure

Under general endotracheal anesthesia, patients were placed in the lateral decubitus position for posterolateral debridement and bone grafting. Then they were moved to the prone position for the posterior internal fixation and deformity correction.[6] Finally, a multi-functional drainage was placed at the lesion for daily irrigation with isoniazid. The resected tissue specimens were sent for culture and pathological diagnosis (Fig. 1).

2.2. Postoperative care

Local chemotherapy was isoniazid (10 ml saline, isoniazid 0.2 g) twice per day. All patients received anti-tuberculosis therapy with HREZ for the next 3 months, and then with HRE treatment for another 9 to 15 months. All patients were prescribed glucurolactone and vitamin B6 to prevent side effects from the TB medicines. Nutritional support was regularly provided for all patients. Early ambulation was permitted 6.1 ± 1.6 days after surgery. All patients were examined clinically and radiologically (X-ray or CT) at 3, 6, 9, and 12 months and then once a year postoperatively. The blood test, ESR and hepatic function results were recorded. Bone grafting fusion was assessed using the radiologic criteria of Lee et al[7] Pre-operative, post-operative and final follow-up changes in kyphosis Cobb angle, neurological status, VAS were also recorded. All data were analyzed with SPSS 20.0 software. The paired t test was used to analyzed dates pre- and post-operatively, and at final follow-up. Differences were considered significant at $p<0.05$.

Table 1

Clinical data on the patients.

Gender (M/ F)	11/14
Age (years)	38.5 ± 15.3
Operation time (mins)	349.6 ± 64.2
Blood loss (ml)	774.0 ± 204.7
Duration of follow-up (mons)	39.0 ± 10.7
Fusion time (mons)	6.7 ± 1.9
Duration of symptoms (mons)	5.4 ± 2.0

M = male; F = female; mins = minutes; mons = months.

Table 2

Clinical outcomes of surgical treatments for multisegmental thoracic spinal tuberculosis.

Cobb angle (°)	
Pre★	30.7 ± 7.4
Post☆[1]	12.2 ± 2.9
FFU☆[2]	12.9 ± 2.7
VAS	
Pre◆	6.1 ± 1.6
FFU◇	0.7 ± 0.6
ESR (mm/h)	
Pre▲	60.2 ± 12.8
FFUΔ	9.6 ± 2.8

Pre = pre-operative, Post = Postoperative, FFU = final follow-up, VAS = Visual analogue scale scores, ESR = erythrocyte sedimentation rate.
The date analyzed by paired *t* test.
Compare between pre and post cobb angle: ★, ☆1 $p < 0.01$.
Compare between post and FFU cobb angle: ☆1, ☆2 $p > 0.05$.
Compare between pre and FFU VAS score: ◆, ◇ $p < 0.01$.
Compare between pre and FFU ESR score: ▲, Δ $p < 0.01$.

3. Results

The duration of follow-up was 39.0 ± 10.7 months (range 24–60). Culturing of *M. tuberculosis* had low positivity rate at only 15%. Wounds were healed without sinus formation and no recurrences occurred. The mean duration of surgery was 349.6 ± 64.2 min. The amount of blood loss during the surgery was 774.0 ± 204.7 ml and the average pretreatment ESR was 60.2 ± 12.8 mm/h (41–82 mm/h), which returned to normal (9.6 ± 2.8 mm/h) within 6 months postoperatively in all patients. Preoperatively the mean kyphotic angle was 30.7 ± 7.4°corrected to 12.2 ± 2.9° postoperatively, and became 12.9 ± 2.7° at the final follow up. Compared with the preoperative kyphotic angle, there were significant differences in the kyphotic angle postoperatively ($p<0.01$), but no significant difference between postoperatively and last follow up ($p>0.05$). At final follow-up, the 25 patients with preoperative neurologic deficit recovered to normal, except for 2 patients who recovered to Grade D (Tables 1–3). All patients achieved bone fusion within 6.7 ± 1.9 months after surgery and the average preoperative VAS was 6.1 ± 1.6, which decreased to 0.7 ± 0.6 at last follow-up ($p<0.01$).

Table 3

The neurological function evaluated by the ASIA impairment scale.

ASIA scale	Pre	FFU
A	1	0
B	5	0
C	12	0
D	7	2
E	0	23

ASIA = American Spinal Injury Association, Pre = pre-operative, FFU = final follow-up.

4. Discussion

In recent years the recommended treatment strategies for spinal tuberculosis has vacillated between nonoperative therapy and surgery. There is no doubt that most spinal tuberculosis patients can be cured with conservative therapy. However, it is imperative to perform surgical intervention in the following cases:

(1) poor outcomes were achieved with conservative treatment,
(2) neurological impairment,
(3) pain due to instability,
(4) progression of kyphosis.

Various surgical management strategies for thoracic spinal tuberculosis have been reported, for example, anterior, posterior, and combined approaches. The thoracic lateral width between 18 mm and 11.5 mm, whereas the anteroposterior depth of the thoracic canal is only 13.5 mm.[8] This poses a great challenge to the surgery intervention for thoracic spinal tuberculosis. Thoracic tuberculosis primarily involves the anterior column, thus, the anterior approach was considered to be the gold standard in view of radical debridement. In 1960, Hodgson et al[9] first reported on their Hong Kong operation and its satisfactory outcomes for spinal TB. Nevertheless, the resulting deformity corrections are often dissatisfying or cause progression of kyphosis.[10] Most importantly, if multi-segmental vertebrae are involved, it is difficult to carry out long anterior instrumentation, and it is difficult to place screws in the upper thoracic spine because of its special anatomical structure.

It is believed that posterior transpedicular instrumentation is better suited than anterior fixation for this surgery as it can provide rigid segmental fixation and effectively correct kyphosis deformity.[11] Accordingly, anterior debridement, interbody fusion and posterior instrumentation have also been performed by clinicians,[12–15] and this approach has been shown to be effective for correcting kyphotic deformity and restoring spinal stability. Even so, the approach may have complications related to exposure inherent in the anterior approach. This surgery may not be tolerated by elderly or upper thoracic spinal tuberculosis because of the two incisions, a larger amount of bleeding, a longer operation time, larger wounds, a higher complication rate and prolonged bed rest.[16]

Studies on posterior internal fixation, debridement, and interbody fusion for spinal TB treatment have also been reported.[17,18] These studies declared that posterior approach has advantage such as minor surgical invasion, effective kyphosis correction and fewer complications. The posterior approach allows operation on the vertebral body at limited angle for debridement and interbody fusion. Owing to spinal instability caused by posterior laminectomy and there is a risk of spinal cord injury, the final outcome was controversial. In addition, studies by both Ramdurg and Muthukumar showed that debridement using the posterior approach could cause central nervous system complications, such as tuberculosis meningitis.[19,20]

Taking these points into account, we used posterolateral decompression, allografting, posterior instrumentation, and local continuous chemotherapy for the surgical treatment of thoracic spinal tuberculosis. The posterolateral approach is characterized as a simple approach due to its distance from the thoracic cavity and avoiding thoracotomy and chest tube. In our study involved the resection of the small rib (4 cm) and the rib head to gain enough operating space, allowing for debridement under direct visualization. Because *M. tuberculosis* usually destroys the anterior aspect, this approach allows partial or complete debridement to relieve spinal cord compression compare with anterior surgery. After posterolateral debridement was finished, residual abscesses or tissue could not be removed completely. The residual pus, blooding, exudation was drained via the drainage tube. In this research, all patients received continuous local chemotherapy by drainage and low-dose local anti-tuberculous therapy.

More than 2 centuries ago, Potts observed that when sinuses formed and abscesses were drained, spinal tuberculosis symptoms could be alleviated. As technologies have developed, percutaneous catheter drainage has become an important clinical form of treatment for spinal tuberculosis. Abbas et al[21] reported that local chemotherapy and systemic chemotherapy could minimize surgical intervention in most patients. Our institution has also accumulated experiences in treating spinal tuberculosis by percutaneous drainage and low-dose local anti-tuberculous therapy and have achieved good clinical efficacy.[22] Postural drainage improved local blood supply and relieved nidus pressure, which may prevent the development of further pathological changes. Furthermore, local chemotherapy drugs could kill pathogenic bacteria, enhance local tissue repair and promote the bone healing.

In 2014, a study found in 27 spinal tuberculosis patients receiving CT-guided intervertebral catheterized infusion chemotherapy, their symptoms immediately lessened after operation, there was no recurrent tuberculous infection.[23] Zhou et al[24] reported on the satisfactory outcomes for lumbar tuberculosis via posterior surgery and local continuous chemotherapy as all the patients achieve good clinical results. However, fusion was significantly more rapid in the local continuous chemotherapy group (6.4 ± 0.5 months) than no local continuous chemotherapy group 8.9 ± 0.6 months. This indicates that local chemotherapy and postural drainage can effectively eliminate infectious lesions caused by abscess remnants and enhance reconstruction of segmental stability. Our results showed that local chemotherapy and postural drainage can effectively eliminate infection lesion caused by abscess remnants, inhibit the progression of pathological changes, and promote healing of the lesion. All 25 patients were healed without chronic infection, fistula formation, or recurrence

In general, the good results are attributable to the fact that posterior transpedicular internal fixation provided sufficient spinal stability and the improvement of deformity[25,26]. It is well known that the early correction of spinal instability plays an important role in treating spinal tuberculosis because it better controls the infection and creates a relatively stable internal environment to suppress recurrence. In our series, preoperatively the mean kyphotic angle was $30.7 \pm 7.4°$ corrected to $12.2 \pm 2.9°$ postoperatively, and became $12.9 \pm 2.7°$ at final follow-up; this correction was satisfactory.

In our experience, it is well established in spine tuberculosis surgery that nutritional support is an important part of therapy. Zachariah et al[27] found that malnutrition in patients with tuberculosis is a risk factor associated with early death. Similarly, in 2010, Mendoza[28] reported that the main risk factors for TB development were malnutrition, and malnutrition was a better predictor of TB development. Therefore, enhancement of nutrition and correction of anemia and hypoproteinemia are routinely carried out for the spine tuberculosis patients at our institution. Secondly, severe spinal cord compression and even paralysis in the disease early stage can occur because of thoracic spinal canal relatively narrow. This risk emphasizes the importance of high index of suspicion and early diagnosis in the treatment of thoracic tuberculosis. We recommend that MRI examination must be included in preliminary diagnosis as it

combines high sensitivity with satisfactory specificity and thoracic X-rays are often normal in the early stage of spinal tuberculosis.

Next, it is essential to sacrifice intercostal nerves for enough operating space, whereas, the exposure and visualization of the affected anterior column may be limited in some patients, especially in the patients with no obvious kyphotic deformity. Here, it is difficult to carry out radical debridement for patients with thoracic spinal tuberculosis. The local chemotherapy and postural drainage can effectively eliminate infected lesions caused by abscess remnants, inhibit the progression of pathological changes, and promote healing of the lesion. Regardless of surgery progresses technically, anti-tuberculosis therapy is the cornerstone of spine tuberculosis. Moreover, posterior pedicle screw and circumferential fusion provide the most immediately powerful stabilization of the spine to permit patient to normal ambulation for 3 to 5 days postoperatively. Meanwhile, a rigid posterior stabilization system is beneficial to the control of the local tubercular focus. Additionally, the approach has the advantage of avoiding donor site morbidity. It is possible that

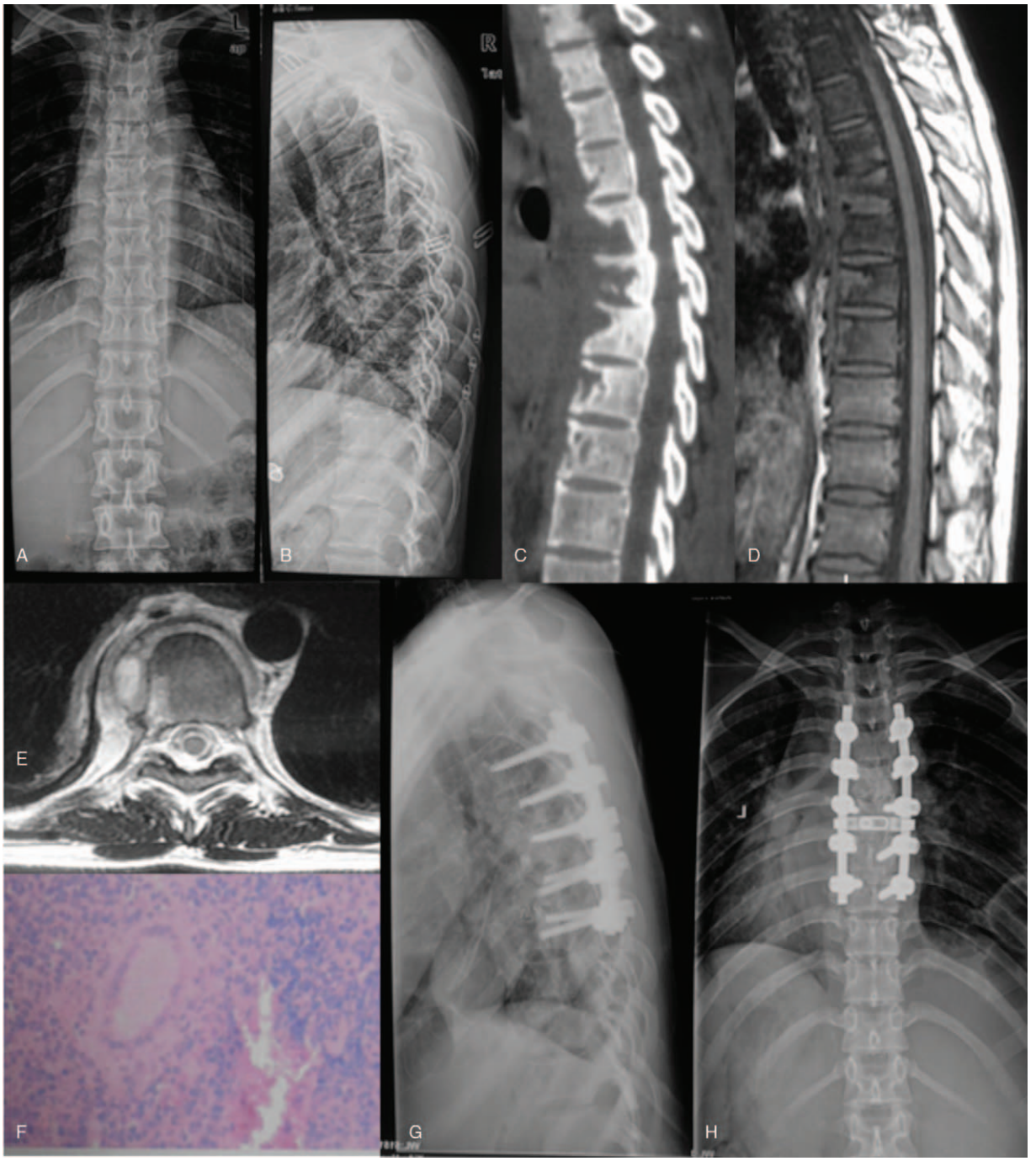

Figure 1. Case presentation of a 27 years-old female. (a,b) Pre-operative imaging showed shows tuberculosis at T4–8 segment; (c,d,e) pre-operative MRI and CT showed T4-8 segmental sagittal instability with kyphosis, complicated by paravertebral abscesses; (f) histopathologic examination (HE), indicating caseous necrosis; (g,h) anteroposterior and lateral X-ray at final follow up showed that fixation was in good position and bone union.

the parietal pleura could be damaged during the operation, so the learning curve for this surgery may be steep for beginners. Sixthly, it is essential to sacrifice multiple intercostal nerves to carry out debridement for enough operating space in the multi-segmental thoracic spinal tuberculosis. There were some limitations related to our study that should be noted, such as small simple size, a lack of long-term observation, and without control. More prospective trials should be carried out in the future to verify our results.

5. Conclusion

Surgical management of thoracic spinal tuberculosis by postero-lateral decompression, bone graft fusion, posterior instrumentation achieved satisfactory spinal cord decompression with minimal trauma as well as kyphosis correction, neurological recovery, and spinal stability reconstruction. Local continuous chemotherapy may have eliminated infection foci caused by abscess remnants and at the same time accelerated bone repair.

Author contributions

Conceptualization: Zhongkai Liu.
Data curation: Zhongkai Liu.
Formal analysis: Liang Yan.
Funding acquisition: Liang Yan.
Investigation: Ke Zhang.
Methodology: Ke Zhang.
Project administration: BaoRong He, Dingjun Hao.
Resources: BaoRong He, Dingjun Hao.
Supervision: Ming Yang.
Validation: Ming Yang.
Writing – original draft: Xinhua Yin.
Writing – review & editing: Xinhua Yin.

References

[1] Wang X, Pang X, Wu P, et al. One-stage anterior debridement, bone grafting and posterior instrumentation vs. single posterior debridement, bone grafting, and instrumentation for the treatment of thoracic and lumbar spinal tuberculosis. Eur Spine J 2014;23:830–7.

[2] Li M, Du J, Meng H, et al. One-stage surgical management for thoracic tuberculosis by anterior debridement, decompression and autogenous rib grafts, and instrumentation. Spine J 2011;11:726–33.

[3] He B, Hu Z, Hao J, et al. Posterior transpedicular debridement, decompression and instrumentation for thoracic tuberculosis in patients over the age of 60. Arch Orthop Trauma Surg 2012;132:1407–14.

[4] Sahoo MM, Mahapatra SK, Sethi GC, et al. Posterior-only approach surgery for fixation and decompression of thoracolumbar spinal tuberculosis: a retrospective study. J Spinal Disord Tech 2012;25:E217.

[5] Xi-feng Zhang MD, Yan WM, Shong-hua Xiao , et al. Treatment of lumbar and lumbosacral spinal tuberculosis with minimally invasive surgery. Orthop Surg 2010;2:64–70.

[6] Sundararaj GD, Venkatesh K, Babu PN, et al. Extended posterior circumferential approach to thoracic and thoracolumbar spine. Oper Orthop Traumatol 2009;21:323–34.

[7] Lee CK, Vessa P, Lee JK. Chronic disabling low back pain syndrome caused by internal disc derangements. The results of disc excision and posterior lumbar interbody fusion. Spine 1995;20:356–61.

[8] Tan SH, Teo EC, Chua HC. Quantitative three-dimensional anatomy of cervical, thoracic and lumbar vertebrae of Chinese Singaporeans. Eur Spine J 2004;13:137–46.

[9] Hodgson AR, Stock FE, Fang HS, et al. The operative approach and pathological findings in 412 patients with Pott's disease of the spine. Br J Surg 1960;48:172–8.

[10] Wang YX, Zhang HQ, Liao W, et al. One-stage posterior focus debridement, interbody graft using titanium mesh cages, posterior instrumentation and fusion in the surgical treatment of lumbo-sacral spinal tuberculosis in the aged. Int Orthop 2016;40:1–1.

[11] Cui X, Ma YZ, Chen X, et al. Outcomes of different surgical procedures in the treatment of spinal tuberculosis in adults. Med Princ Pract 2013;22:346–50.

[12] Abulizi Y, Liang WD, Maimaiti M, et al. Smith-Petersen osteotomy combined with anterior debridement and allografting for active thoracic and lumbar spinal tuberculosis with kyphotic deformity in young children: A prospective study and literature review. Medicine 2017;96: e7614.

[13] Yao Y, Zhang H, Liu H, et al. Prognostic factors for recovery after anterior debridement bone grafting and posterior instrumentation for lumbar spinal tuberculosis. World Neurosurg 2017;104:660–7.

[14] Zhang HQ, Hu X, Yin X, et al. One-stage combined anterior-posterior approach treatment of multiple cervicothoracic spinal tuberculosis with kyphosis. Int Orthop 2015;39:1605–10.

[15] Liu J, Wan L, Long X, et al. Efficacy and safety of posterior versus combined posterior and anterior approach for the treatment of spinal tuberculosis: a meta-analysis. World Neurosurg 2015;83: 1157–65.

[16] Yin XH, Zhou ZH, Yu HG, et al. Comparison between the antero-posterior and posterior only approaches for treating thoracolumbar tuberculosis (T10-L2) with kyphosis in children: a minimum 3-year follow-up. Childs Nerv Syst 2016;32:127–33.

[17] Rawall S, Mohan K, Nene A. Posterior approach in thoracolumbar tuberculosis: a clinical and radiological review of 67 operated cases. Musculoskelet Surg 2013;97:67–75.

[18] Zhang H, Sheng B, Tang M, et al. One-stage surgical treatment for upper thoracic spinal tuberculosis by internal fixation, debridement, and combined interbody and posterior fusion via posterior-only approach. Eur Spine J 2013;22:616–23.

[19] Ramdurg SR, Gupta DK, Suri A, et al. Spinal intramedullary tuberculosis: a series of 15 cases. Clin Neurol Neurosurg 2009;111: 115–8.

[20] Muthukumar N, Venkatesh G, Senthilbabu S, et al. Surgery for intramedullary tuberculoma of the spinal cord: report of 2 cases. Surg Neurol 2006;66:69–74.

[21] Abbas A, Rizvi SRH, Mahesri M, et al. Conservative management of spinal tuberculosis: initial series from Pakistan. Asian Spine J 2013;7: 73–80.

[22] Yin XH, Zhang HQ, Hu XK, et al. Treatment of pediatric spinal tuberculosis abscess with percutaneous drainage and low-dose local antituberculous therapy: a preliminary report. Childs Nerv Syst D 2015 1149–55.

[23] Hou X, Sun X, Zhang Z, et al. Computed tomography-guided percutaneous focal catheter infusion in the treatment of spinal tuberculosis. Acta Orthopaedica Belgica 2014;80:501–7.

[24] Zhou Y, Song Z, Luo J, et al. The efficacy of local continuous chemotherapy and postural drainage in combination with one-stage posterior surgery for the treatment of lumbar spinal tuberculosis. BMC Musculoskelet Disord 2016;17:1–7.

[25] Hirakawa A, Miyamoto K, Masuda T, et al. Surgical outcome of 2-stage (posterior and anterior) surgical treatment using spinal instrumentation for tuberculous spondylitis. J Spinal Disord Tech 2010;23:133–8.

[26] Lee TC, Lu K, Yang LC, et al. Transpedicular instrumentation as an adjunct in the treatment of thoracolumbar and lumbar spine tuberculosis with early stage bone destruction. J Neurosurg 1999; 91:163–9.

[27] Maro I, Lahey T, Mackenzie T. Low BMI and falling BMI predict HIV-associated tuberculosis: a prospective study in Tanzania. Int J Tuberc Lung Dis 2010;14:1447–53.

[28] Morán-Mendoza O, Marion SA, Elwood K, et al. Risk factors for developing tuberculosis: a 12-year follow-up of contacts of tuberculosis cases. Int J Tuberc Lung Dis 2010;14:1112.