



LATERAL EXTRACAVITATORY APPROACH WITH CIRCUMSPINAL DECOMPRESSION IN TUBERCULOUS SPONDYLITIS: A 5 YEAR FOLLOW-UP STUDY

Orthopaedics

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ABSTRACT

Introduction: Spinal tuberculosis has been managed with various modalities of treatment ranging from only antituberculous drugs to radical surgical extirpation. Opinion is divided on management of Potts Paraplegia with respect to surgical approach to the lesion. Results are conflicting on anterior versus posterior approaches as well combined approach. There is also confusion on when to do anterior first or to operate from posterior first, in combined approaches. In the present study we present 10 year follow-up of our results, clinical and radiological outcomes, of Single stage Circumspinal decompression and pedicle screw fixation through lateral extracavitary approach with anterior and posterior spinal fusion in cases of Pott's paraplegia.

Methods: The study was a retrospective and prospective follow up of 30 patients with active tuberculosis of thoracolumbar spine with neurological deficit, who underwent posterior spinal instrumentation with lateral extra cavitory approach with circumspinal decompression and pedicle screw instrumentation. Diagnosis of spinal tuberculosis was made by laboratory findings such as anaemia, elevated ESR, radiological features with typical MR imaging findings. 8 patients had multilevel involvement. Kyphosis of 250 to 550 was present. Circumspinal decompression, correction of kyphosis, anterior and posterior spinal fusion was performed in a single stage. The average follow up was 7.67 years (92 months).

Results: The mean kyphosis angle improved from 320 preoperatively to 80 in early follow up, followed by a minor loss of correction of 30. Neurological recovery occurred in 28 patients out of 30 patients. 15 patients recovered from Asia A to AIS E. 13 patients recovered to ASIA D. The visual analog scale and ASIA grade improved in all the cases. Implant failure in the form of rod breakage was seen in 1 patient but with no neurological complications.

Conclusion: Drainage of abscess, debridement by extracavitary route constitutes a less demanding, relatively safe, minimally traumatic operative technique with adequate circumspinal decompression of spinal cord, correction and maintenance of sagittal balance with relatively less morbidity is the added advantage.

KEYWORDS

tuberculous spondylitis, lateral extracavitary, posterior instrumentation

INTRODUCTION

Treatment of spinal tuberculosis must be aimed at eradication of infection. Very small proportion of patients require surgical management to relieve severe pain, prevent or reverse the neurological deficits or correction of kyphotic deformity and maintenance or stabilization of the kyphotic deformity. The biomechanical capability of the spine is inversely proportional to the involvement of spine. So long the disease remains in biologic phase the disease may be cured but once it poses biomechanical threat it should be operated at the earliest. Surgical management of tuberculosis of the spine has evolved considerably, since 1895 when Me'nard decompressed tubercular abscess around spinal cord. (1) Posterior spinal fusion with bone grafting alone was introduced in 1911 by Hibbs (2) and Albee (3) but posterior bone grafting alone had either no benefit and was even harmful in the presence of active tuberculosis. (4, 5) Higher degree of progression of kyphosis has been observed following non-operative treatment and non-instrumented anterior fusion. Anterior debridement and bone grafting and instrumentation have been attempted by many researchers as an effective treatment for the thoracolumbar spinal tuberculosis. (6, 7, 8) However these procedures carry a risk of cardio pulmonary complications and prolonged recovery time.

Anterior instrumentation poses danger of injury to viscera, vascular structures, sympathetic chain and thoracic duct. Anterior instrumentation may have poor purchase in the weak, osteoporotic bone of long standing tuberculosis and also limits to single rod constructs in thoracic spine which may not provide adequate stability. Kyphosis poses threat to quality of life and survival, not only being a cosmetic problem it may lead to delayed paralysis. (9) Recovery of the neurologic deficits is unpredictable even despite the deformity being corrected by surgery. Hence for active tuberculosis with kyphosis, foremost objectives must be debridement and correction of deformity.

The aim of the study was to assess the functional and radiological

outcomes of posterior instrumented fusion in patients with tuberculous spondylitis with active disease, associated with paraplegia of early onset. We are of the opinion that circumspinal decompression through lateral extracavitary approach and with effective chemotherapy present today eliminates the need for radical anterior debridement and complications peculiar to anterior approaches. Also, posterior instrumentation serves to minimise the progression of kyphosis and creates an opportunity for stable biomechanical construct to prevent sagittal plane deformity.

MATERIALS & METHODS:

This was a retrospective and prospective study of patients from August, 2009 to January, 2013 diagnosed with tuberculous spondylitis involving dorsal and lumbar spine. All surgeries were done at single centre. Patients underwent surgery in the form of single stage circumspinal decompression, debridement and pedicle screw fixation with posterior and anterior spinal fusion through posterior approach. Only patients with early onset neurological involvement (para-paresis associated with active tubercular disease) were included in the study. All the 43 had thoracic or thoracolumbar Spinal tuberculosis, paraplegia with active stage involving two or more adjacent vertebrae with more than 50% destruction of the involved vertebral bodies. All the cases were confirmed histopathologically for Tuberculosis. Initial diagnosis of tuberculous spondylitis was based on clinical features and imaging. Anti tuberculous treatment was started after getting baseline haematological and biochemical parameters. Permission of the hospital ethics committee and written informed consent of the patients were obtained, required for the study.

Out of 43 patients enrolled, 13 were excluded due to lack of follow-up. There were 20 males and 10 females. The mean age of the patients was 42yrs. The mean duration of the follow up was 7.5years. Minimum duration of the follow up was 5.5 years. 8 patients had multilevel involvement. 16 patients had single level disease and 11 patients had

disease involving more than 2 contiguous disks. The percentage of vertebral involvement varied from more than 25% to near total collapse. Duration of symptoms prior to initial presentation was ranged from 2 weeks– 8 months. All the patients had neurological involvement of the lower limbs at the time of presentation. Neurological assessment was performed using AIS (American spinal injury association impairment scale). 14 patients were in AIS A, 12 patients were in AIS B and 3 patients were in AIS C. All the patients had preoperative anteroposterior and lateral radiographs of spine. Diagnosis of spinal tuberculosis was made by laboratory findings such as anaemia, elevated ESR (erythrocyte sedimentation rate), CRP (C-reactive protein), radiological features with typical MR image findings. MRI (magnetic resonance imaging) was used to document the presence of vertebral body and cord edema, cord compression, para vertebral abscess and skip lesions.

Chemotherapy was instituted soon after the diagnosis was suspected, with measures to improve general health and nutrition along with bed rest. Surgery was performed under the cover of chemotherapy. The antitubercular regime followed was 4 drugs (rifampicin, isoniazid, pyrazinamide and ethambutol) for initial two months in standard adult doses followed by 2 drugs (rifampicin, isoniazid) for the next 10 months. Antitubercular drugs were given for a period of 12 months in all the cases. (10) The drug response was monitored by serial ESR and radiographs in two planes. Surgery was considered in patients with significant pain and neurological deficits despite chemotherapy, severe kyphosis and paraplegia at the time of presentation, progression of neurological deficits despite chemotherapy following guide line of “middle path regime” by Tuli. (11) Patients with old healed disease with paraplegia of late onset, bony gibbus and intrinsic cord lesions were excluded.

Surgical method

The goal of surgery was to adequately debride the lesion so as the chemotherapeutic effect of anti-tubercular drugs is maximum, to decompress the spinal cord 360° so that we can expect maximal recovery, to correct the deformity and give a near normal sagittal balance to spine. The surgery was performed under general anaesthesia. The patient was operated in prone position. This positioning itself helps in reducing considerable amount of kyphosis due to body weight correcting the sagittal balance. With midline incision after careful retracting the paravertebral muscles, the pedicle screws were inserted in the unaffected vertebrae 2 levels above and below the diseased site. The span of fixation depended on the quality of bone involved and the bone above and below the lesion and degree of kyphosis. In the involved vertebrae screws were directed away from the damaged end plate. After placement of pedicle screws, decompression was performed at the diseased level. The level and side of decompression were decided from the extent of extradural compression in the MRI. The more affected side of the vertebra, or the presence of large abscess was selected for lateral extracavitary debridement. The less affected side was chosen to stabilize the spine with a temporary rod. Through this lateral extracavitary route, minimal laminectomy, facetctomy, pedicle excision and exposure of cord circumferentially was done with maximum granulation tissue, sequestra, fragmented disc and pus removed and sent for histopathology. Care was taken not to do radical debridement and the concept of adequate debridement is followed. “Adequate debridement is just removal of macroscopic inflamed tissues and debris leaving the normal bone” for further anterior reconstruction. All patient underwent posterior and anterior spinal fusion by harvesting corticocancellous grafts from left iliac crest. Large chunk of corticocancellous grafts were packed in the anterior void created by the debridement through lateral extracavitary route. Regular follow-ups at 3-month intervals for first year followed by every year till five years was done

Radiographs were taken in each follow-up to see remineralization of osteopenic bones, sclerosis at the end of contiguous involved vertebral bodies, resolution of abscess shadows, alignment of spinal column, position of implants, fusion, local and global form of the spine and angle of kyphosis.

Angle of kyphosis was calculated from X-rays by the method described by Cobbs from plain lateral view film. Loss of correction was calculated as difference between final and immediate postoperative kyphosis angle. The initial loss of vertebral body (VBL) and predicted angle of kyphosis (if managed nonsurgically, $Y=5.5+30.5 \text{ VBL}$) was calculated from the lateral radiograph by the

method described by Rajasekaran and Shanmugasundaram. The disease was considered as healed when clinically no Spinal tenderness was noticed and Haematological parameters returned to near normal levels and sound fusion was evident on follow up radiographs. Radiographically fusion was considered as sound when there was bony bridge with trabeculation of density equal to adjacent vertebrae, radiolucent zones were absent and no abnormal motion between the segments according to criteria by Schofferman et al and Kim et al. (12, 13) representative images are shown in figure 1 and 2.

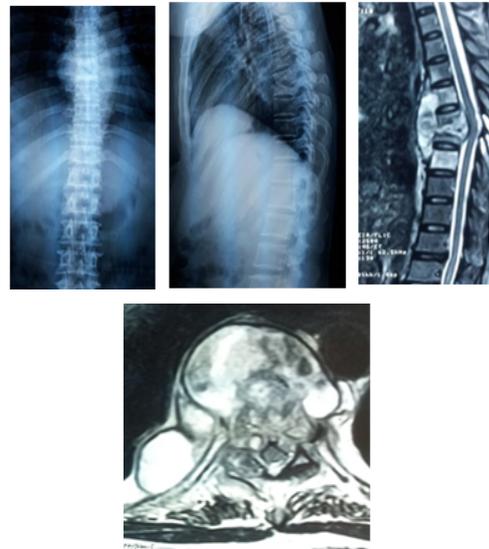


Figure 1 (A-F): 35 year old male with tuberculous spondylodiscitis T7-8. (A-B) antero-posterior and lateral radiographs showing destruction of vertebral bodies T7-8. (C-D) Sagittal and axial MR images showing collapse of vertebral bodies with subsequent kyphosis and spinal canal compromise. (E-F) Post-operative images showing restoration of sagittal balance and posterior instrumentation with pedicle screws and rods.



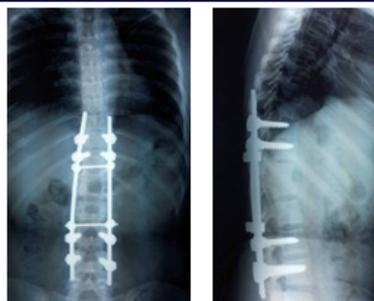


Figure 2 (A-F) 24 year old female with tuberculous spondylodiscitis T12-L1. (A-B) anteroposterior and lateral radiographs showing destruction of vertebral bodies T12-L1. (C-D). Sagittal and axial MR images showing collapse of vertebral bodies with subsequent kyphosis and spinal canal compromise. (E-F). Post-operative images showing restoration of sagittal balance and posterior instrumentation with pedicle screws and rods

RESULTS:

The Mean hospital stay was 12 days (10 – 14 days). All the patients with neurological deficits showed improvement in AIS grade post-operatively but for 2 patients with no improvement (6.6%). Preoperatively the mean kyphosis angle was 39.6±14.51° (95% CI between 11.4 to 18.5) and was corrected post-operatively to 18.2 ±9.17° (95% CI between 7.3 to 12.3) with an average correction of 21.4 ±9.24° (54.2%; 95% CI between 7.3 to 12.4). At the latest follow-up there was mean loss of correction of 3.3 0 resulting in 19.5±8.73° of final correction (49.2 % of deformity). The mean kyphosis angle at the

latest follow up (19.5±8.73°) was found to be significantly less than the preoperative kyphosis and predicted angle of kyphosis (mean, 39.4±14.9° and 95% CI between 33.8 to 45). *p* value for preoperative and immediate postoperative kyphosis correction was 0.018 (<0.05). *p* value for preoperative and follow up kyphosis correction was 0.022 (<0.05). There was significant relief of pain in all patients with improvement of VAS from 7.1 ± 0.77 preoperatively to 1.46 ± 0.81 postoperatively. (*p*<0.05 with 95% CI between 5.3 to 5.9). There was significant relief of pain in all patients with improvement of VAS from 7.1 ± 0.77 preoperatively to 1.46 ± 0.81 postoperatively. (*p*<0.05 with 95% CI between 5.3 to 5.9) Complications in terms of implant failure (rod breakage) was seen in one of the patient, but patient had no symptoms and good radiological union. Neurological improvement was seen in all but 2 patients. (Table 1). Patient clinical and radiological data is shown in table 2.

Table 1: preoperative and post-operative comparison of AIS grade:

Pre-Operative AIS Grading	Nos.	Post-Operative AIS Grading	Nos.
A	14	2	2
B	12		Nil
C	4		Nil
D	Nil		13
E	Nil		15

Complication were minor in nature with rod breakage in one patient without any neurological complications. No major complications were noted. There was no significant loss of kyphosis correction once bony inter-body fusion was apparent on the radiographs.

Table 2: Patient clinical and radiological data

S.NO	VAS pre-op	VAS post-op	AIS-Grade pre-op	AIS-Grade postop	Predicted kyphosis	Pre-op kyphosis	Post-op kyphosis	Follow up kyphosis	Correcti on loss	No. of vertebrae involved
1	7	1	B	E	29.9	30	13	17	4	2
2	7	2	B	D	54.3	51	24	27	3	3
3	8	2	A	E	26.85	30	18	22	4	2
4	8	2	C	E	23.8	25	15	18	3	2
5	9	2	A	A	72.6	72	23	28	5	3
6	7	1	A	D	42.1	48	18	21	3	3
7	8	1	B	E	42.1	38	13	16	3	2
8	8	1	B	E	29.9	30	16	20	4	2
9	7	1	A	E	26.85	30	12	15	3	2
10	6	1	B	D	29.9	32	18	22	4	2
11	7	2	B	D	48.2	44	15	18	3	3
12	6	1	B	E	29.9	31	15	18	3	2
13	7	2	A	D	48.2	48	16	19	3	3
14	8	2	C	E	23.8	24	13	15	2	2
15	7	1	B	D	42.1	42	16	19	3	3
16	8	2	A	E	26.85	32	12	15	3	2
17	6	1	B	E	42.1	45	8	11	3	3
18	7	1	A	D	72.6	65	36	39	3	4
19	7	2	A	E	29.9	35	16	20	4	2
20	6	1	B	D	60.4	58	35	41	6	3
21	7	1	A	E	54.3	55	18	20	2	3
22	7	1	A	D	29.9	34	16	18	2	2
23	7	2	B	E	23.8	29	13	16	3	2
24	6	2	A	E	26.85	25	11	13	2	2
25	7	3	A	D	29.9	27	15	17	2	2
26	7	2	A	D	29.9	28	17	20	3	2
27	8	3	A	A	72.6	80	55	60	5	4
28	7	2	A	E	42.1	40	19	24	5	3
29	7	2	A	D	35.5	32	15	18	3	2
30	7	1	B	D	35.5	28	15	19	4	3

DISCUSSION:

Treatment of tuberculosis of Spine is essentially conventionally, however a small subset of patient who develop complications of tuberculosis of spine requires surgery. Surgery in Pott's spine is to overcome the complications, removal of focus, complete decompression of nerves, correction of spinal deformities and reconstruction spinal stability (14) because spinal tuberculosis mostly involves the spinal exterior column. Surgical treatment through an anterior approach was long considered to be the "Gold standard ". As it can provide direct access to the diseased area allowing for efficient reconstruction of anterior spinal column. Anterior approach, many

authors have considered to be invasive and often unnecessary. It may involve division of the diaphragm and segmental spine nerves. (15) Vascular complications, injury to lung, damaged already by scarring and pleural adhesions, retrograde ejaculation were some of the major complications. (16) Though anterior approach may be helpful in management of kyphosis of healed disease and late onset paraplegia they may not find a significant role in management of active disease and early onset paraplegia. With chemotherapy, spontaneous inter-body bones healing has been observed to occur without anterior surgery. (17, 18) Laminectomy in the presence anterior diseased column is said to aggravate the Spinal instability. (19)

With the advent of modern posterior spinal instrumentation, stability of vertebral column following posterior decompression is no longer a major concern. (20) Apprehensions regarding usage of metal implants in presence of active disease were overcome following realisation that Tuberculous bacilli have slow rates of division lower bacillary counts and lack of biofilm production. (21, 22) Every attempt should be made to correct the sagittal imbalance in spine while addressing the issue. (23) This is for several reasons, one is cosmesis and the more important because kyphosis other than normal in any part of spine ventralizes the spinal vertical axis and predispose to chronic backache. Kyphosis begets kyphosis and this perpetuates and leading to late neurology. The block of vertebra formed will also predispose to adjacent segment degeneration if it remains in kyphosis. This issue can be well addressed when the lesion is wet so that a more morbid osteotomy of spine can be avoided. Literature strongly suggests that early and prompt surgical decompression in Pott's paraplegia with correction of sagittal balance leads to recovery of paraplegia and near normal life.

The long term goal in treatment of Potts Paraplegia should be not only circumspinal decompression, facilitating neurological recovery but also achieving stability to spine and correcting and maintaining the sagittal balance of spine. Poor sagittal spinal correction has been documented following anterior approach alone. While anterior instrumentation may prevent progression of kyphosis during treatment, it is not so effective in correcting pre-existing kyphosis, this is due to the hard unyielding laminar bone over the kyphus which does not yield to anterior correction. The lateral extracavitary route to debride and address the anterior column for reconstruction and fusion seems to be the best in present day. Fixation of pedicle screw with three columns (24) supplies good support force including anti-torsion and antibuckling capabilities, corrects the deformity, adequate decompression circumspinally and stabilizes the spinal level. With posterior and anterior bone grafting, reconstruction of stability of posterior column can be achieved. There is always an ease to extend the fixation both above and below which probably is difficult with anterior approach. However patients with multisegment involvement and huge prevertebral abscess and healed lesions, it is difficult to achieve satisfactory debridement by the post approach.

The results of present study revealed that surgical management of T-L tuberculosis spondylitis with single stage posterior approach, which allows decompression, deformity correction, bone grafting and internal fixation in a single incision and position, is valid in present day management of tuberculous spondylitis where MR imaging has enabled for early diagnosis and effective ambulatory chemotherapy is available to control the disease in early stage and limit bony destruction. Careful selection of patients is essential for success with this procedure. We achieved a mean kyphosis correction of 19.5° (49.2%) correction rate, higher than the previously reported (44.8%) Lowe et al and less than Jain et al (51.1%). (25, 26) During follow up, correction was satisfactorily preserved with loss of correction of 3.3°, better than Sudararaj et al (4.64°) and less than Moon et al 3°. (27, 28)

Kyphosis did not increase in late post-operative period, probably due to the inter body bony fusion which occurred in all the patients and further vertebral collapse did not occur after this point. In our study neurological function of patients with paraplegia was significantly improved postoperatively. Posterior fixation with pedicle screws can also be pressurised to correct kyphosis. Use of the "bowstring" principle to further relieve the Spinal cord compression and intra-operative pressure on the graft bone mass solidifies the graft. (29)

There are few limitations to our study, firstly it is a prospective follow-up of retrospectively collected patients, which has its inherent limitations, secondly fewer number of subjects, this may be due to increased knowledge of the disease and investigations to detect the disease in early stages and good chemotherapy options.

CONCLUSION:

Drainage of abscess, debridement by extracavitary route constitutes a less demanding operative technique. Better correction of kyphosis, adequate circumspinal decompression of spinal cord and maintenance of sagittal balance with relatively less morbidity is the added advantage. This procedure is relatively safe, minimally traumatic, has a high correction rate and prevents progression of kyphosis.

REFERENCES

1. Moon M-S (2006) Development in the management of tuberculosis of the spine. *Curr*

- Orthop 20:132-140
2. Hibbs RA (1911) An operation for Pott's disease of the spine. *J Am Med Assoc* 59:433-436.
3. Albee FH (1911) Transplantation of a portion of the tibia into the spine for Pott's disease. A preliminary report. *J Am Med Assoc* 57:885-886.
4. McKee GK (1937) A comparison of the results of spinal fixation operation and non-operative treatment in Pott's disease in adults. *Br J Surg* 24:456-468.
5. Seddon HJ (1938) Pott's paraplegia, prognosis and treatment. *Br J Surg* 22:769.
6. Tamura M, Saito M, Machida M et al (2005) A transsternoclavicular approach for the anterior decompression and fusion of the upper thoracic spine. *J Neurosurg Spine* 2(2):226-229.
7. Benli IT, Acaroglu E, Akalin S et al (2003) Anterior radical debridement and anterior instrumentation in tuberculosis spondylitis. *Eur Spine J* 12(2):224-234
8. Zhang HQ, Guo CF, Xiao XG et al (2007) One-stage surgical management for multilevel tuberculous spondylitis of the upper thoracic region by anterior decompression, strut autografting, posterior instrumentation, and fusion. *J Spinal Disord Technol* 20(4):263-267.
9. Rajasekaran S, Shanmugasundaram TK (1987) Prediction of the angle of Gibbus deformity in tuberculosis of the spine. *J Bone Joint Surg Am* 69:503-509.
10. S Rajasekaran ASSI. *Spinal Infections And Trauma*. Jaypee Publishers, Delhi, pg 137.
11. Tuli SM (2010) *Tuberculosis of the skeletal system*, 4th edn. Jaypee Publishers, Delhi, p 215.
12. Schofferman J, Slosar P, Reynolds J, Goldthwaite N, Koestler M (2001) A prospective randomized comparison of 270 degree fusions to 360 degree fusions (circumferential fusions). *Spine* 26(10):E207-E212.
13. Kim KT, Lee SH, Lee YH, Bae SC, Suk KS (2006) Clinical outcomes of 3 fusion methods through the posterior approach in the lumbar spine. *Spine* 31(12):1351-1357.
14. Jain AK (2010) Tuberculosis of the spine: a fresh look at an old disease. *J Bone Joint Surg Br* 92(7):905-913.
15. Jin D, Qu D, Chen J, Zhang H (2004) One-stage anterior interbody auto grafting and instrumentation in primary surgical management of thoraco-lumbar spinal tuberculosis. *Eur Spine J* 13(2):114-121.
16. Jarrett CD, Heller JG, Tsai L (2009) Anterior exposure of the lumbar spine with and without an "access surgeon": morbidity analysis of 265 consecutive cases. *J Spinal Disord Tech* 22(8):559-564.
17. Jain S (2010) Comment on Huang et al. One-stage surgical management for children with spinal tuberculosis by anterior decompression and posterior instrumentation. *Int Orthop* 34(5):769-770.
18. Pu X, Zhou Q, He Q, Dai F, Xu J, Zhang Z, Branko KA (2012) Posterior versus anterior surgical approach in combination with debridement, inter-body auto grafting and instrumentation for thoracic and lumbar tuberculosis. *Int Orthop* 36:307-313.
19. Chiriano J, Abou-Zamzam AM Jr, Urayeneza O, Zhang WW, Cheng W (2009) The role of the vascular surgeon in anterior retroperitoneal spine exposure: preservation of open surgical training. *J Vasc Surg* 50(1):148-151.
20. Moon M-S et al (1986) Harrington rods in treatment of active spinal tuberculosis with kyphosis. *J West Pac Orthop Assoc* 23:53.
21. Oga M, Arizono T, Takasita M et al (1993) Evaluation of the risk of instrumentation as a foreign body in spinal tuberculosis. *Clin Biol Study Spine* 18:1890-1894.
22. Ha KY, Chung YG, Ryoo SJ (2004) Adherence and bio-film formation of *Staphylococcus epidermidis* and *Mycobacterium tuberculosis* on various spinal implants. *Spine* 29(24):1-6.
23. Jain AK, Dhammi IK, Jain S, Mishra P. Kyphosis in spinal tuberculosis - Prevention and correction. *Indian J Orthop* 2010;44:127-36.
24. Zhang HQ, Wang YX, Guo CF, Liu JY, Wu JH, Chen J, et al. One-stage posterior approach and combined interbody and posterior fusion for thoracolumbar spinal tuberculosis with kyphosis in children. *Orthopedics* 2010;33:808.
25. Louw JA (1990) Spinal tuberculosis with neurological deficit. Treatment with anterior vascularised rib grafts, posterior osteotomies and fusion. *J Bone Joint Surg Br* 72:686-693.
26. Jain AK, Dhammi IK, Prasad B, Sinha S, Mishra P (2008) Simultaneous anterior decompression and posterior instrumentation of the tuberculous spine using an anterolateral extrapleural approach. *J Bone Joint Surg Br* 90:1477-1481.
27. Sundararaj GD, Behera S, Ravi V, Venkatesh K, Cherian VM, Lee V (2003) Role of posterior stabilisation in the management of tuberculosis of the dorsal and lumbar spine. *J Bone Joint Surg Br* 85:100-106.
28. Moon MS, Woo YK, Lee KS, Ha KY, Kim SS, Sun DH (1995) Posterior instrumentation and anterior interbody fusion for tuberculous kyphosis of dorsal and lumbar spines. *Spine (Phila Pa 1976)* 20:1910-1916.
29. Zhang HQ, Chen LQ, Liu SH et al (2010) Posterior decompression with kyphosis correction for thoracic myelopathy due to ossification of the ligamentum flavum and ossification of the posterior longitudinal ligament at the same level. *Neurosurg Spine* 13(1):116-122.