



■ SPINE

The posterior-only surgical approach in the treatment of tuberculosis of the spine

OUTCOMES USING CORTICAL BONE ALLOGRAFTS

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Aims

The surgical treatment of tuberculosis (TB) of the spine consists of debridement and reconstruction of the anterior column. Loss of correction is the most significant challenge. Our aim was to report the outcome of single-stage posterior surgery using bone allografts in the management of this condition.

Patients and Methods

The study involved 24 patients with thoracolumbar TB who underwent single-stage posterior spinal surgery with a cortical bone allograft for anterior column reconstruction and posterior instrumentation between 2008 and 2015. A unilateral approach was used for 21 patients with active TB, and a bilateral approach with decompression and closing-opening wedge osteotomy was used for three patients with healed TB.

Results

A median of 1.25 vertebrae were removed (interquartile range (IQR) 1 to 1.75) and the median number of levels that were instrumented was five (IQR 3 to 6). The median operating time was 280 minutes (IQR 230 to 315) and the median blood loss was 700 ml (IQR 350 to 900). The median postoperative kyphosis was 8.5° (IQR 0° to 15°) with a mean correction of the kyphosis of 71.6%. Good neurological recovery occurred, with only two patients (8%) requiring assistance to walk at a mean follow-up of 24 months (9 to 50), at which time there was a mean improvement in disability, as assessed by the Oswestry Disability Index, of 83% (90% to 72%).

Conclusion

The posterior-only approach using cortical allografts for anterior column reconstruction achieved good clinical and radiological outcomes. Differentiation should be made between flexible (active) and rigid (healed) TB spine.

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The 2015 World Health Organization (WHO) Global Tuberculosis Report, shows that despite a reduction in the global incidence of tuberculosis (TB), and despite the fact that nearly all patients can now be cured, the disease remains a major threat.¹ The WHO highlights the problem that outbreaks of TB are related to the human immunodeficiency virus (HIV) epidemic. Up to 70% of adults who have TB are HIV-positive and about 60% of these patients have skeletal complications, compared with only 3% to 5% in HIV-negative patients.² Nearly 50% of musculoskeletal TB affects the spine,³ with the lower thoracic region being the most common site.⁴ Typically, TB affects two contiguous vertebrae, with the intervertebral disc being affected last. Atypical manifestations may be encountered in HIV-posi-

tive patients.⁵⁻⁷ In 2014, the South African National TB Management guidelines confirmed that HIV infection increases the risk of progression of both recent TB infections and reactivation of latent TB, by between 5% and 15%.⁸

Globally, it is estimated that 3.3% of new TB patients, and 20% of those previously treated, have multidrug-resistant tuberculosis (MDR-TB), increasing the complexity and cost of diagnosis and treatment.^{1,2,5-7} Anti-tuberculosis drugs form the cornerstone of treatment of all manifestations of the disease, including the spine, although the duration of treatment for musculoskeletal involvement remains controversial. Historically, the Medical Research Council and the 'middle-path' recommendations of Tuli⁹ confirmed the effectiveness of medical treatment, reserving surgery for medical failures.¹⁰

Historically, the surgical treatment of TB of the spine has consisted of radical anterior debridement, reconstruction, and fusion using iliac crest strut grafts. Loss of correction, however, is the most significant complication and is primarily due to the quality of the strut graft and the lack of instrumentation.¹¹ Allografts and titanium cages are alternatives to autograft struts; Govender and Parbhoo,¹² Riemer and Dunn,¹³ and Kawahara et al¹⁴ have reported their successful use through an anterior-only approach.

In order to address the problem of loss of correction, a combined anterior and posterior approach was developed. However, this requires long operating time. When it is staged, the patient may develop pneumonia between the procedures, leading to a delay.^{15,16} Yin et al¹⁷ have reported good results using a single-stage extrapleural costotransversectomy approach for anterior decompression combined with posterior instrumentation. Several authors have advocated using a single posterior approach in order to obviate the need for a second operation and to minimize the additional morbidity associated with a combined approach.^{14,18,19} This operation with a corrective osteotomy for angular kyphotic deformity was first described in 1945 by Smith-Petersen et al.²⁰ Kawahara et al¹⁴ later described the correction of post-traumatic thoracic and thoracolumbar kyphotic deformities using a closing or opening wedge osteotomy, through a single posterior approach. The procedure combined an *en bloc* spondylectomy described by Tomita et al,²¹ which had been developed for spinal tumours, with the approach devised by Smith-Petersen et al,²⁰ with modifications such as using a strut autograft or titanium mesh cage and posterior instrumentation. Despite its technical complexity, Kawahara et al¹⁴ suggested that access to the apex is easier posteriorly and that their technique can be used even in patients with normal spinal alignment, achieving satisfactory correction without jeopardizing the integrity of the spinal cord. Lonstein et al²² also found that both the spinal cord and the compressing wedge fragment were safely identified under direct vision from the lateral side. Leatherman and Dickson²³ stressed the principle that shortening and straightening rigid spinal deformities was possible for the correction of deformity with reduced neurological complications. Suk et al¹⁸ used a single posterior vertebral column resection in patients with a rigid kyphosis, of whom 25 were post-infective, and they were able to achieve up to 47.5° of sagittal correction. Wang et al¹⁹ modified this technique and reported similar results, using a limited combined resection of diseased vertebral bodies and posterior elements resulting in spinal shortening, without the need for an anterior spacer. Yang et al²⁴ confirmed better clinical outcomes through the posterior approach in a meta-analysis on the clinical efficacy and safety of these surgical approaches in the treatment of spinal TB.

The single-stage posterior-only approach has been used in our unit for patients who have conditions of the spine apart from TB, such as tumours, congenital malformations, and rigid adolescent idiopathic scoliosis. We have extended the indications to include two groups of patients with spinal TB: those with a flexible deformity, representing the active phase of the disease, who require a limited unilateral approach; and those with a rigid

angular kyphotic deformity, representing the healed phase of disease, who require a bilateral approach, decompression, and a closing or opening wedge osteotomy.

The aim of this study was to report the outcome of the posterior-only approach and the use of cortical bone allografts in the surgical management of patients with spinal TB. A secondary aim was to analyze the neurological recovery, the extent of incorporation of the graft, and the degree of correction of the kyphosis at final follow-up.

Patients and Methods

This was a retrospective study of 24 consecutive patients with TB of the thoracolumbar spine who underwent single-stage posterior-only spinal surgery and cortical bone allograft for anterior column reconstruction between March 2008 and July 2015. Ethical approval was obtained from the University of the Witwatersrand's Ethics Committee as well as administrative approval from the Chief Executive Officer of the Charlotte Maxeke Johannesburg Academic Hospital (CMJAH).

The presenting symptoms and signs were recorded, and the American Spinal Injury Association (ASIA)²⁵ impairment scale and the Frankel Grade²⁶ were used to assess neurological status and at final review. The Oswestry Disability Index (ODI) was used to assess function on admission and at the time of the final review.²⁷ Plain radiographs of the thoracolumbar spine were obtained at presentation, immediately postoperatively, and at the final review. The degree of kyphosis was recorded as described by Cobb²⁸ and Konstam and Blesovsky.²⁹ Radiological evidence of bony fusion or incorporation of the allograft was recorded using the criteria of Bridwell.³⁰ Where there were doubts, incorporation was assessed on CT scans using the classification system of Tan et al.³¹ MRI scans of the thoracolumbar spine were performed in all patients to assess the cause of neurological deficits, the number of vertebrae involved, and the status of the vertebrae that were to be included in the instrumentation.

Anti-tuberculosis therapy was initiated at the time of diagnosis in all patients and consisted of isoniazid, rifampicin, ethambutol, and pyrazinamide for two months initially during the intensive phase. This was followed by rifampicin and isoniazid for seven months during the continuation phase, according to our national guidelines.⁸ Rifampicin and isoniazid were continued for a further three months if the patient remained symptomatic or did not show radiological evidence of healing, or had evidence of ongoing disease with a persistently elevated erythrocyte sedimentation rate (ESR).³²

All operations were performed by the senior author (MML) with intraoperative motor evoked potential monitoring in seven patients (the four ASIA D patients and the three ASIA E patients). Following a posterior midline incision, pedicle instrumentation of the indexed segments and temporary stabilization of the contralateral side were performed with a pedicle screw and rod system. The extracorporeal approach was then accomplished through one- or two-level unilateral costotransversectomy in patients with a flexible spine or bilaterally in those with a rigid spine^{14,21} After completion of the

Table I. Characteristics of the patients

Variable	HIV-negative (n = 8)	HIV-positive (n = 16)	Total (n = 24)
Median age, yrs (IQR)	35.1 (21 to 49.5)	32 (29 to 37.5)	32 (27.5 to 41.5)
Gender, n (%)			
Male	2 (25)	5 (31.3)	7 (29.2)
Female	6 (75)	11 (68.8)	17 (70.8)
Spine region affected, n (%)			
Thoracic	4 (50)	10 (62.5)	14 (58.3)
Thoracolumbar	1 (12.5)	1 (6.3)	2 (8.3)
Lumbar	3 (37.5)	5 (31.3)	8 (33.3)
Median preoperative kyphosis (IQR)	34 (0 to 15)	30 (24 to 55)	30 (24.5 to 55)

IQR, interquartile range



Fig. 1a



Fig. 1b

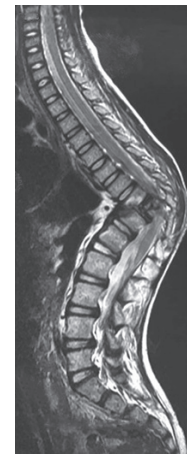


Fig. 1c

a) and b) Photographs and c) MRI T2-weighted sagittal image of the thoracolumbar spine of a ten-year-old HIV-positive boy (CD4:682), who was Frankel grade E but had a marked gibbus.

vertebral clearance, an allograft of the appropriate size (fibula, humerus, or tibia), packed with morcellized bone from the osteotomy and ribs, was placed into the space, followed by standard correction and stabilization. For centres that do not have access to allograft, a mesh cage or fibula autograft can be used.^{12,13} In those patients with healed TB, an extended laminectomy was performed to avoid dural and spinal cord buckling during the reduction and definitive fixation. The exiting nerve roots at T10 and above were ligated and all attempts were made to save the nerve roots below T10. When the parietal pleural was perforated, an intercostal chest drain was inserted.²⁰

Statistical analysis. Data analysis was carried out using Stata 13 software (StataCorp, College Station, Texas). Descriptive statistics of median, interquartile range, frequency, and percentage were used to analyze the data.

Results

The median age of the patients at the time of diagnosis and treatment was 32 years (interquartile range (IQR) 27.5 to 41.5) (Table I). A total of 16 patients (66.7%) were HIV-positive, with a median cluster of differentiation 4 (CD4) count of 342 cells/mm³ (IQR 262 to 445).

The median follow-up was 27 months (IQR 9 to 50); 17 patients (58.8%) were followed up for more than 24 months. Four patients (18.1%) were lost to follow-up. Most presented with constitutional symptoms of TB, associated with acute or chronic back pain, spinal deformity, difficulties with walking, or a combination of these symptoms.

A total of 11 presented with a kyphosis (gibbus) (Fig. 1). Two had a draining sinus, 21 had active TB, three had healed TB, and 19 had some neurological involvement at the time of presentation.

The surgical details of the patients are shown in (Table II). One patient had wound dehiscence that healed by secondary intention. A draining sinus that was present preoperatively in two patients healed spontaneously. The median kyphosis was 30° (IQR 24.5° to 55°) preoperatively and 8.5° (IQR 0° to 15°) at the final follow-up, representing correction of 71.6%.

Clinical and radiological outcomes. There was satisfactory neurological recovery in 22 patients with two requiring assistance to mobilize at the final follow-up (Table III).

The mean improvement in ODI at the time of the final review was 85% (90 to 72) (Fig. 2).

The diagnosis was made histologically and necrotizing granulomatous inflammation (NGI) was found in 22 patients

Table II. Surgical procedures

Surgery	
Median surgery duration, minutes (IQR)	280 (230 to 315)
Median level of instrumentation (IQR)	5 (3 to 6)
Graft position, n (%)	
Eccentric	6 (26.1)
Central	17 (73.9)
Blood loss	
Median blood loss, ml (IQR)	700 (350 to 900)
Median high care or intensive care unit stay, days (IQR)	1 (1 to 2)
Median hospital stay (operation to discharge), days (IQR)	11.5 (9 to 21)
Median vertebrae removed (IQR)	1.25 (1 to 1.75)

IQR, interquartile range

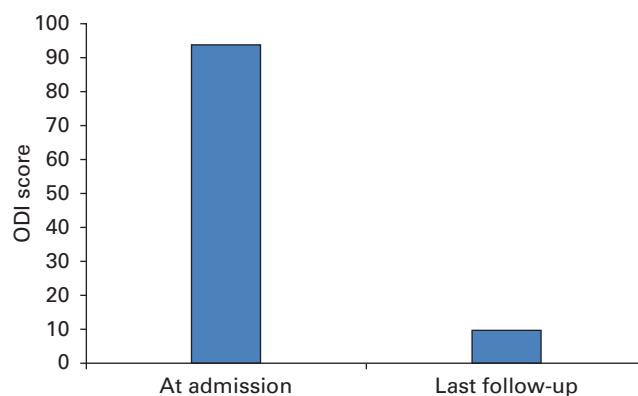


Fig. 2

Histogram showing the Oswestry Disability Index (ODI) at admission and at the time of the final review.

(92%). Five (21%) were positive for acid-fast bacteria (AFB) on standard stained smear microscopy. Four (17%) with negative AFB results had a positive polymerase chain reaction (PCR) and two of these (8) had a positive histology result.

The correction of kyphosis was maintained until the final review in each patient (Fig. 3). A total of 13 patients (54 %) had radiological evidence of complete fusion with remodelling of the allograft and cross-trabeculation (Grade 1). One patient (4%) had loss of correction with a displaced graft (Grade 4). For further assessment of fusion, 11 patients (45%) had CT scans. Using the classification of Tan et al,³¹ complete (grade I) fusion occurred in eight patients; two had only partial fusion (grade II).

Transient neurological complications occurred in three patients (13%) (Table IV). These symptoms resolved in two and improved to Frankel grade D at last final review in the third patient.

One patient developed a chest infection and superficial surgical site infection that resolved with antibiotics. No patient developed spinal sepsis related to the instrumentation. There were two deaths. One patient, with Frankel grade B neurological deficit (only sensory function below the level of the surgery level) died at home from complications of HIV. One patient with an L3 lesion had significant perioperative venous

blood loss and developed multiple organ failure and died in the intensive care unit.

Discussion

In this study, 16 patients (66%) with TB of the spine were HIV-positive. Most were women with a median age of 32 years (IQR 30 to 41). No patients had MDR-TB strains. The indication for surgery was a neurological deficit that had not responded to medical treatment, in all patients except three (12.5%). These three had a rigid angular kyphotic deformity and surgery was performed to improve both cosmesis and function, and to prevent progressive neurological symptoms. In this study, fewer vertebrae were removed and fewer levels were instrumented compared with Suk et al,¹⁸ who removed a mean of 2.5 vertebrae and fused a mean of 6.4 levels in a series of 70 patients. This is probably because a higher proportion of our patients had a flexible spine. The operating time in our series was comparable with that reported by both Suk et al¹⁸ and Wang et al,¹⁹ but shorter than that reported by Kawahara et al.¹⁴

The median intraoperative blood loss in our series (0.7 l, IQR 0.35 to 0.9) was less than that reported by Suk et al¹⁸ (2.98 l), Wang et al¹⁹ (2.93 l), or Kawahara et al¹⁴ (2.39 l), with the exception of one patient with blood loss of 7.0 l. Most patients



Fig. 3a



Fig. 3b



Fig. 3c

a) and b) Photographs showing maintenance of correction and c) Lateral CT view showing incorporation of the allograft, four years' follow-up.

Table III. American Spinal Injury Association (ASIA) scores preoperatively and at the final review

Preoperative ASIA score	Last follow-up ASIA score, n*				
	A	B	C	D	E
A			2	1	
B					2
C					6
D					4
E					3

*Four patients were not available for the final ASIA scoring

Table IV. Surgical complications

	HIV-negative	HIV-positive	Total
ASIA B immediately postoperatively, n	1	2	3
Chest infection, surgical site infection, n	1	1	2
Death, n	0	2	2
Loss of correction, no fusion, n	0	1	1
Bleeding, n	0	1	1

ASIA, American Spinal Injury Association

in our study had a full neurological recovery. However, three patients had postoperative neurological complications; these resolved in two patients and improved to ASIA D at last final review in the third patient. This is similar to others who have reported neurological complications in up to 10% of patients.¹⁹ We found a significant mean improvement in the ODI postoperatively of 83%, which was better than the reported 20% improvement following surgery for degenerative conditions of the lumbar spine.

We noted a mean correction of kyphosis of 71.6%, which is again comparable to other series.^{18,19} This correction was maintained and there was radiological evidence of allograft incorporation in 16 patients (94%) at follow-up. One HIV-positive patient with a low CD4 count lost correction and required anterior revision surgery using a titanium mesh cage and anterior instrumentation. Suk et al¹⁸ reported a similar rate

of complications, and our results also compared well with those of Govender and Parbhoo¹² and Riemer and Dunn,¹² who used an alternative anterior approach.

The posterior-only approach has an advantage over the anterior approach at the thoracolumbar junction, in that it is not necessary to reflect the diaphragm. The posterior approach is also useful at the cervicothoracic and upper thoracic region where visualizing the spine for inserting the graft can be difficult when using the anterior approach.

The study has limitations, including its small sample size and the fact that four patients were lost to follow-up. In conclusion, however, good clinical and radiological outcomes may be obtained for reconstruction of the anterior column in patients with TB of the spine using a posterior-only approach and cortical allografts. The deformity was corrected with incorporation of the graft. Although the procedure can be technically demand-

ing, correction can be obtained with less risk to the spinal cord. We would also recommend that a distinction is made between flexible (active) and rigid (healed) TB spines before surgery is performed, as we found that a flexible TB spine can be safely managed with a unilateral rather than a bilateral approach.



Take home message:

- The posterior-only approach using cortical bone allografts for anterior column reconstruction for the surgical management of tuberculosis of the spine achieved good clinical and radiological outcomes.

- Spinal correction and bone graft incorporation were obtained. Although the surgical procedures are technically demanding, they offer good correction with less risk when working around the spinal cord.

- The authors recommend that differentiation should be made between flexible (active) and rigid (healed) tuberculosis (TB) spines before surgery, as the flexible TB spine can be safely managed with a unilateral approach.

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U. N. F. Ukunda: Protocol, Literature review, Collecting and analyzing the data, Writing the manuscript.

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