



ISSN: 2395-1958  
IJOS 2017; 3(4): 824-829  
© 2017 IJOS  
www.orthopaper.com  
Received: 21-08-2017  
Accepted: 22-09-2017

**Dr. Anil Kumar Chitumallah**  
Assistant Professor, Kamineni  
Institute of Medical Sciences,  
Narketpally, Nalgonda District,  
Telangana State, India

**Dr. Shravan Kumar  
Peddamadyam Anjaneyulu**  
Assistant Professor, Nizam's  
Institute of Medical Sciences,  
Hyderabad, Telangana State,  
India

**Dr. Raju Iyengar**  
Professor, Nizam's Institute of  
Medical Sciences, Hyderabad,  
Telangana State, India

**Correspondence**  
**Dr. Shravan Kumar  
Peddamadyam Anjaneyulu**  
Assistant Professor, Nizam's  
Institute of Medical Sciences,  
Hyderabad, Telangana State,  
India

# International Journal of Orthopaedics Sciences

## Evaluation of efficacy and clinical outcomes of posterior surgical approach and posterior instrumentation in the management of tuberculosis of spine

**Dr. Anil Kumar Chitumallah, Dr. Shravan Kumar Peddamadyam Anjaneyulu and Dr. Raju Iyengar**

**DOI:** <https://doi.org/10.22271/ortho.2017.v3.i4l.111>

### Abstract

**Introduction:** Pott's disease or Pott's disease is a form of tuberculosis that occurs outside the lungs whereby disease is seen in the vertebrae. Tuberculosis can affect various tissues apart from the lungs including the spine, a kind of tuberculous arthritis of the inter-vertebral joints and it is usually termed as extra-pulmonary tuberculosis. The disease involving the spine is named after Percivall Pott (1714–1788), a British surgeon. The lower thoracic and upper lumbar vertebrae are the areas of the spine most often affected.

**Materials and methods:** 12 patients with active spinal tuberculosis with severe kyphosis, neurological deficits and radiologically evident disease were included. Aim was to evaluate the efficacy and clinical outcomes of posterior surgical approach and posterior instrumentation in the management of tuberculosis of spine.

**Results:** Total 12 patients were included 6 males and 6 females with average age being 37.2 years. 3 patients had history of tuberculosis in the past. Two patients had pleural effusion; one patient had tuberculosis of the elbow. The average number of vertebra involved is 1.8 (range 1-3 vertebra). 10 cases had cold abscess with tubercular debris (wet lesion). And two cases were dry lesions. Graft consolidation and functional outcome was excellent in most of cases and good in remaining cases.

**Conclusion:** The posterior approach to Thoraco lumbar spine has many advantages and it doesn't have complications associated with the other approaches. Our results show that single stage circumspinal decompression + anterior spinal fusion + posterior Moss-Miami instrumentation + posterior spinal fusion through posterior approach is an alternative treatment for Thoraco lumbar spinal tuberculosis. It is a minimum surgical intervention that has minimum morbidity compared to other approaches and encourages neurological recovery, good correction and prevention of progressive kyphosis.

**Keywords:** Pott's spine, tubercles, mycobacterium, graft, kyphosis, neurological deficit

### Introduction

Tuberculous bacilli have long association with the mankind since time immemorial. In India, Rig Veda and Atharva Veda (3500-1800 B.C. approx.), Samhita of Charaka and Sushruta (1000 and 600 B.C. approx.), have mention of this disease by the name Yakshama in all its forms (Duraiswami and Tuli 1971) [1, 2]. Greco-roman civilization recognized it as phthisis or consumption. Tuberculous lesions have been recorded in Egyptian mummies. In the Western World, the clinical features and communicability of tuberculosis were known before 1000 B.C (Yeager 1963) [1]. Lichtor and Lichtor (1957) also reported paleo-pathological evidence of tuberculosis of bones, joints, and spine in prehistoric humans [3]. Tuberculous disease of the spine was described by Percivall Pott in 1799 as "That kind of palsy of lower limbs which is frequently found to accompany a curvature of the spine" [1, 4]. Nearly one-third of the global population, i.e. two billion people is infected with Mycobacterium tuberculosis and at risk of developing the disease. More than 90% of global TB cases and deaths occur in the developing world, where 75% of cases are in the most economically productive age group (15-54 years). Magnetic Resonance Imaging (MRI) and Computerised Tomography (CT) scans have helped the clinicians to suspect and detect the disease at a predestructive phase especially when the disease is present at difficult and rare sites, such as craniovertebral region, cervicodorsal spine,

sacrum and coccyx. According to current estimates of the World Health Organization, tuberculosis will exist in humans so long as there are predisposing and favorable factors such as malnutrition, poor sanitation, crowded living conditions, exanthematous fevers, repeated pregnancies, immunodeficient status, alcohol and substance abuse, and people living with diabetes and advanced age present in society<sup>[5, 6]</sup>. Co-infection with the human immunodeficiency virus (HIV) significantly increases the risk of developing TB. At the same time, multidrug resistance, which is caused by poorly managed TB treatment, is a growing problem of serious concern in many countries around the world. Of all the patients suffering from TB nearly one to three percent has involvement of the skeletal system. Although osteoarticular TB was becoming a disappearing problem (prior to 1985) in many Western countries, however, in economically developing countries like Nigeria, India, Southeast Asia and Korea this continued to pose one of the major public health problems.

### Aims and objectives

To evaluate the efficacy and clinical outcomes of posterior surgical approach and posterior instrumentation in the management of tuberculosis of spine (POTT'S SPINE).

### Materials and methods

The study was conducted between JUNE 2006 and AUGUST 2011. 12 patients were included in the study and all 12 had active spinal tuberculosis. None of the patients had draining sinuses before surgery.

#### Criteria for selection of cases

- Clinical symptoms suggestive of tuberculosis (any two of the following)
- Severe Kyphosis
- Neurological deficits (graded as per Frankel's classification)
- Developing neurological deficits during surgery
- Radiologically suggestive of tuberculosis
- AP and LATERAL radiographs of the involved area
- MRI of affected area (showing cord compression) with screening of entire spine to look for skip lesions
- Degree of kyphosis is calculated as angle between upper borders of cephalad and lower border of healthy vertebra caudad to diseased vertebra.
- Kyphosis classified as (according to Kaplan's criteria)
  - Mild (<30 degrees)
  - Moderate (30-60 degrees)
  - Severe (>60 degrees)
- Diagnosis is confirmed by presence of cold abscess and with histopathological diagnosis of tissue taken from the affected vertebra at the time of surgery.

Once the clinic-radiological diagnosis was made by above mentioned clinical criteria and radiological investigations patients are started on ATT (EHRZ regimen as per prescribed body weight dose) and taken up surgery as soon as the patient's general condition was fit for surgery. The chemo therapy was continued for about a total duration of 15-18months (EHRZ-2 months and HR-13-16 months).

#### Indications for Surgery

- No sign of progressive recovery
- Development of fresh neurological deficits
- Worsening of neurological complications
- Recurrence of neurological complications

- Significant neurological compromise with motor power 3/5 or less than 3/5 and /or/bowel/bladder involvement

### Indication for Instrumentation

#### Progressive deformity with active disease

Surgical technique used-All patients were operated under general anaesthesia with endotracheal intubation in the prone position, through a posterior midline approach, paravertebral muscles were sub periosteally dissected and the lamina, facet joints, transverse processes and costotransverse articulations were exposed extending from 2-3 healthy vertebra above and 2-3 vertebra below the diseased vertebra depending on level of implantation, then transpedicular screws were placed in the desired vertebra, transpedicular screws were also placed in the affected vertebra if the upper part of the vertebra was not destroyed by the infection. A temporary connecting rod on the mild side of the focus was stabilized to avoid spinal cord injury induced by instability of the spine during decompression and focal debridement. Bilateral costotransversectomy at thoracic levels drained prevertebral abscesses and exposed diseased vertebral bodies. Circumspinal decompression done according to the level of the lesion, and abscesses were evacuated. Following completion of the corpectomy and debridement, the deformity was corrected by installing permanent rods with compression manoeuvres under vision. Posterior interbody grafts were applied after ensuring no compression of the spinal cord. The posterior elements of the spine were decorticated and posterior spinal fusion was done using corticocancellous bone graft procured from posterior iliac crest which was packed into the decorticated posterior elements of spine. Skin closed in layers over a suction drain which was left in situ for about 48 hours after surgery. Biopsy material was sent for culture and histopathological examination and confirmation.

#### Postoperative management

Postoperatively all patients were given absolute bed rest for at least 3 months or until the graft has stabilized (whichever is longer).

#### Criteria for graft stabilization

##### Clinical

- ✓ No tenderness over kyphosis

##### Radiological

- ✓ Absence of graft slippage which is confirmed by no change in graft position both in AP and lateral radiographs
- ✓ No progression of kyphosis for more than 5 degrees compared to previous radiograph

Once patient is fit for mobilization (Frankel Grade-D power and above; graft has stabilized), he is mobilized using a modified Taylor's brace (TLSO-thoraco lumbo sacral orthosis) or TBCB (total body contact brace). The brace was discontinued once the graft had consolidated. All patients received ATT for total of 15-18 months (EHRZ - 2 months and HR - 13-16 months).

#### Function of graft related to prevention of progression of kyphosis was classified as follows (Rajasekaran, 1989)<sup>[7]</sup>

- **Excellent:** consolidation of the graft, with some correction of the angle as compared with the preoperative kyphotic angle
- **Good:** consolidation of the graft, with no progression of

the kyphotic angle as compared with the preoperative angle

- **Fair:** consolidation of the graft, with an increase in the kyphotic angle of less than 20 degrees
- **Poor:** consolidation of the graft, with an increase of the kyphotic angle of more than 20 degrees.

**Follow -up**

All the patients were monitored clinically for bony tenderness at the kyphosis, neurological improvement, radiologically for graft consolidation and maintenance of kyphosis correction and erythrocyte sedimentation rate. Liver function test was monitored intermittently until patients had completed their chemotherapy.

**End point of treatment**

We followed the criteria followed by Laheri *et al* [8] in deciding the end point of treatment which are as follows.

- 1) **Clinical:** Relief of pain, absence of abscess or discharging sinus, improvement in neurological function
- 2) **Radiological:** Bony fusion, graft consolidation, sclerosis of contiguous surfaces of disc spaces.

Though they suggested another parameter which is ESR less than 50 percent of original value, it was not strictly adhered to in our series.

**Criteria for graft consolidation are**

- No loss of correction
- No graft resorption or graft bed resorption
- Visible graft remodeling such as trabeculation between graft beds and graft
- Graft hypertrophy

**Table 2:** showing neurological status

Frankel's grade	GRADE A	Grade B	Grade C	Grade D	Grade E	Total
Pre-operative	7 cases	Nil	4 cases	1 case	Nil	12 cases
Post-operative	2 cases	Nil	3 cases	2 cases	4 cases	11 cases 1 expired

All patients had neurological involvement before surgery (Frankel's Grade A in 7 patients, Grade C in 4 patients, Grade D in 1 patient). Postoperatively, 2 patients improved to Grade D. One patient died of acute renal failure after one month of surgery. At the end of first follow up (after 2 months) 4 patients improved to Grade E, while 2 patients improved to Grade D, 3 patients improved to Grade C, 2 patients persisted to have Grade A involvement. At the latest follow up [average follow up duration is 18 months (range 1-41 months)], 8 patients improved to Grade E, 1 patient improved to grade D, one patient improved to grade C, one patient had persisted to have grade A involvement. The average duration of neurological involvement before surgery was 9.7 weeks (range 1-36 weeks) and duration of ATT was 2.1 weeks (range 1-8 weeks) prior to surgery.

All these patients had kyphotic deformity and backache. Average kyphosis before surgery was 30.9 degrees (range 7 - 60 degrees) and average kyphosis postoperatively was 13.3 degrees (range 2 - 35 degrees) with a correction of 27.6 percent. Average kyphosis at latest follow up was 16.6 degrees (range 2-45 degrees) with an average follow up duration of 18 months (range 1-41 months) with a final correction of 14.6 percent.

**Functional Outcome of Surgery**

To evaluate the functional outcome of the surgery, we followed *FOUR* grades as divided by Chen *et al* [9] which are as follows.

- **Excellent:** No back pain, no limitation of activities.
- **Good:** Back pain improved with little medication, minimal restriction of activities
- **Fair:** Pain improved with frequent medication, moderate restriction of activities
- **Poor:** No improvement or worse, severe restriction of activities

A satisfactory outcome included an excellent or good result.

**Results**

In this study, total 12 patients were included 6 males and 6 females with average age being 37.2 years. 3 patients had history of tuberculosis in the past. Two patients had pleural effusion; one patient had tuberculosis of the elbow. The average number of vertebra involved is 1.8 (range 1-3 vertebra). 10 cases had cold abscess with tubercular debris (wet lesion). And two cases were dry lesions.

**Table 1:** level of lesion

Level of lesion	Number of cases
Thoracic	8
Thoraco-lumbar	3
Lumbar	1
Total	12

One patient had past history of involvement of L2 vertebra which was treated conservatively & had fresh involvement of T10-T11.

**Table 3:** Indication for surgery

Neurological status	Number of cases
Significant neurological compromise with motor power 3/5 or less than 3/5	7 CASES
Development of fresh neurological deficits	3 CASES
Recurrence of neurological complications	1 CASE
No sign of progressive recovery	1 CASE
Total	12 CASES

Surgical procedure done was Circumspinal decompression + anterior spinal fusion + posterior Moss-Miami instrumentation + posterior spinal fusion with posterior approach. Type of Graft used was Tricortical iliac crest graft was used in all the cases.

**Table 4:** function of the graft

Function	Number of cases
Excellent	7
Good	4
Fair	0
Poor	0

In this study, we did not come across any intraoperative complication but we encountered one death due to acute renal failure postoperatively.

**Table 5:** Time taken for graft consolidation

Duration	Number of cases
5 Months	3
7 Months	4
8 Months	2
9 Months	2

Average time taken for consolidation for graft is 8.4 months (range 4.5-12 months).

**Table 6:** mobilization of patient

Mobilization (Months)	3-6 Months	7-12 Months	13-18 Months
With brace	11 CASES	NIL	NIL
Without brace	NIL	3 CASES	8 CASES

Patients were immobilized with strict bed rest for about an average of 3 months (range 3-6 months). Patients were mobilized with brace after an average period of 3 months (range 3.5-6 months), and without brace after an average period of 13.5 months (range 12-18 months) and unrestricted mobility after an average period of 18.6 months (range 16-21 months). Patients were mobilized with Taylor's brace (3 patients) or TBCB (8 patients). The average follow up duration was 18 months (range 1-41 months). Functional outcome of the surgery was Excellent in 7 cases, good in 3 cases and poor in 1 case.

## Discussion

Spinal tuberculosis prevails in many parts of the world and is a severe orthopedic problem, usually presenting with kyphosis, neurological deficit, and even paraplegia [10, 11, 12].

The definitive management of Pott's disease has always been a topic of controversy. MRC studies have shown that attainment of so-called "favorable status" defined as full physical activity; clinical and radiographic evidence of quiescence of the disease; and no central nervous system involvement, sinuses, or clinical evidence of residual abscess — at five years by chemotherapy alone compares favorably with the results of radical surgery [13-19].

Although chemotherapy may inactivate the disease, the vertebral collapse may continue until the vertebral bodies in the region of the kyphosis meet anteriorly or until the caseated material in the region of the vertebral bodies and the highly vascular granulation tissue mature into bone. When there is loss of most of two vertebral bodies, or more, a severe kyphosis must result before healthy vertebrae can come into contact and consolidation of bone can occur. Gross deformity is perhaps the greatest disadvantage of treatment by chemotherapy alone [7].

Rajasekaran *et al* suggested a strong correlation (correlation coefficient: 0.83) between the initial loss of vertebral body and the final gibbus in patients who had tuberculosis lesions of the thoracic and thoracolumbar spine [20]. They suggested the formula  $Y=a+bx$ , where  $y$  is the measurement of final angle of gibbus deformity,  $X$  is the amount of initial loss of vertebral body, and 'a' and 'b' are constants 5.5 and 30.5 respectively. Thus with a loss of every whole vertebra, 30-35degrees of gibbus deformity occurred.

Surgical attempts to prevent deformity initially were toward posterior fusion because the techniques of the anterior

approach to the spine were not perfected. Albee (1911, 1930) and Hibbs (1912, 1918, 1928) introduced the operation of posterior spinal fusion. Such operations were carried out to shorten the period of immobilization in bed, and to provide a permanent internal stability to the tuberculous spine to avoid recurrence of the disease & development of paraplegia. The initial enthusiasm toward posterior fusion as an isolated procedure soon declined because of its high failure rate. Debridement of the disease focus without insertion of a graft also has been shown to be ineffective. Progression of the deformity frequently results despite any or all of these measures. In contrast, surgical extirpation of the focus of disease and its replacement by a bone graft in a structurally sound position has been shown to be effective [21].

Since Hodgson and Stock's report in 1960, anterior arthrodesis has been advocated as the treatment of choice for tuberculosis of the spine [20]. For successful anterior radical surgery, they showed that surgical extirpation of the tuberculous focus and its replacement with a bone graft or grafts in a structurally sound position were the key to effectiveness.

In 1998 the MRC Working Party on Tuberculosis of the Spine published findings of a 15 year follow-up study of series of patients with spinal tuberculosis who received a variety of treatments. They found anterior radical debridement and anterior strut grafting to be the most successful procedure for neurologic recovery, fusion and preventing kyphotic deformity, when compared against ambulatory chemotherapy, non-ambulatory chemotherapy with debridement and chemotherapy with Hong Kong procedures. However anterior surgery has been considered to be too drastic by some authors, because anterior extension of surgery may necessitate division of the diaphragm and many segmental vessels. Serious complications and death have been reported. Also the British Medical Research Council studies proved the importance of bone-grafting in addition to debridement for prevention of progression of the deformity, but they did not include detailed analysis of the status and functions of the bone grafts [7].

There are various surgical approaches to different regions of the spine used by different workers. For Dorsal spine, The approaches are 1. Anterolateral extrapleural approach as developed by Griffiths (1956), Seddon (1956), and Roaf (1959). 2. Transpleural anterior approach developed by Hodgson and stock (1956, 1960). 3. Macrae (1957) performed bilateral costectomy to evacuate any pus and then irrigated the area with streptomycin from each side through a catheter. 4. Martin (1970, 1971) favoured a "posterolateral approach". Thoracolumbar region is approached through extra-pleural anterolateral exposure as described by Lagenskiold and Riska (1967). or extra-pleural and extra-peritoneal Lumbar spine approach through the bed of 11<sup>th</sup> rib as described by Hodgson *et al*. Lumbar spine is approached through a retroperitoneal approach. Lumbosacral region is approached through hypogastric paramedian transperitoneal approach.

There are many surgical complications associated with the above mentioned surgical procedures such as excessive bleeding from the paravertebral venous plexus, tear of the pleura, risk of damage to aorta and pleura, and in patients who have pulmonary compromise, these approaches will further deteriorate the pulmonary function. If posterior instrumentation is required the surgeon should give another posterior midline incision. This combined procedure has a longer operation time, longer healing duration, and higher surgical trauma.

In our series, we approached thoracic and lumbar spine through single stage posterior approach. We preferred the posterior approach because surgery by the other approaches has high anaesthetic risk, with a potential for severe postoperative complications. A mere posterior approach for debridement, fusion, and instrumentation often limits the extent of surgical intervention to a minimum [23]. This approach reduces total operative time and morbidity and allows early mobilization, which reduces the complication risk of long term bed rest and hospitalization cost. Also, a posterior approach offers good access to the spinal canal for efficient decompression of the neural elements, especially in cases of epidural abscess [24, 25].

The long posterior Transpedicular instrumentation can provide rigid segmental fixation along 3 columns of spine and effectively correct kyphosis [26]. This not only prevents loss of correction of the vertebral alignment in the long term but also provides immediate relief of pain due to spinal instability [27]. Indirect decompression during deformity correction and stabilization with posterior instrumentation was beneficial in improving the neurological function [28]. Meanwhile, posterior interbody grafts and a supplementary posterior short segment fusion were performed to guarantee an equal growth of anterior and posterior height after effective posterior correction, which prevents an increase in kyphosis during the growth period and provide structural support [29, 30, 31].

### Conclusion

The posterior approach to Thoraco lumbar spine has many advantages and it doesn't have complications associated with the other approaches. Our results show that single stage circumspinal decompression + anterior spinal fusion + posterior Moss-Miami instrumentation + posterior spinal fusion through posterior approach is an alternative treatment for Thoraco lumbar spinal tuberculosis. It is a minimum surgical intervention that has minimum morbidity compared to other approaches and encourages neurological recovery, good correction and prevention of progressive kyphosis.

### References

1. Tuli SM. Historical aspects of Pott's disease (spinal tuberculosis) management. *European Spine Journal*. 2013; 22(Suppl 4):529-538.
2. Duraiswami PK, Orth M, Tuli SM. 5000 years of orthopaedics in India. *Clin Orthop Relat Res*. 1971; 75:269-280.
3. Lichtor J, Lichtor A. Paleopathological evidence suggesting pre-Columbian tuberculosis of spine. *J Bone Joint Surg Am*. 1957; 39-A(6):1938-1939.
4. Bick KM. *Classics of orthopaedics*. Philadelphia: JB Lippincott Co. 1976.
5. Barnes PF, Barrows SA. Tuberculosis in the 1990s. *Ann Intern Med*. 1993; 119:400-410.
6. Patel S, Collins DA, Bourke BE. Don't forget tuberculosis. *Ann Rheum Dis*. 1995; 54(3):174-175.
7. Rajasekaran S, Soundarapandian S. Progression of kyphosis in tuberculosis of the spine treated by anterior arthrodesis. *JBJS (Am.)* 1989; 71-A(9):1314-1323.
8. Laheri VJ *et al*. Single stage decompression, anterior interbody fusion and posterior instrumentation for tuberculous kyphosis of the dorso-lumbar spine. *Spinal Cord*. 2001; 39:429-436.
9. Chen *et al*. Combined anterior and posterior surgeries in the treatment of spinal tuberculous spondylitis. *CORR* 2002; 398:50-59.
10. Lönnroth K, Raviglione M. Global epidemiology of tuberculosis: prospects for control [published online ahead of print September 22, 2008]. *Semin Respir Crit Care Med*. 2008; 29(5):481-491.
11. Jain AK. Tuberculosis of the spine. *Clin Orthop Relat Res*. 2007; (460):2-3.
12. Tuli SM. Tuberculosis of the spine: a historical review. *Clin Orthop Relat Res*. 2007; (460):29-38.
13. Medical Research Council Working Party on Tuberculosis of the Spine: A Controlled Trial of Ambulant Out-Patient Treatment and In-Patient Rest in Bed in the Management of Tuberculosis of the Spine in Young Korean Patients on Standard Chemotherapy. A Study in Masan, Korea. *JBJS*. 1973; 55-B(4):678-697.
14. Medical Research Council Working Party on Tuberculosis of the Spine: A Controlled Trial of Plaster-of-Paris Jackets in the Management of Ambulant Outpatient Treatment of Tuberculosis of the Spine in Children on Standard Chemotherapy: A Study in Pusan, Korea. *Tubercule*. 1973; 54:261-282.
15. Medical Research Council Working Party on Tuberculosis of the Spine: A Controlled Trial of Debridement and Ambulatory Treatment in the Management of Tuberculosis of the Spine in Patients on Standard Chemotherapy. A Study in Bulawayo, Rhodesia. *J. Trop. Med. and Hyg*. 1974; 77:72-92.
16. Medical Research Council Working Party on Tuberculosis of the Spine: A Controlled Trial of Anterior Spinal Fusion and Debridement in the Surgical Management of Tuberculosis of the Spine in Patients on Standard Chemotherapy: A Study in Hong Kong. *British J. Surg*. 1974; 61:853-866.
17. Medical Research Council Working Party on Tuberculosis of the Spine: A Five-Year Assessment of Controlled Trials of In-Patient and Out-Patient Treatment and of Plaster-of-Paris Jackets for Tuberculosis of the Spine in Children on Standard Chemotherapy. *Studies in Masan and Pusan, Korea*. *JBJS*. 1976; 58-B(4):399-411.
18. Medical Research Council Working Party on Tuberculosis of the Spine: Five-Year Assessments of Controlled Trials of Ambulatory Treatment, Debridement and Anterior Spinal Fusion in the Management of Tuberculosis of the Spine. *Studies in Bulawayo (Rhodesia) and in Hong Kong*. *JBJS*. 1978; 60-B(2):163-177.
19. Medical Research Council Working Party on Tuberculosis of the Spine: A 10-Year Assessment of a Controlled Trial Comparing Debridement and Anterior Spinal Fusion in the Management of Tuberculosis of the Spine in Patients on Standard Chemotherapy in Hong Kong. *JBJS*. 1982; 64-B(4):393-398.
20. S. Rajasekaran, T.K. Shanmuasundaram. Prediction of the angle of gibbus deformity in tuberculosis of the spine. *JBJS (Am.)* (1987) 69: 503-509.
21. Rajasekaran S.. The problem of deformity in spinal tuberculosis. *CORR*. 2002; 398:85-92.
22. Hodgson AR, Stock FE. Anterior Spinal Fusion for the Treatment of Tuberculosis of the Spine. The Operative Findings and Results of Treatment in the First One Hundred Cases. *JBJS*. 1960; 42-A:295-310.
23. Yilmaz *et al*. Anterior instrumentation for the treatment of spinal tuberculosis. *JBJS (Am.)*. 1999; 81:1261-7.
24. Güzey FK, Emel E, Bas NS *et al*. Thoracic and lumbar tuberculous spondylitis treated by posterior debridement, graft placement, and instrumentation: a retrospective

- analysis in 19 cases. *J Neurosurg Spine*. 2005; 3(6):450-458.
25. Malawski S. Clinical value of the posterolateral approach, supplemented with pedicle excision of the arch, to the anterior wall of the spinal canal within the thoracolumbar (Th11-L1) and lumbar spine [in Polish]. *Chir Narzadow Ruchu Ortop Pol*. 1994; 59(4):265-273.
  26. Zindrick MR, Wiltse LL, Widell EH *et al*. A biomechanical study of intrapeduncular screw fixation in the lumbosacral spine. *Clin Orthop Relat Res*. 1986; (203):99-112.
  27. Lee SH, Sung JK, Park YM. Single-stage transpedicular decompression and posterior instrumentation in treatment of thoracic and thoracolumbar spinal tuberculosis: a retrospective case series. *J Spinal Disord Tech*. 2006; 19(8):595-602.
  28. Chen YC, Chang MC, Wang ST, Yu WK, Liu CL, Chen TH. One-stage posterior surgery for treatment of advanced spinal tuberculosis. *J Chin Med Assoc*. 2003; 66(7):411-417.
  29. Rajasekaran S, Prasad Shetty A, Dheenadhayalan J, Shashidhar Reddy J, Naresh-Babu J, Kishen T. Morphological changes during growth in healed childhood spinal tuberculosis: a 15-year prospective study of 61 children treated with ambulatory chemotherapy. *J Pediatr Orthop*. 2006; 26(6):716-724.
  30. Fountain SS, Hsu LC, Yau AC, Hodgson AR. Progressive kyphosis following solid anterior spine fusion in children with tuberculosis of the spine. A long-term study. *J Bone Joint Surg Am*. 1975; 57(8):1104-1107.
  31. Schulitz KP, Kothe R, Leong JC, Wehling P. Growth changes of solidly fused kyphotic bloc after surgery for tuberculosis. Comparison of four procedures. *Spine (Phila Pa 1976)*. 1997; 22(10):1150-1155.