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Original Article

Single stage decompression, anterior interbody fusion and posterior instrumentation for tuberculous kyphosis of the dorso-lumbar spine

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Study design: To evaluate the role of single stage decompression with anterior interbody fusion with posterior instrumentation and deformity correction of tuberculous kyphosis of the dorso-lumbar spine in patients with/without neurological deficit.
Objectives: (1) To evaluate the amount of kyphosis correction with single stage surgery and its progression with time. (2) To evaluate the neurological recovery. (3) To evaluate the bony anterior interbody fusion.
Setting: King Edward Memorial Hospital, Bombay, India.
Methods: Twenty-eight patients with post-tuberculous kyphosis deformity averaging 64.3° (range 17 to 105) were treated by a single stage posterolateral decompression, correction of kyphosis, anterior interbody fusion and posterior instrumentation.
Results: The mean kyphosis correction obtained was 62.5% with the mean post-operative kyphosis angle reducing to 24.1 (range 5–60). At a mean follow-up of 5.8 years (4–7 years) the mean kyphosis angle loss was 3.2° (range 0–5°). Of the 23 patients with neurological deficit, recovery was seen in 21 cases (91.3%) while deterioration was seen in one case (4.3%). The remaining five patients were neurologically intact pre-operatively. Bony fusion was seen in all cases at 9 months. One patient with subpulmonary function died post-operatively (mortality 3.5%).
Conclusion: The results of our series are encouraging. However single stage decompression with fusion and kyphosis correction is a very demanding surgery and should be performed after taking into account the risks and benefits involved. This surgery perhaps prevents progression of neurological deficit and recurrence of late onset paraplegia in these complex cases in developing countries.
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Keywords: tuberculosis; kyphosis; fusion; decompression

Introduction

Tuberculosis of the spine is a common cause of severe kyphosis deformity of the thoraco-lumbar spine. Anti-tuberculous chemotherapy revolutionised its treatment in the 1950s but did not arrest the development of kyphosis.

Rajasekaran and Soundarapandian[1] stated that anterior debridement alone did not control kyphosis, and an increase in the deformity was seen in patients with extensive involvement of the vertebral body involving two disc spaces. Lesions of the thoracic vertebrae were associated with many poor results and patients with marked kyphosis did not do well. They advocated additional measures to enhance graft stability to prevent graft collapse in patients in whom the length of the graft exceeds two disc spaces.

Oga *et al*[2] stated that grafts are prone to failure and resorption especially when more than two vertebrae are excised. Moon *et al*[3] suggested that posterior instrumentation, anterior interbody fusion is helpful in arresting disease, providing early fusion, correcting kyphosis and preventing progression of kyphosis. Jenkins *et al*[4] reported a 46.4% increase in kyphosis in children with posterior instrumentation. Hongkong treatment (anterior debridement, decompression and autologous bone grafting.

Thus the problem of post-tubercle kyphosis is a complex one, with no easy solution. We report our results of single stage posterolateral decompression, anterior interbody fusion, posterior segmental instrumentation and correction of post-tuberculous kyphosis of the thoraco-lumbar spine.

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Materials and methods

From January 1990 to December 1994, 28 patients with post-tubercle thoraco-lumbar kyphosis deformity were managed with single stage posterolateral decompression, anterior interbody fusion, posterior segmental instrumentation and correction of post-tuberculous kyphosis of the thoraco-lumbar spine (Table 1).

Pre-operative evaluation

The criteria for entry in the study was histopathological confirmation of tuberculosis. There were 16 male and 12 female patients with a mean age of 28.3 years (range 3–61 years).

Neurological function on admission was graded according to Frankel *et al*,[5] three patients were grade A (complete motor and sensory deficit), three grade B (sensory sparing but no motor function), 15 grade C (motor sparing but functionally useless), two grade D (functionally useful motor power) and five grade E (normal motor and sensory function). Eighteen patients were paraparetic for an average of 6 months (range: 2 weeks to 8 months). Five patients had sudden deterioration in neurological function prior to admission, necessitating emergency decompression.

Anterioposterior, lateral radiographs and technetium 99 bone scans of the entire vertebral column did not reveal any skip lesions (more than 1 level affection).

The progression of kyphosis was studied on pre-treatment and end-treatment lateral radiographs. The kyphosis angle was determined by Konstam and Blesovsky method.[6] Accordingly there were five patients with mild kyphosis ($<40^\circ$), 12 with moderate kyphosis ($40-80^\circ$) and 11 with severe kyphosis ($>80^\circ$). The mean preoperative kyphosis angle was 63.5° (range $17-105^\circ$). Hyperextension lateral radiographic views confirmed that the kyphosis deformity was rigid in all cases.

Table 1 Demographic and treatment details of patients treated with single stage decompression, anterior interbody fusion and posterior instrumentation for tuberculous kyphosis of the dorsolumbar spine

No	Age (years)	Sex	Fu (years)	Vert. level	Prev. surg	Preop angle (deg)	Postop angle (deg)	Preop neuro: Frankel	Postop neuro: Frankel	Fix[n]	Graft consolidation (month)	Complication	Cosmesis
1	5	M	4.5	D5,6	–	60	5	A	D	HH	2	–	E
2	3	M	7	D10–L1	–	105	12	C	E	HH	3	Pleural tear	E
3	9	M	6.5	D12–L1	–	60	12	B	E	HH	2.5	Dural tear	E
4	11	M	7.2	D5–7	–	62	12	C	E	HH	3	–	E
5	60	M	4.4	D8–10	ALD	82	20	A	D	HH	6	–	E
6	53	M	6	D11–12	AKT	34	14	C	E	S	3.5	–	E
7	58	M	7	D7–9	AKT	56	22	C	E	HH	6	–	E
8	21	M	4	D11–L1	ADF	82	36	B	A	S	–	Died	–
9	19	M	4.5	D11–L1	ADF	84	42	C	E	HH	3	–	G
10	38	M	6	D5–7	ALD	96	60	E	E	HH	3	Dural tear	P
11	46	M	4	D10–L1	AKT	82	32	D	E	HCS	6.5	–	E
12	39	M	7	D10–L1	AKT	62	30	C	E	S	6.5	–	E
13	14	M	4.5	D10–L1	–	96	18	C	E	HH	9	–	E
14	23	M	6.2	D10–11	–	38	8	E	E	HCS+ rev[n] to S	4.5	Implant failure +graft slippage	G
15	46	M	4.5	D6	–	17	5	E	E	HH	3	–	E
16	24	M	6.2	D8–9	ADF	82	34	E	E	HH	3.5	–	G
17	4.5	F	7	D7–8	AKT	72	34	C	E	HH	2	Pleural tear	G
18	10	F	4	D6–7	–	52	18	E	E	HH	2.5	–	E
19	11	F	6	D10–L1	–	24	12	C	E	HH	3.5	–	E
20	53	F	7.2	D7–D9	AKT	42	14	A	A	HH	3	No neur. recovery	E
21	61	F	4.5	D6–8	ALD	56	18	C	E	HH	6	–	E
22	26	F	7	D10–12	AKT	46	22	B	E	HH	3.5	–	E
23	18	F	4.2	D7–9	ALD	42	20	C	E	HH	9	Wound inf[n]	E
24	24	F	6.5	D11–L1	AKT	80	40	C	E	HH	4	–	G
25	28	F	7	D11–L1	–	82	38	D	E	HCS	6	–	G
26	31	F	4.6	D12–L1	AKT	38	10	C	E	S	3.5	–	E
27	42	F	7.2	D10–L1	–	65	42	E	E	S	9	Wound inf[n]	P
28	16	F	7	D9–D11	AKT	82	30	C	A	S	9	Neuro. deterioration	G

AKT: anti-tuberculous drug treatment, ADF: anterior debridement and fusion; ALD: anterolateral debridement; HH: Hartshill rectangle; HCS: Harrington compression system; S: Steffe pedicular fixation; E: excellent, G: good; P: poor

Destruction of vertebral bodies, as shown on the lateral radiographs was recorded as the total number of vertebral bodies that had been destroyed by tuberculosis. The average number of vertebrae affected were 2.8 (range 1–4 vertebrae). One level affection was seen in one patient, 2 level in eight patients, 3 level in 13, and 4 level affection in six patients. In 16 patients the kyphosis was thoracic and 12 had junctional thoraco-lumbar kyphosis. Eleven patients had no previous treatment, nine were on antituberculous chemotherapy treatment, four had previous aterolateral decompression and three had previous anterior debridement and fusion. MRI scans were taken in patients with neurological deficit and in patients who had severe kyphosis in which the lateral radiographs anatomy was difficult to interpret.

Principle of surgery
The operation consisted of posterolateral approach, release of tether, removal of granulation tissue, pus, caseous material and sequestrum, decompression of cord, tricortical iliac crest bone grafts (23 patients) or iliac crest and rib grafts (four patients) or fibular graft (one patient), and segmental posterior spinal instrumentation. Twenty patients had an acute lesion consisting of pus, caseous material, granulation tissue and sequestrum, while eight patients had a dry lesion.

Postoperative treatment
Postoperatively all patients were given bed rest for 6 weeks. Mobilisation was started after 6 weeks using a TLSO (thoraco-lumbarsacral orthosis)-modified Taylor's brace with axillary support. The brace was discontinued once the graft had consolidated. All patients received antituberculous chemotherapy consisting of streptomycin, isoniazid, rifampicin, pyrazinamide and pyridoxine for 2 months and later isoniazid, pyrazinamide and pyridoxine for an additional 7 months.

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 tests were monitored till the patients had completed their chemotherapy.

The end point of the treatment was indicated by the following criteria:

(1) Clinical: Relief of pain, absence of abscess or discharging sinus, improvement in neurological function.
(2) Laboratory results: Erythrocyte sedimentation rate of <10 mm/h.
(3) Radiological: Bony fusion, graft consolidation, remodelling and hypertrophy, sclerosis of contiguous surface of disc spaces and absence of motion on lateral hyperextension radiographs.

Operative method
The operation was carried out under additional antibiotic cover using first generation cephalosporin. All patients were preoperatively started on four drug antituberculous chemotherapy.

Posterolateral retropleural approach (Modified Rene' Louis approach):[7] With the patient in prone position a midline incision was made centred on the kyphosis. After the paraspinal muscles were retracted, a costotransversectomy and excision of pedicle was carried out at the apex of the kyphosis deformity. The abscess was drained and granulation tissue and bony sequestrum were debrided and the cord decompressed. All bony and soft tissue tethers preventing correction of kyphosis were removed. The operating table was tilted to facilitate this decompression. Subsequently, correction of the kyphus was achieved by segmental spinal instrumentation using Hartshill rectangle with sublaminar or costotransverse wiring in 19 patients and stefee pedicular instrumentation in six patients. In three patients a Harrington compression instrumentation was used. The Kyphosis deformity was gradually corrected taking full care that the spinal cord was not stretched or distracted. Because of financial constraints the surgery was carried out without cord monitoring. The anterior defect was subsequently grafted using tricortical iliac crest, rib grafts or fibular strut grants after proper slots to engage the grafts were made in the recipient vertebral bodies. The pleural continuity was then confirmed and the wound was closed in layers over a negative suction drain.

The aim of single stage surgery is to achieve maximum correction of the kyphosis by elongation of the anterior column. The spinal cord is kept under constant vision to ensure neither distraction nor compression of the cord occurs. The instrumentation extended two normal vertebrae above and below the apex of the kyphosis and tuberculous focus in 23 cases and one level above and below in five cases. Posterior segmental instrumentation resulted in short segmental immobilisation resulting in mobility of the remaining spine, graft stability and good correction of the kyphosis deformity.

Results

The average time to bony fusion was 4.5 months (range 2–9 months). Bony fusion was seen in 18 patients at 3 months, 24 patients at 6 months and in all 28 patients by 9 months. Three stages of bone graft consolidation were observed: (1) No new bone, lytic area around the graft; (2) Callous formation but no bridging trabaculae; (3) Trabaecular continuity with no lytic areas.

We used a constant distance to take radiographs to eliminate any magnification error and used the width of the vertebrae at the upper end of the graft as a

control between serial radiographs. Significant hypertrophy was seen in 24 of the 28 patients. Hypertrophy of graft was recorded as significant when its post-operative diameter on the lateral radiograph had increased by at least 25%.

The mean operative blood loss was 850 ml (range 400–2000 ml). The mean pre-operative kyphosis angle of 63.5° (range 17–105°) was reduced to 23.5° (range 5–60°) post-operatively, a 40° mean correction. At a mean follow-up of 5.8 years (range 4–7 years) the average correction was 26.7°, a loss of 3.2° (range 0–5°). Thirteen patients had a kyphosis angle of less than 20°, 11 less than 40° and four had a post-operative kyphosis angle of more than 40° at final follow-up (Figure 1).

Neurological improvement from admission to latest follow-up was a mean of 2.6 Frankel grade. Twenty-three patients had a normal neurological function (Frankel grade E) while three walked with the help of crutches (Frankel grade D). One patient had neurological deterioration while one failed to recover (Frankel grade A). Full neurological recovery was achieved by 50% in 3 months, 70% in 6 months, 80% at 9 months and 95% at 15 months. One patient had postoperative implant failure with graft slippage which required revision of instrumentation with graft repositioning (Figure 2). One patient with subpulmonary function (pulmonary tuberculosis with decreased suboptimal pulmonary function test) who had neurological deterioration after surgery died

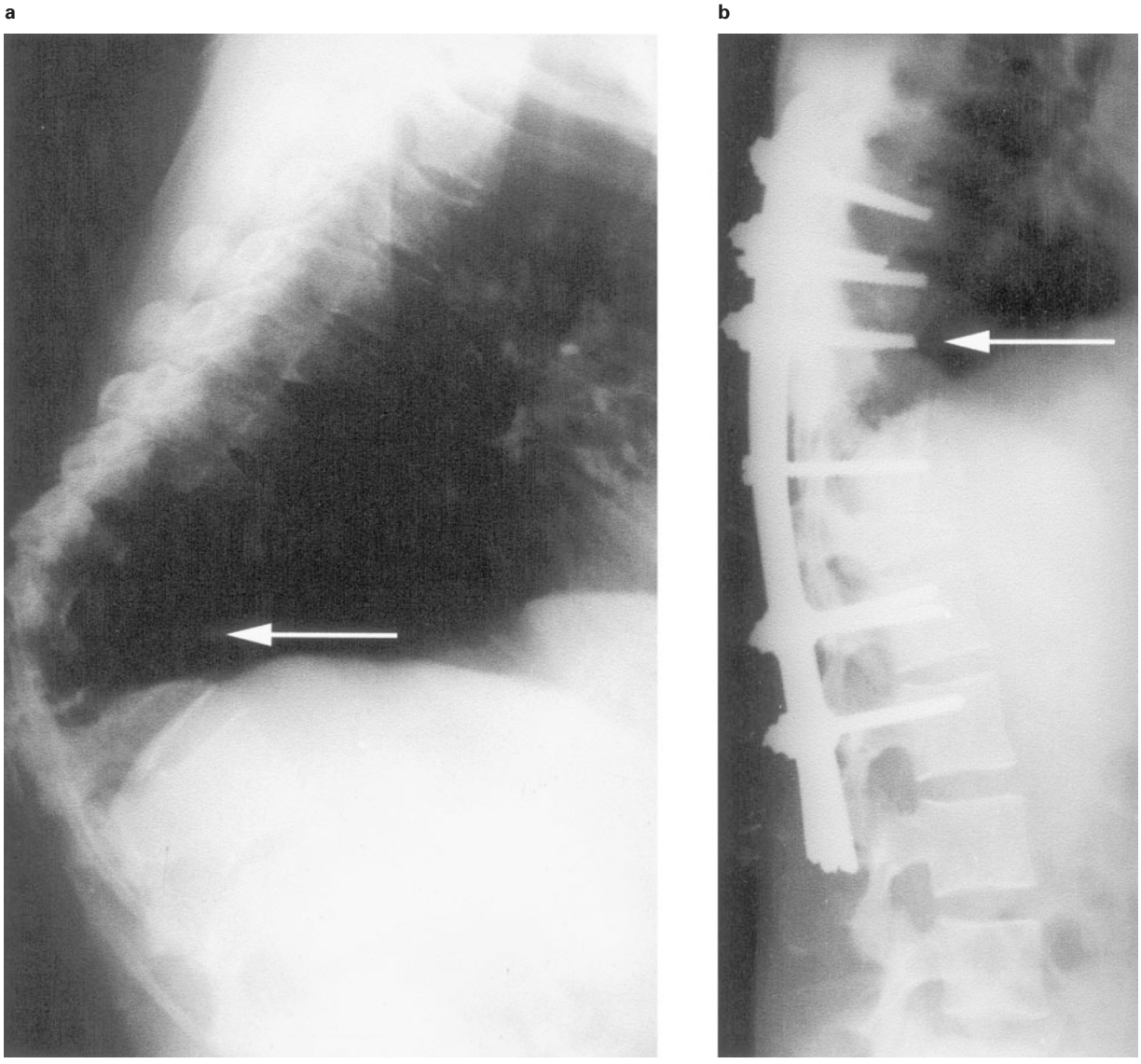

Figure 1 (**a**) Preoperative x-ray showing D11-12 tuberculous kyphosis with neurological deficit. (**b**) Postoperative X-ray showing kyphosis correction with fusion and segmental instrumentation using steffe pedicular plate fixation

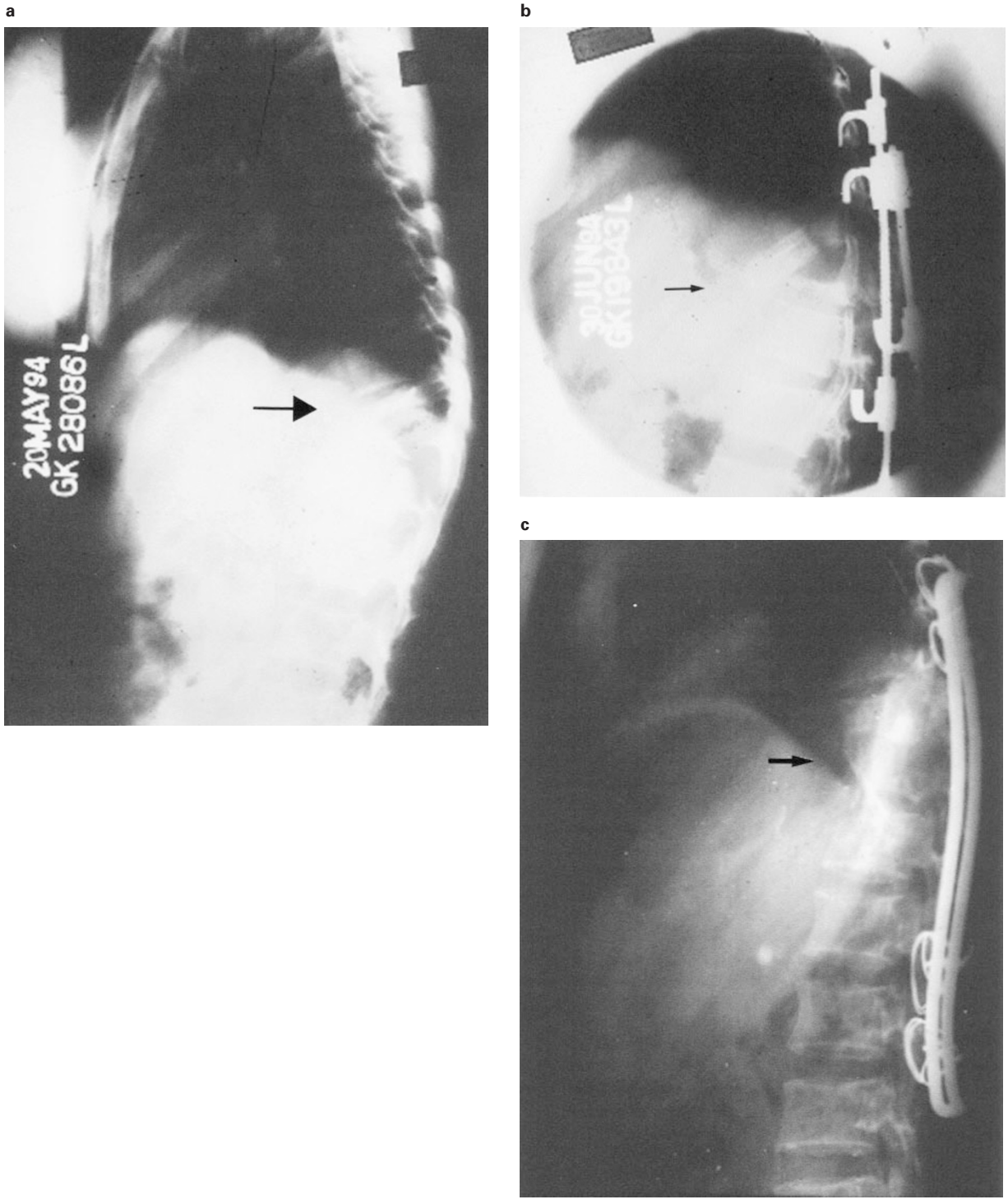

Figure 2 (**a**) Preoperative X-ray showing D10-11 kyphosis without neurological deficit. (**b**) Postoperative X-ray showing graft dislodgement and implant failure after use of Harrington compression system. (**c**) Follow up X-ray showing graft consolidation after revision surgery (Graft repositioning and Hartshill rectangle)

(mortality, 3.5%). This patient was excluded from the review.

Patients or parents rated cosmetic correction as excellent in 18, good in seven and poor in two patients. An important feature of reduction of the kyphosis, was restoration of normal spinal balance.

The surgical complications encountered during this procedure are summarised in Table 2.

Table 2 Complications of single stage surgery

1	Implant failure (requiring revision)	1
2	Graft slippage (requiring repositioning)	1
3	Dural tear (sutured)	2
4	Pleural tear (intercostal drainage tube)	2
5	Worsening of neurological status	1
6	Superficial wound infection	2
7	Mortality	1

Discussion

Although tuberculosis has been brought well under control in most healthier countries, it may still be described as a world-wide scourge. It is estimated by The World Health Organisation that there are 30 million patients with overt tuberculosis.[8] There is an increasing trend towards an increase in developed as well as developing countries in parallel with growing number of immunocompromised patients.[9]

Rajasekaran *et al*[9] suggested a strong correlation (correlation coefficient: 0.83) between the initial loss of vertebral body and the final gibbus in patients who had tuberculous lesions of the thoracic and thoracolumbar spine. 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, $30-35^\circ$ of gibbus deformity occurred.

The Medical Research Council's trial suggested treatment of paraplegia due to active tuberculosis of the spine could be managed conservatively by antituberculous drugs alone.[10] However this trial dealt mainly with limited disease with little kyphosis deformity.

In 1960, Hodgson and Stock[11] advocated anterior arthrodesis as treatment of choice for tuberculosis of spine. They also advocated posterior instrumentation to correct unfixed kyphus with prior anterior release.[12] Moon *et al*[3] advocated two stage spinal surgery with posterior instrumentation and anterior arthrodesis under cover of chemotherapy to arrest the disease early, achieve early fusion, prevent progression and correcting kyphosis and satisfying cosmetic and aesthetic demands of patients with kyphosis. Luk suggested radical surgery as treatment of choice to prevent late deformity and paraplegia which can be unresolvable.[13] Yau *et al*[14] advocated correction of kyphosis with spinal osteotomy, halopelvic distraction, anterior and posterior fusion.

Louw[23] advocated the 'Kalafong procedure' for treatment of spinal tuberculosis with neurological deficit. It consisted of anterior debridement with decompression of cord (Hodgson and Stock[11]) osteotomy and/or soft tissue release and a vascular rib pedicle bone graft (Rose *et al*[15]; Bradford[16]). This is followed either at same stage or second stage by posterior multilevel osteotomies, spinal instrumentation and fusion.

Single stage combined posterior and anterior procedure allows reduction of long standing rigid kyphosis. An important feature of reduction of kyphosis is restoration of normal spinal balance. The most feared complication, that of spinal cord damage, is avoided by meticulous attention to total release of all anterior and lateral adhesions allowing spinal cord to move forward unhindered during reduction of kyphosis. Segmental instrumentation is preferred as it provides a very effective three point fixation system. Posterior instrumentation also helps to maintain correction of kyphosis till fusion is solid.

Upadhyay *et al*[17] in their study with a 17-year follow-up compared the Hong Kong operation (radical surgery) with debridement surgery for short and long term outcome of deformity. They state that deformity angles at 6 months post-operative evaluation compared to preoperative values were significantly different between radical and debridement group. Those patients who underwent radical surgery showed an overall correction, whereas those with debridement surgery showed deterioration. They therefore suggested that correction after surgery is important because it is virtually maintained up to final follow-up.

It is difficult to compare our series with that of other series reported in literature because of varying clinical presentation and different treatment modalities used.

The radical surgical treatment (Hong Kong treatment) consisting of anterior debridement, decompression and autologous bone grafting gave a 1° correction in their series but gave a 21° deterioration in the South African series.[10,18] Jenkins *et al*[4] reported a 46.4% increase in kyphosis at a 10-year follow-up in children managed by anterior decompression and fusion. Lifeso *et al*[19] in his series of 107 adult patients with predominantly thoraco-lumbar spine affection had 65 patients with neurological involvement. Twenty-nine (94%) of the 31 patients who had anterior decompression improved and 19 (79%) of the 24 with chemotherapy alone, and five (55%) of the nine improved after a laminectomy. The average time to neurological recovery after anterior decompression was 5.6 months to 6.6 months in patients treated conservatively with chemotherapy. The kyphosis angle worsened by 0.6° in patients operated by anterior decompression to 3.2° in patients treated by medical regime.

Yau *et al*[14] treated 30 patients with spinal osteotomy, halopelvic distraction, anterior and posterior fusion. The mean pre-operative kyphosis angle was 115.5° which improved by 32.4° (28.3%). Three patients had more than 10° loss of correction due to fatigue failure of grafts. Three patients died postoperatively suggesting the high mortality and risks associated with this procedure.

Moon *et al*[3] treated 39 patients with posterior instrumentation and anterior interbody fusion for

thoraco-lumbar tuberculous kyphosis. The mean preoperative kyphosis angle of 37° improved to 16°. At a mean follow-up of 3.6 years the angle was 18°. No patient had a loss of correction of more than 3°.

Yilmaz *et al*[20] treated 38 patients with anterior instrumentation and fusion. With a mean follow-up of 2 years and 5 months 22 patients who had one to two level affection had a 64% correction of kyphosis (58% – 90%). Sixteen patients who had more than 2 level affection had a 81% (75% – 97%) correction. The maximum loss of correction was 3° in 16 patients. Neurological recovery was seen in 37 patients and one patient with paraplegia died post operatively. They suggest that posterior instrumentation is associated with increase operative time, greater blood loss, prolonged anaesthesia and increased postoperative morbidity. Anterior instrumentation on the other hand avoided all these complications. It gave better correction of deformity and decreased time to fusion. Kostuik *et al*[21] and Maskovich *et al*[22] also advocated the use of anterior instrumentation for these deformities.

Louw[23] treated 19 patients with anterior vascularised rib grafts, posterior osteotomies and fusion (Kalafong procedure) either in one or two stages. The mean pre-operative kyphosis angle of 56° improved to 27° postoperatively. At a mean follow-up of 25.5 months there was a 3° loss of correction 18 patients (95%) had a normal neurological function post-operatively at 14 months. Radiological fusion was achieved at an average of 3.3 months.

Despite the excellent results of the Kalafong procedure which have been reproduced in our series, there may be doubt as to whether all the additional effort and risks are justified in adult patients where cosmetic results may be less important than treatment of neurological deficit. However treatment of Pott's paraplegia of late onset, especially in the inactive stage, is a difficult problem as suggested by Hsu *et al*,[24] and hence the necessity for correction of kyphosis deformity. We, however, believe that non-vascularised autogenous grafts are just as effective to achieve spinal fusion as vascularised rib grafts, and do not recommend this difficult and longer operation.

Conclusion

Single stage combined posterior instrumentation and anterior fusion using the posterolateral approach allows decompression of the cord, reduction of long standing kyphus and restoration of normal spinal balance. The most feared complication, that of spinal cord damage, is avoided by meticulous attention to release of all anterior and lateral tethers and adhesions allowing the spinal cord to move forward unhindered during the reduction of the kyphus.

Segmental instrumentation is preferred as it provides a very effective 3-point system. Posterior instrumentation aids kyphosis correction, provides graft stability and aids early mobilisation.

The correction of post-tuberculous kyphosis is a demanding surgery. This should be performed after proper patient selection taking into account the risks and the benefits involved.

The results of this series are encouraging. Decompression with correction of deformity is perhaps a practical answer to prevent progression of neurological deficit, kyphosis and the late onset paraplegia in these complex cases in the developing countries.

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