

Surgical treatment of tuberculosis of spine: Nepalese experience

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ABSTRACT

Introduction

Spinal tuberculosis treatment goal is eradication of the disease, neurological protection, and deformity prevention. Accepted indications for conservative or surgical management of the disease are still lacking. The purpose of this study was to classify disease based on pre- and post-treatment clinical and radiological criteria to help management.

Material and methods

Out of 101 patients, retrospectively reviewed between 2007 and 2015, seventy adult patients (44 males, mean age 29 years, range 16-76) were included in the study. Patients were evaluated clinically for pain, deformity and neurological status while radiological evaluation included sagittal deformity, vertebra destruction and number of vertebrae involvement. 60 patients underwent surgery (abscess drainage, 2; anterior radical debridement and fusion, 12; anterior debridement + posterior instrumentation, 26; posterior instrumentation, 20) All patients were given anti-tuberculous treatment for 12 months. Mean follow up period was 44.9 months (range: 6-108 months).

Result

Pre-treatment pain (Visual analogue score, VAS 0-10, mean 7.52) improved by 0.99 at last follow up. Number of vertebrae involved ranged from 1 to 15 (mean 4.2). 38 patients had obvious clinical deformity with Cobb angle mean 36.6° (range 10°-130°). Deformity was corrected at mean of 17.5° (range: -60° to 90°) at last follow up.

There were two ASIA A, eight ASIA B, five ASIA C, four ASIA D and 51 patients with ASIA E neurology at the time of presentation. One patient with ASIA A neurology remained same even after decompression while other patient died on the day of surgery. Out of 8 patients with ASIA B neurology six patients improved to ASIA E, one patient remained same and one patient deteriorated to ASIA A. In ASIA C group, three patients improved to ASIA E. One patient deteriorated to ASIA A. All four patients with ASIA D neurological status improved to ASIA E. And all 51 patients with pre-operative ASIA E status remained same but one deteriorated to ASIA C.

Eight patients had deformity progression, two patients had deep vein thrombosis, two patients had superficial wound infection and one patients had recurrent cold abscess. Two patients died due to associated co-morbidities.

Based upon the clinical and radiological pre- and post-operative findings; Uncomplicated spines were managed conservatively or with abscess drainage (USG or CT – guided). Complicated spines were managed with posterior instrumentation and complex spines were managed with anterior / posterior procedure (posterior only approach)

Conclusion

Based upon the outcome of treatment of spinal tuberculosis, conservative treatment results in healing of the disease process with residual deformity while surgical treatment in selected cases results in early pain alleviation, spinal balance, neurologic protection and eventually early return to work.

Keywords: **Spine, Tuberculosis**

Introduction

Tuberculosis (TB) remains the major killer in infectious disease, especially in developing countries where treatments are not sufficiently available. The risk of developing tuberculosis is found to be at least 20 times higher in populations with human immunodeficiency virus (HIV). Globally, there are 9.4 million incidences of tuberculosis and approximately 1.2 million of newly diagnosed tuberculosis patients are associated with HIV in each year¹. Among these numbers, Africa and South East Asian regions contributed 90% of the cases. Skeletal involvement is found in around 10% of patients with spine, hip and knee as the common spreading sites².

Spinal tuberculosis, also known as Pott's disease of the spine, accounts for 17-39% of spinal infections¹. This happens when tuberculosis spreads out of the lungs and reaches the spine via the rich vascular supply to the vertebrae. Once *Mycobacterium tuberculosis* has formed a granuloma and has become necrotic, bone destruction occurs and leads to collapse of the vertebral bodies. The classic radiological features are 1) vertebral body destruction, and collapse, 2) soft tissue abscess,

3) vertebral wedging, 4) kyphosis, and 5) gibbus formation. This characteristic leads to cord compression, spinal deformities, and neurological deficits and hence, it has been described as the most serious form of osteoarticular tuberculosis associated with high morbidity^{2,3}. The goals of treatment in tuberculosis of the spine are to 1) eradicate necrotic tissue and large tuberculosis abscesses, 2) prevent neurological deterioration, and 3) prevent deformity⁴.

Though chemotherapy is the cornerstone of treatment of spine tuberculosis, the addition of surgical intervention in selected cases results in the optimum outcome in terms of pain alleviation, neurological protection, spinal alignment and eventually early return to work or other activities. The type of radiological and clinical presentation varies between patients. The accepted indications for conservative or surgical management of the disease are still lacking. The majority of recent literatures reviewing the surgical outcomes of TB have been reported from China and India. This report proposed to share our surgical experiences on spinal tuberculosis in Nepal.

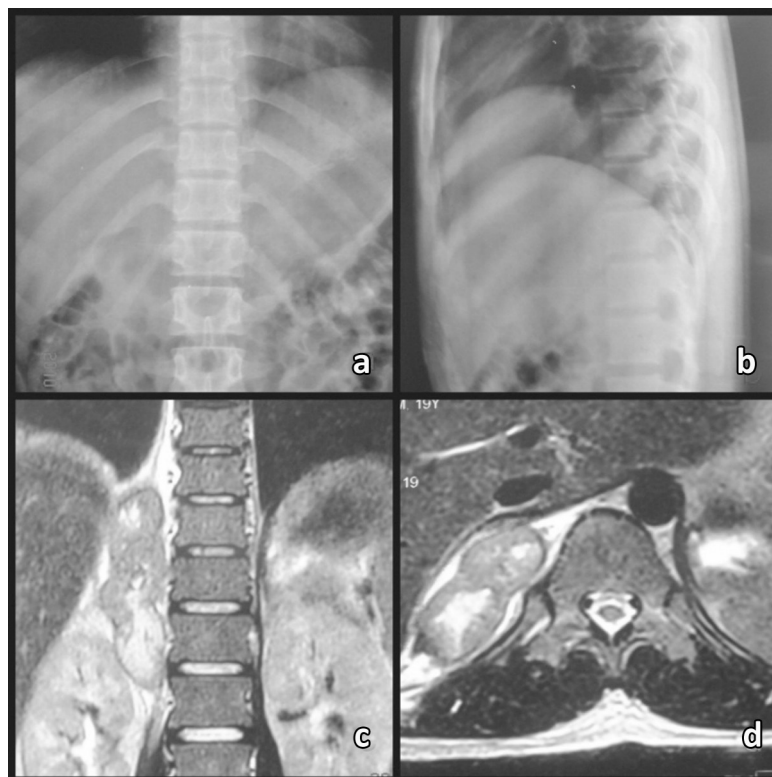


Figure 1: a, b - Antero-posterior and lateral views of thoracic spine showing no abnormalities. c, d - MRI coronal and axial films showing right paravertebral mass.

Material and methods

A retrospective review of 101 patients treated between 2007 and 2015 was done. There were 62 males and 39 females consisting of 31 patients in pediatric age group between 0 to 15 years (18 M, 13 F), 58 patients in adult age group between 16 and 60 years (39 M, 19 F) and 12 elderly patients above 60 years (5 M, 7 F). Age ranged from 4 to 76 years with the average being 29 years.

All the patients presenting to the hospital were clinically evaluated for pain, deformity and neurological status. Routine laboratory evaluation included Complete Blood Count (CBC), Erythrocyte Sedimentation Rate (ESR), C – Reactive Protein (CRP), and Hemoglobin levels. Those subjected to surgery were also tested for HIV and HBsAg. Pre-treatment ESR was evaluated in all patients. Since there was no homogeneity in post-treatment ESR evaluation, it was not considered in the study.



Figure 2: Same patient from Fig.1. **a, b** - MRI coronal and axial films 6 weeks after empirical start of anti-tuberculosis therapy showing increase in size of the right sided paravertebral mass. **c, d, e** - MRI sagittal, coronal and axial films one year after starting anti-tuberculosis treatment.

In the growing spine, the posterior elements continue to grow while there is tethering of the growth anteriorly due to tuberculous posing a risk of progression of deformity. The anterior-only procedure will risk deformity progression. Thus posterior instrumentation and fusion along with anterior debridement and reconstruction are recommended in the pediatric age group. Thus due to the difference in management in the growing spine from the adult spine, 31 patients from the pediatric age group were excluded from the study. So the study group consisted of 70 adult patients with 44 males and 26 females. The age ranged from 16 to 76 years with the average being 29 years.

Plain x-rays of the involved segments and MRI of the affected level were routinely performed. In later cases, we started doing screening MRI of the whole spine to rule out non-contiguous or skip lesions, where these features will suggest atypical presentation requiring special attention.

Pain experienced by the patient was evaluated by the visual analogue score. The clinical deformity was evaluated for knuckle, gibbus or kyphus. Deformity of the spine was measured on the plain x-rays according to Cobb's method. In lumbar and cervical region, loss of lumbar and cervical lordosis is added to the measured kyphotic deformity to

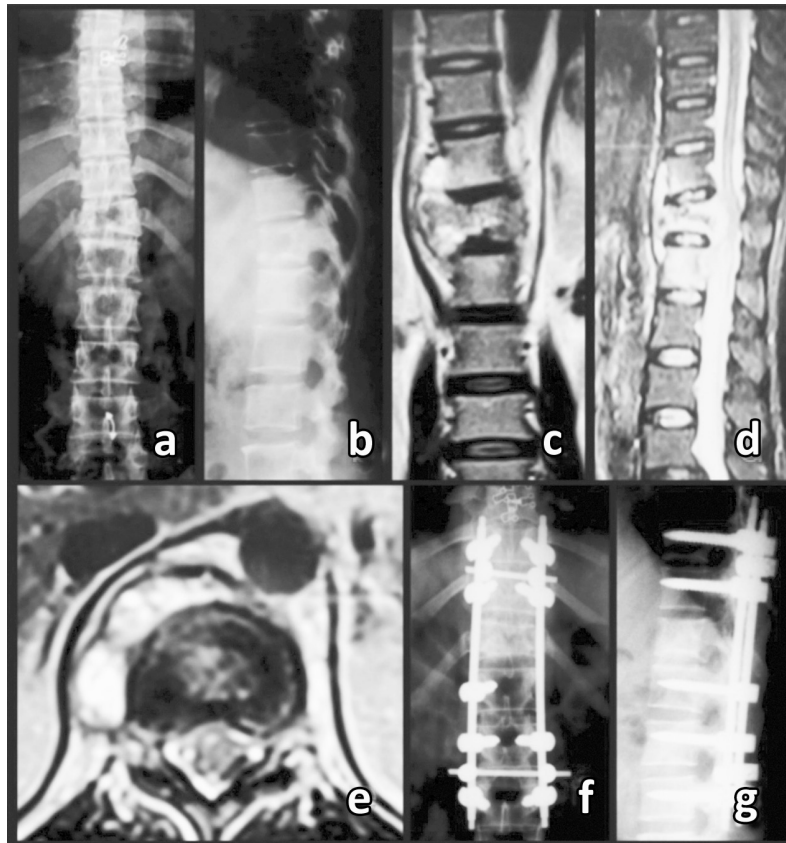


Figure 3: a, b, c, d, e - Plain x-ray and MRI of a 38 years old lady showing involvement of D 12 and L 1 vertebrae along with pre- and para-vertebral abscess. X-rays showing fairly maintained vertebral height with slight asymmetrical collapse whereas MRI showed two vertebrae involvement. f, g - Immediate and one year post - posterior instrumentation showing healed lesion and good spinal alignment.

calculate the total magnitude of the deformity. Average normal lordosis is considered to be around 40° and loss of lumbar lordosis is regarded as lumbar hypokyphosis. Neurological status was evaluated accordingly to ASIA scoring system. MRI was evaluated for the region of involvement, the amount of vertebral destruction, the number of vertebrae involved, contiguity of the involvement, pre- or paravertebral abscesses, epidural abscesses and cord compression.

The spine was considered unstable if vertebral body destruction of more than 50% occurred in a single vertebra or involvement of two or more contiguous vertebrae, kyphotic deformity of more than 20° , or translation of more than 5° .

The decision for treatment was made on the basis of clinical as well as radiological findings. The treatments delivered were conservative in 10 patients (5M, 5F) and surgery in 60 patients (39M and 21F). In the surgical group, abscesses were drained in 2 patients (both males), anterior radical debridement and fusion was done in 12 patients (8M, 4F), anterior debridement and posterior

instrumentation was done in 26 patients (15M, 11F) and posterior instrumentation only was performed in 20 patients (14M, 6F). In all patients combined anterior/ posterior procedures were from the posterior-only approach in single stage.

All patients had histopathologically proven tuberculosis. Tissue culture and ZN staining were also done in some patients but it was not consistent in all patients, so was not considered in the study. All patients were given anti-tuberculosis treatment consisting of four drugs (Rifampicin, Isoniazid, Pyrazinamide and Ethambutol) for 3 months as intensive phase and then two drugs (Rifampicin and Isoniazid) for another 9 months as a maintenance therapy.

Postoperative follow-up was done at 6 weeks, 3 months, 6 months, 1 year and subsequently every year. During each follow-up patient was evaluated for pain, deformity and neurological status. Plain x-rays were obtained to assess deformity progression, consolidation of the diseased vertebrae and status of the implants. The follow-up period ranged from 1.5 months to 108 months with the average being 44.9 months.

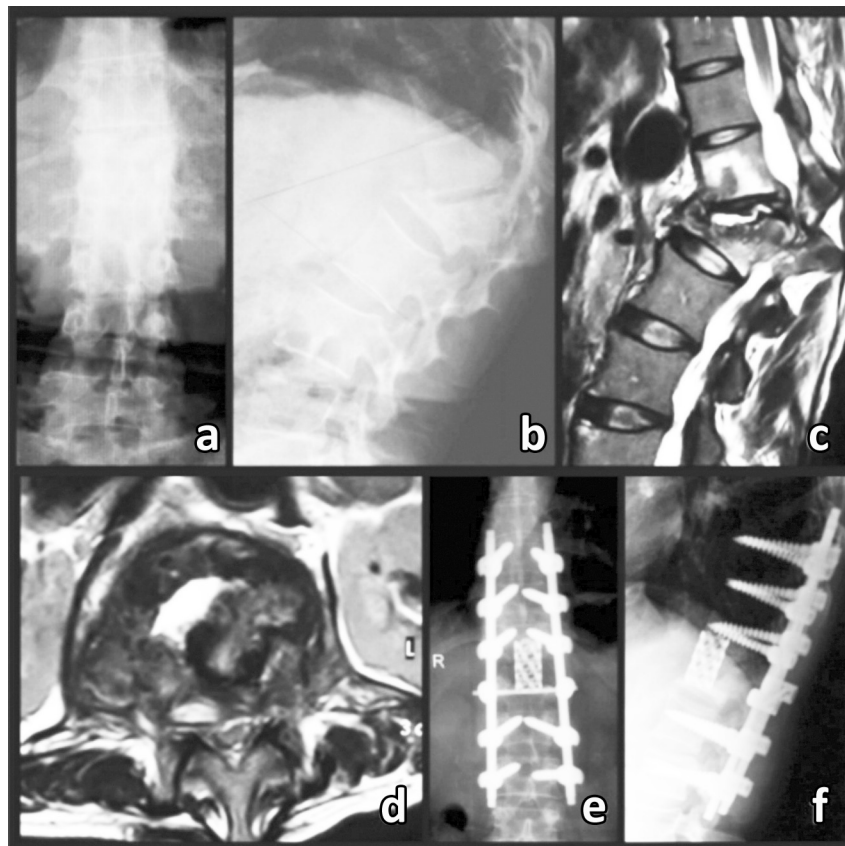


Figure 4: a, b, c, d - Pre-operative plain x-rays and MRI of 46 /F showing significant vertebral collapse and kyphosis at L 1 level. e, f - One year post-operative imaging showing excellent correction and spinal alignment.

Results

Most of the patients presented late ranging from 15 days to 4 years with the average being 4.6 months. All patients presented with pain except two patients who presented with deformity of the back and progressive neurological deficits. Both the cases were old healed tuberculosis with severe kyphosis. The pre-treatment visual analogue score (VAS) ranged from 0 to 10 with the average being 7.52, which improved to 0.99 during the last follow-up indicating reduction in pain with stabilization of the spine.

There were 2 patients with cervical, 1 patient with cervico-dorso-lumbar involvement. Of the 22 patients (15 M, 7 F) who had dorsal spinal tuberculosis, an average of 2.5 numbers of vertebrae was involved resulting in kyphotic deformity of 37.7° on average. Fifteen patients (6 M, 9 F) had dorso-lumbar vertebral involvement with an average 2.6 vertebrae affected resulting in a deformity of 36.6° . And there were 29 patients (20 M, 9 F) with lumbar (n-17), lumbo-sacral (n-10)

and Sacral (n-2) involvement with an involvement of 2.4 vertebrae on average causing deformity of 18.6° along the sagittal plane. Two patients had cervical tuberculosis (both male) with the mean of 4.2 vertebral involvements. One male patient had cervical-dorso-lumbosacral lesion involving 15 vertebrae while another male patient had dorso-lumbosacral lesion involving 5 vertebrae. Contiguous involvement of vertebrae was observed in 59 (84.3%) patients while non-contiguous involvement was seen in 11 (15.7%) patients. The number of vertebrae involved ranged from 1 to 15 with the average being 2.6 vertebrae.

Thirty-eight (54.3%) patients (23 M, 15 F) had an obvious clinical deformity of the back during clinical examination in the form of the knuckle, gibbus, kyphus or kypho-scoliosis. 32 patients (21 M, 11 F) had no obvious deformity on clinical examination. However, they did have radiological deformity in the form of loss of lumbar or cervical lordosis or exaggeration of thoracic kyphosis. All those patients who did not demonstrate clinical deformity had involvement of lumbar, lumbosacral

or cervical involvement. Two patients who had no obvious clinical deformity had multiple dorsal vertebrae involvement but no vertebral body collapse. Wedging of D3 vertebra in one patient exhibited radiological kyphosis, but clinically it was masked by natural dorsal kyphosis. The Cobb angle in the deformity group ranged from 10° to 130°. The average deformity measured in the sagittal plane was 36.6°. Ten patients had deformity along the coronal plane (cervical 1, dorsal 1, dorsolumbar 4, lumbar 4) ranging from 5° to 30° with the average of 2.2°. ESR ranged from 5 to 126 mm in 1st hour (mean - 59 mm in 1st hour).

Table 1: Number of kyphosis and scoliosis in different genders

Gender	Kyphosis	Scoliosis
Male	33	7
Female	19	3

with 90° of kyphosis at D7-8 level. Anterior decompression and posterior stabilization were performed in order to decompress the cord and correct the deformity. Another patient who remained in status quo after surgery had 130° of hair-pin kyphotic deformity with late onset paraplegia. In this patient laminectomy and posterior pedicle screws stabilization was done. In ASIA C group, 3 patients improved to ASIA E. One 76 years old patient with 6 vertebrae involvement who presented with progressively deteriorating neurology died because of her associated co-morbidities of dilated cardiomyopathy 14 days after decompression and posterior instrumentation. One patient deteriorated to ASIA A neurological status postoperatively. He was operated with anterior radical debridement and reconstruction with cage and vertebral body screws. The complication was considered iatrogenic. All four patients with pre-operative ASIA

Table 2: Regions, characteristics and severity of deformities in all patients (n=70)

Region	No. of patients			No. of vertebrae involved	Contiguity		Kyphosis in Degrees (°)	Scoliosis in Degrees (°)
	Male	Female	Total		Contiguous	Non-contiguous		
Cervical	2	0	2	2.5	2	0	0	0
Cervico-Dorso-Lumbar	1	0	1	15	0	1	40	0
Dorsal	15	7	22	2.5	19	3	37.7	10
Dorso-Lumbar	6	9	15	2.6	9	6	36.6	2
Dorso-Lumbo-Sacral	0	1	1	5	0	1	0	0
Lumbar	17	7	24	2.4	24	0	15	1.9
Lumbo-Sacral	1	2	3	2.3	3	0	30.9	0
Sacral	2	0	2	1.5	2	0	10	0
Total	44	26	70	Average	59	11	Average	Average
				4.2			21.3	1.7

Neurologic severity was classified by the American Spinal Injury Association (ASIA) system. Two patients had ASIA A, 8 patients had ASIA B, 5 patients had ASIA C, 4 patients had ASIA D and 51 patients had ASIA E at the time of presentation. One patient with ASIA A neurology remained the same even after decompression while another patient died on the day of surgery because of myocardial infarction. Out of 8 patients with ASIA B neurology 6 patients improved to ASIA E, one patient remained the same and one patient deteriorated to ASIA A neurological status. The patient who deteriorated had healed tuberculosis

D neurological status improved to ASIA E. All but 1 patient in a total of 51 patients with pre-operative ASIA E status remained in the same status. The lone patient's status which deteriorated to ASIA C had long segment epidural abscess extending from D 10 to L 4 anterior to the cord. There was a post-infective block vertebra L 3 and L 4. During decompression, there was an iatrogenic dural tear which was repaired and sealed with fibrin glue. He developed weakness on his left sided L 2, L 3 and L 4 myotome. His sensory distribution was normal. Bowel and bladder functions were unaffected.

Table 3: American Spinal Injury Association (ASIA) impairment scale grading in all patients (n=70)

Neurology grading (ASIA)	Region	Gender		Total
		Male	Female	
A	Dorsal 1, Dorso-Lumbar 1	1	1	2
B	Dorsal 6, Dorsolumbar 1, Cervico-Dorso-Lumbar 1	4	4	8
C	Dorsal 3, Dorsolumbar 2	3	2	5
D	Cervical 1, Dorsolumbar 1, Lumbar 1, Lumbo-sacral 1	1	3	4
E	Cervical 1, Dorsal 1, Dorsolumbar 10, Dorso-lumbo-sacral 1, Lumbar 23, Lumbosacral 2, Sacral 2	35	16	51
Total		44	26	70

Table 4: Complications (n=70)

Complications	Number	Remarks
Death	2	Both patients died because of associated cardiac co-morbidities.
Deformity progression	6	Anterior 3, Posterior 1, Combined 1, Conservative 1
Junctional Kyphosis	2	Combined 2
Neurological deterioration	3	Dorsal tuberculosis. Two cases had iatrogenic
Recurrent cold abscess	1	Drained under CT and USG guidance
Wound Dehiscence	1	Chronic smoker
Deep Vein Thrombosis	2	Both the patients were bed ridden for long time

Table 5: Preoperative and postoperative neurology grading

Preoperative neurology grading (ASIA)	Postoperative neurology grading (ASIA)	Treatment
A (n=2)	A (n=1) One died due to MI on the day of surgery	Posterior (n=1) Anterior / Posterior (n=1)
B (n=8)	A (n=1) B (n=1) E (n=6)	A - Anterior / Posterior (n=1) B - Posterior (n=1) E - Anterior (n=3), Posterior (n=3)
C (n=5)	A (n=1) D (n=1) E (n=3)	A - Anterior (n=1) D - Posterior (n=1) E - Anterior (n=1), Posterior (n=1), anterior / posterior (n=1)
D (n=4)	E (n=4)	E - Anterior / Posterior (n -3), Anterior (n-1)
E (n=51)	E (n=50) C (n=1)	Anterior (n-6), Posterior (n-15), Anterior / Posterior (n-17), Abscess drainage (n-2), Conservative (n-9)

Discussion

Treatment of tuberculosis of the spine is debatable and controversies exist regarding efficacy of conservative versus surgical management. In surgical management, there is no general consensus about the best approach. However, there is a general agreement that in addition to eradication

of the disease and prevention of neurological deterioration, the correction and prevention of the spinal deformity should also be a primary goal.

A basic literature review was conducted to determine the current approaches and their outcomes.

Table 6: Summary of recent studies focusing on surgical outcome

Author (Year)	Surgery/ Total no. of patients	Age \pm SD (Range)	Study period	Country	Type of Surgical treatment	Summary
Upadhyay et al. ¹³ (1993)	80/80	7.6 \pm 5.14 (Radical) 5.1 \pm 4.06 (debridement)	Unknown	Hong Kong	Radial surgery or debridement surgery on thoracic, thoracolumbar and lumbar	All patients fully regained their motor, sensory and bladder function. No kyphotic pain and leg pain were reported by the patient during the final follow-up. The angle of kyphosis was reduced in the radical group (25° to 21°) but increased in debridement group (12° to 15°).
Pertuiset et al. ¹⁴ (1999)	25/103	17-84	1980-1984	France	Surgical decompression	A patient with spondylodiscitis and paraplegic underwent surgical decompression and antituberculous therapy but died after 4 months due to E. coli septicemia. The others regained their neurologic functions during the follow-up.
Benli et al. ⁴ (2003)	63/63	46.8 \pm 13.4	Unknown	Turkey	Anterior radical debridement and anterior instrumentation	An average correction was described as 35.9° \pm 9.0°, 4.5° \pm 6.9° and -33.0° \pm 4.5° in the thoracic, thoracolumbar and lumbar spine. All patients with neurologic deficits demonstrated improvement with 80% of them fully recovered. No pseudoarthrosis or implant failures were encountered. However, 2 patients developed a non-specific infection after the removal of implants at 14 th and 16 th postoperative months.
Bezer et al. ¹⁵ (2007)	16/16	51 (27 -65)	1993 - 1999	Turkey	Transpedicular Decancellation Osteotomy in thoracic, lumbar and lumbosacral	Pain, the main complaint, was found to be significantly relieved with pain visual analogue scale dropping from 9.1 to 1.3. The angle of kyphosis was reduced from 29.9 to 12.2. There was 1 case of wound infection and 1 case of pneumothorax where these conditions were treated with antibiotics and chest tube respectively. No failure of fixation and bone fusion was reported.
Wang et al. ¹⁶ (2009)	9/9	26.2 (16 - 46)	August 2004 to October 2006	China	Multilevel modified vertebral column resection	Bone fusion was confirmed starting from 12 months and the average mean correction was described as 80°. All patients were able to lie down in dorsal position postoperatively. The only case of complication is found to be neurological deficits in 1 patient where he experienced incomplete paraplegia starting from T9 postoperatively. 9 months of rehabilitation improved his deficits from ASIA B to ASIA D). Otherwise, no other complications or unfavorable surgical events were reported.
Rajasekaran et al. ¹¹ (2010)	17/17	18.3 \pm 10.6 (4-40)	Unknown	India	Single-stage closing-opening wedge osteotomy of thoracolumbar, lumbar and thoracic	14/14 patient using pedicle screw-rod system achieved spinal stabilisation. There were 2 cases of wound infection, 1 case of temporary neurological deterioration and jaundice. One implant failure requiring revision was reported. However, no girdle pain was reported in all patients. All patients demonstrated radiological fusion where no difference was found in iliac crest grafts, rib grafts or cages. Over 85% patient achieved grade E postoperatively and an average of 5.4° correction was demonstrated.
Rangel-Castilla et al. ¹⁷ (2012)	Case report	3	Unknown	USA	Single-stage costotransversectomy for vertebral column resection, anterior reconstruction and posterior pedicle screw instrumentation of thoracic spine	The patient was able to start walking a few days after the surgery. CT scan demonstrated satisfactory spinal decompression, alignment and hardware placement. 11 months' post-surgery, the patient was able to walk without bracing and returned to his normal activities.
Shi et al. ⁹ (2012)	29/29	40 (16-64)	January 2000 to January 2007	China	Complete debridement, deformity correction, graft fusion, and internal fixation for patients with non-contiguous multifocal spinal tuberculosis.	The correction rate is 67.7% and graft union was found on an average of 5 months. Patients with nerve lesion recovered to grade E while the recover to their normal states. No major surgical complications other than fat liquefaction in wound healing.

Author (Year)	Surgery/ Total no. of patients	Age \pm SD (Range)	Study period	Country	Type of Surgical treatment	Summary
Chandra et al. ¹² (2013)	146/212	34.8 (10 -75)	January 1999 to June 2011	India	Instrumented fusions or circumferential fusions	Over 70% of patients recovered from pain, sensorimotor deficits, bladder symptoms and paraplegia. 89% achieved a favourable neurological outcome in follow-up. However, wound infections were found in 3 cases. 15 patients with thoracic screw developed complications including 1 haemoptysis and 14 pleural consolidations. 12 patients developed urinary tract infection required long-term indwelling catheters. 1 patient with pyonephrosis developed chronic renal failure and required dialysis.
Jin et al. ¹⁸ (2014)	289/289	41 (18-82)	January 2000 to January 2010	China	Complete debridement on thoracolumbar spine	22 patients experienced a surgical complication, including wound infection, graft shifting, fat liquefaction, incisional hernia and pleural effusion. 21 patients were found to have incomplete debridement and underwent either a second surgery or percutaneous abscess aspiration or cured by delayed chemotherapy. 4 patients required traditional debridement due to indistinct anatomy and bleeding caused by severe adhesion. Pain alleviation was achieved in 216 patients and 244 patients returned to normal after 4 -6 months with a mean correction of 63.40%.
Shim et al. ¹⁰ (2014)	1/1	60	Unknown	Korea	Posterior laminectomy at lumbar spine L4-L5 with anterior lumbar interbody fusion in the lumbosacral spine and posterior fixation from PLF and PF from T9 to the ilium	The patient's low back pain and numbness in her right calf and foot disappeared post-surgery. No complication was found during and after the operation. The patient's motor function and sensory function improved after the operative and during the 3 months follow-up. She remained symptom-free 3 months after surgery.
Zhang et al. ⁸ (2012)	36/36	68.4 (65-76)	January 2004 to June 2009	China	Posterior-only versus combined anterior and posterior Approaches in thoracic spine	No patient experienced any instrumentation complications or any wound healing complication. Both approaches demonstrated a successful transformation on lumbar kyphotic angle. The majority of the patient regained a normal neurological status and the rest improved at 2 levels on neurological functions.
Wang et al. ⁵ (2014)	115/115	48.6 (18-76)	January 2006 to January 2010	China	One-stage anterior debridement, bone grafting and posterior instrumentation vs. single posterior debridement, bone grafting, and instrumentation thoracic and lumbar spine	Only 1 patient failed to have interbody fusion with loosening fixation and interbody absorption. 6 patients were found to have operative complications which include wound infection, sinus drainage tube formation, pleural effusion and refractory intercostal neuralgia. All above problems and complications were treated. No severe neurological complications were found in both approaches but unilateral psoas abscess was reported in 3 patients treated by posterior debridement during the 12 months follow-up. The majority of the patients returned to normal with the rest achieved partial recovery.
Zhang et al. ⁷ (2013)	37/37	41.2 (6 - 63)	May 2004 to June 2012	China	One-stage posterior debridement, transformational lumbar interbody fusion, and instrumentation versus posterior instrumentation, anterior debridement and bone graft in a single-stage procedure. lumbar spine	All patients were reported to have no wound infection or instrumental complication. Both approaches increased lumbar kyphotic angle with patients treated by one-stage posterior debridement, TLIF and instrumentation improved to a larger extent. All patients demonstrated recovery and had at least two grades improvement neurological status.

Author (Year)	Surgery/ Total no. of patients	Age \pm SD (Range)	Study period	Country	Type of Surgical treatment	Summary
Zeng et al. ⁶ (2014)	39/39	41 (20-75) 38.5 (19-67)	January 2006 to October 2010	China	Posterior-only and Combined Posterior and Anterior Approach on lumbosacral spine	10/39 patients experienced surgical complications including CSF leakage, water-electrolyte imbalance during surgery and wound infection and blood vessel rupture. No patients developed instrumentation or bone grafting complication. Both approaches demonstrated a reasonable correction of lumbosacral angle. All patients demonstrated improvement in the neurological status with at least two grades improvement and good functional outcome.
Zhang et al. ¹⁹ (2015)	15/15	40.9 (17-67)	December 2006 to June 2011	China	One-stage surgical treatment by posterior fixation, anterior debridement, bone grafting, and anterior fixation of the cervicothoracic spine	Two patients experienced postoperative fever but both were well-managed with anti-inflammatory. No wound infection and other surgical complications were reported and bone fusion was completed within 3-6 months. Cobb angle decreased from 32° to 11.5° at the last follow-up. All patients demonstrated neurological improvement and the majority of them fully recovered with others recovered to grade C or D.
Liu et al. ²⁰ (2015)	60/60	44 (17 -83)	January 2003 and June 2009	China	Anterior approach or posterior approach or combined approach	All surgery achieved 6.28 \pm 5.01 in the average correction of kyphosis. The mean reconstruction in the vertebral body was described as 18.00% \pm 16.40% with the anterior approach showed 1.9 times higher than the others. No outcome on neurological function was investigated in this study.
Zeng et al. ²¹ (2015)	34/34	40.4 \pm 11.2	January 2003 to January 2013	China	One-stage posterior-only transpedicular debridement, interbody fusion and posterior instrumentation	Surgical complications reported in this study included water electrolyte imbalance, wound infection, mild intestinal obstruction, and cerebrospinal fluid leakage. Instrumental or bone graft or permanent complications were not found in this study. Pain relief was achieved in all patients with visual analogue scale decreased from 7.8 \pm 2.1 to 4.2 \pm 1.8 post-operation and 1.4 \pm 0.6 at the final follow-up. All patients demonstrated at least 1 grade of improvement in neurological function where 22 cases achieved 2 or 3 grades of improvement. Kyphosis angle was also found to drop from 34.1 \pm 12.3° to 8.2 \pm 1.8° post-operation.
Zeng et al. ²² (2015)	59/59	52.3 \pm 5.1	January 2000 to January 2013	China	Anterior approach or combined anterior posterior approach (debridement, bone fusion, and instrumentation) or posterior surgery (fixation with posterolateral fusion)	Wound infections or sinus formation was reported in three cases. 7 cases of mild dysphagia were described. In addition, 5 patients, mainly from anterior approach suffered from hardware-related complications including fracture and settlement of fixation. 3 anterior approaches patients also demonstrated pseudarthrosis and cage subsidence postoperatively. Correction of kyphosis was 14.1 \pm 5.3, 29.2 \pm 5.3 and 26.6 \pm 10.8 in group A, B and C respectively. Moreover, all patients demonstrated pain relief post-surgery and achieved bone fusion at 4-8 months.
Liu et al. ²³ (2016)	28/28	5-46	2003 - 2009	China	Vertebral column resection on cervical, thoracic and lumbar spine	3/28 patients experienced intraoperative and postoperative complications which includes dural tear, wound infection, nerve root and spinal cord injury or excessive haemorrhage and postoperative respiratory failure. 13/14 recovered from the preoperative neurological deficit and deformity corrections are observed in all patients during the final follow up. There is no severe instrumentation-related complication but adjacent-segment degeneration is occurred in 3 patients.

Most studies have achieved a satisfactory correction of kyphosis and improvement in neurological functions. Although debridement, instrumentation, and fixation are generally used, whether the treatment should only involve posterior-only approaches or combined anterior-

posterior approaches remains uncertain. While anterior debridement is found to be more effective in eliminating psoas abscess and paravertebral abscess, the combined approaches are associated with a longer operation time and a higher surgical complication rate⁵. Posterior-only approach is

associated with relatively better clinical outcome in both adult and elderly population, but its feasibility is subjective to the accessibility of the distant focus, the degree of bone destruction, and the associated risk of injuring the iliac vessels, aorta, abdominals contents, and the spinal cord⁶⁻⁸. In cases with atypical presenting features where TB involved the posterior column or presented as non-contiguous lesions, multifocal, surgical approaches need to involve complete debridement with combined-anterior-posterior approaches^{9,10}. Apart from the conventional surgical procedures mentioned above, some authors have also proposed new surgical techniques to treat conditions with certain characteristics. For instance, Rajasekaran et al. developed single-stage closing-opening wedge osteotomy which can effectively correct spinal kyphosis when the posterior column remained normal and unaffected¹¹. Consolidating all the studies in Table 6, the common surgical complications include superficial wound infection, pleural effusion, graft shifting, fat liquefaction and incisional hernia. The outcomes of late surgery are still found to be good in terms of treating myelopathy, achieving pain relief and eliminating bladder symptoms when compared to early surgery¹². Though an early operation is still recommended to achieve maximal recovery, surgery should still be considered even in a later stage.

Because of lack of adequate health care facilities, ignorance on patient's part regarding the illness, and poor socio-economic status, most of the patients present late. The average time of presentation in this study was 4.6 months. By the time of presentation, most patients will already have established spinal deformity. The most common deformity encountered

in this series was kyphosis which is more pronounced in the dorsal and dorso-lumbar region. The average kyphotic deformity observed was 37.2°. In the lumbar and lumbo-sacral region, the obvious clinical deformity was masked by natural lordosis which is radiologically observed as a loss of lumbar lordosis. The average deformity observed in this region was 18.6°. In conservatively managed cases, persistent deformity has been observed during follow up x-rays eventually leading to sagittal imbalance. Surgical correction of the deformity at the onset of the disease would have been much easier as compared to late established deformity.

In cases where there is no radiological or clinical spinal deformity, conservative treatment with antituberculosis chemotherapy does result in optimum clinical, radiological and functional outcome. But in cases with established deformity, though the disease can be eradicated or neurological deterioration can be prevented to some extent, the progression of the deformity cannot be stopped which will eventually lead to a sagittal imbalance in the future.

Based on the clinical and radiological findings we have classified tuberculosis into the following categories: 1) Uncomplicated – Patient has pain but no neurological deficit and clinical deformity. Radiologically less than 50% of the vertebral body is destroyed. 2) Complicated – Patient has pain but no neurological deficit. He/she has clinical deformity and radiologically more than 50% of vertebral body has been destroyed. 3) Complex – The patient has pain and neurological deficit with or without deformity. If the patient has a neurological deficit without deformity it is sub-classified as A, and if there is associated deformity, then B.

Table 7: Classification and algorithm of management

Uncomplicated	Complicated	Complex	
Pain Normal neurology No clinical deformity Radiological < 50% vertebral collapse	Pain Normal Neurology Clinical Deformity Radiological > 50% vertebral collapse	Pain Neurological deficit	
		Type A Without deformity	Type B With deformity
Treatment protocol			
Trial of conservative measures with intensive phase of ATT for 6 weeks after confirmation of diagnosis by percutaneous biopsy (CT or Fluoroscopy guided) If improvement- continue treatment with ATT If no improvement – Surgery (Abscess drainage / Posterior instrumentation)	Anterior debridement + Anterior reconstruction + Posterior Stabilization	Epidural abscess drainage + Posterior stabilization	Debridement + Anterior reconstruction + Posterior stabilization

The uncomplicated cases are managed by a trial of conservative treatment for 6 weeks. If the patient responds, then the treatment is continued. If the patient does not show any response, surgery is performed for abscess drainage (open or ultrasound guided), or posterior stabilization only. For complicated cases where there is radiological deformity due to vertebral body destruction of more than 50%, management consists of posterior stabilization, correction of deformity by pre-contouring the rod and draining the paravertebral abscess. The patient is put on antituberculosis treatment as per our protocol. The complex cases are treated with thorough anterior vertebral body debridement and reconstruction followed by posterior stabilization. Based on our experience, our recommended indications for surgery include: 1) Neurological deficit, 2) radiological deformity, and/or 3) severe pain which prevents patient from performing his / her activities of daily living.

Conclusion

This study describes Nepal experience of surgical management of spinal tuberculosis, and proposes a simple, pragmatic scheme for providing treatment for this population of patients.

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