CLINICAL ARTICLE

The surgical management of spinal tuberculosis in children and adolescents

C Reid MBChB(Pret)
Registrar
RN Dunn MBChB(UCT), MMed(Orth), FCS(Orth)SA
Consultant Spine and Orthopaedic Surgeon, Head of Spine Services
Groote Schuur Hospital and Red Cross War Memorial Children's Hospital, Division of Orthopaedic Surgery,
University of Cape Town

Reprint requests:
Prof RN Dunn
Department of Orthopaedic Surgery
Groote Schuur Hospital
H49 OMB
Observatory
Tel: (021) 404-5387
Fax: 086 6715 294
E-mail: info@spinesurgery.co.za

Abstract

Background:

Antituberculous chemotherapy remains the cornerstone of treatment of tuberculosis (TB) of the spine and the paediatric and adolescent populations respond particularly well to medical management. These patients are however more prone to kyphotic deformity of the spine both during the active phase, and after the disease has been cured. The British Medical Research Council Working Party on tuberculosis of the spine has found only slight advantages to surgical management over medical management and advocated ambulant chemotherapy alone where adequate facilities are lacking.[1] However patients with neurological compromise were excluded from the initial trials. Patients managed surgically had either anterior debridement and strut grafting (Hong Kong procedure) or anterior debridement alone. No posterior fusion was performed and no instrumentation was used.

Methods:

We reviewed all patients under the age of 18 years who had undergone surgery for TB spine at Groote Schuur and the Red Cross War Memorial Children's Hospital from 2001-2008. Forty patients were identified on interrogation of the senior author's (RND) prospectively maintained database. The anatomical distribution was: Sixty-six per cent thoracic, 15% lumbar, 14% cervical or cervicothoracic and 5% thoracolumbar. Indications for surgery included: deformity (50%), neurological compromise (44%), instability (13%), pain (10%), revision (10%), diagnosis (4%) and failure of medical management (4%) Surgical procedures included: primary fusion (35), graft revision (5), drainage of psoas abscess (4), costotransversectomy (3) and biopsy (2). The majority of the fusions were anterior and posterior (25) the others were posterior only (9) or anterior only (1).

Results:

Where acute correction of deformity was attempted, an average kyphosis of 53° was improved to an average of 38°. At last follow-up correction was better maintained in cases where instrumentation was used, compared to un-instrumented fusions. No neurological deterioration occurred after surgery but two patients failed to improve despite decompression. The rest became ambulant. Complications included graft failure that required revision in five cases and recollection of psoas abscesses in a patient with multi-drug-resistant (MDR) TB.

Conclusions:

Surgery for spinal TB in the paediatric and adolescent groups can be safe in terms of a low complication rate, and effective with good correction of deformity that is well maintained with instrumentation.

Introduction

Tuberculosis (TB) is endemic to South Africa and the country has the second highest incidence (948 per 100 000 population per year) in the world after Swaziland.[2] Extra-pulmonary TB accounts for 15-20% of cases, 10% of which are skeletal. Spinal TB represents 50% of skeletal TB cases and 0.5-1% of all cases.[3] Children are affected in 5-15% of cases. Therefore TB spine in children accounts for 0.025-0.15% of all TB cases. It is rare for children to have a positive sputum smear and they are rarely infectious. The incidence of TB in children reflects a failure of TB control in adults.[4]

Antituberculous chemotherapy remains the cornerstone of treatment of TB spine and the paediatric and adolescent populations respond particularly well to a typical course of 9 months therapy of rifampicin, isoniazid and pyrazinamide. There is however no doubt that surgical intervention, combined with chemotherapy, has a vital role to play in certain instances. The younger patient poses a few unique challenges to the spinal surgeon. Inability to verbalise symptoms may lead to a delayed presentation. It may also delay recognition of side effects to medication, specifically ethambutol (retro-bulbar neuritis, which becomes irreversible once established). The surgeon is also confronted by the technical difficulties of operating on a small spine, and the problems, or potential advantages, posed by the dynamic nature of a growing spine.

Regardless of the approach, the goals of treatment should be to eradicate the disease, prevent neurological deficit or recover existing deficit and to correct or prevent unacceptable deformity.

Materials and methods

We reviewed 40 consecutive patients under the age of 18 years who had undergone surgery for TB spine at Groote Schuur and the Red Cross War Memorial Children's Hospital. Surgery had been performed by the senior author (RND) between 2001 and 2008. Gender distribution was 17 male and 23 female (1:1.35). In our department, paediatric TB spine patients are primarily managed by the paediatric orthopaedic unit. The patients in this series were ones who had been referred to the spinal unit for surgical consideration. There was therefore a selection bias.

Patients ranged in age between 2 years 9 months and 17 years 7 months, with a mean age of 9 years 6 months at the time of surgery. The majority of patients had more than one complaint at presentation; 50% complained of pain, 45% of weakness and almost a third were aware of a gibbus. The average ESR was 67 (10-140). Patients were initially not routinely tested for HIV and of the latter 13 tested, two were positive (15%). Special investigations directed specifically at testing for TB included a Mantoux skin test in the younger patients as well as microbiology and histology on specimens collected at surgery.

The majority of patients had already commenced TB treatment prior to referral to the spinal unit, which accounts for a relatively low yield from Ziehl-Nielsen stain and culture *(Figure 1)*. Histology was regarded as positive if necrotising granulomata or acid-fast bacilli were observed, and suggestive if non-necrotising granulomata were observed. The diagnosis of TB was either confirmed or highly suggested in all but one patient. In this patient the diagnosis was based on radiological findings and response to treatment. The thoracic spine was affected in the majority of cases (66%), followed by the lumbar spine (15%), with the cervical and cervico-thoracic spine accounting for 14% and thoraco-lumbar 5%.

Many patients had more than one indication for surgery. Deformity was the most common indication (50%) followed by neurological compromise (44%) and instability (13%). Primary fusions accounted for 72% of the procedures. Of the 35 primary fusions done 25 were anterior and posterior fusions. In all of these cases an anterior strut graft was used, 19 had posterior onlay bone grafting, six had posterior instrumentation and four had anterior instrumentation. Nine patients had posterior fusions only, eight of whom had *in situ* posterior onlay fusions and one was an instrumented fusion. One patient had an anterior fusion only with a strut graft and instrumentation *(Figure 2)*.

Results

Deformity correction

Twenty-four spinal fusions were done for severe deformity (35°-84° kyphosis). During the initial period of this series all of the fusions were un-instrumented. With growing confidence in the use of instrumentation in spinal TB surgery, and improved funding, there has been a gradual increase in the use of instrumentation and it is currently preferred in most cases where deformity correction is sought *(Figure 3)*.
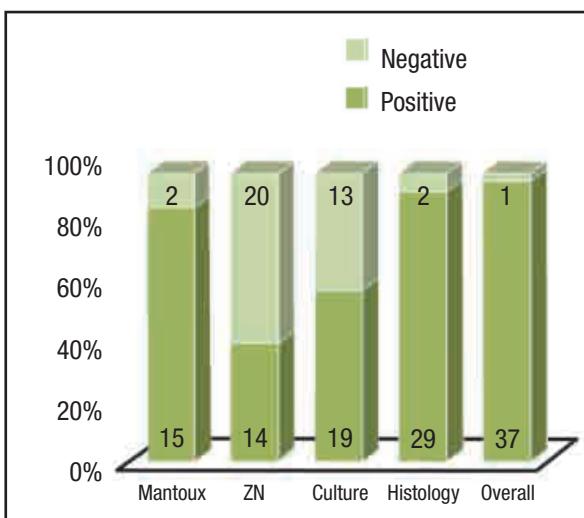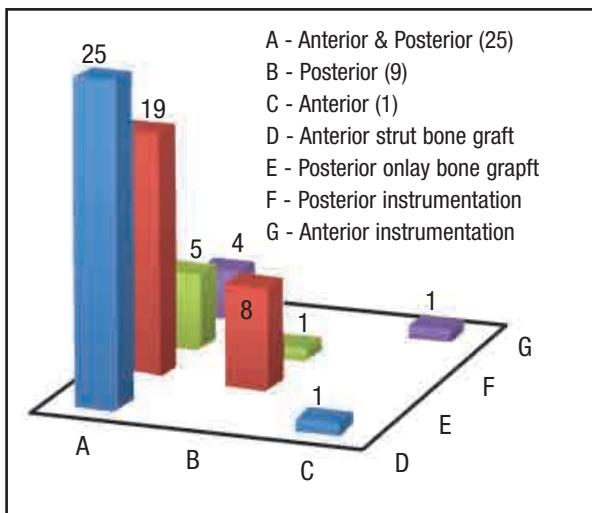

Figure 1: TB diagnostic tests

25
19
5   4
8
1
1

A - Anterior & Posterior (25)
B - Posterior (9)
C - Anterior (1)
D - Anterior strut bone graft
E - Posterior onlay bone grapft
F - Posterior instrumentation
G - Anterior instrumentation

1

A   B   C   D   E   F   G

Figure 2: Breakdown of the 35 primary fusions

Table I details the breakdown of the procedures performed for deformity correction. Twelve patients who had anterior and posterior un-instrumented fusions (anterior strut graft and posterior onlay bone graft) had an average pre-operative kyphosis of 54° and at follow-up an average of 47°. In three cases where an anterior strut graft was combined with posterior instrumentation (pedicle screws and rods), an average pre-op kyphosis of 55° was improved to 35° at follow-up. In two cases where anterior vertebral body screws and rods were also added, similar results were seen. In one case an anterior locked plate and posterior onlay bone graft was done for a C4-T1 fusion. The kyphosis of 55° was corrected to 20°, but subsequently 10° of correction was lost.

When fusing a growing spine it is essential to fuse both anteriorly and posteriorly to prevent deformity with growth[5] (the 'crankshaft phenomenon'). The exception is when the surgeon plans to utilise remaining growth to assist with deformity correction. In our series one anterior fusion only (strut and instrumentation) was performed in a skeletally mature patient.
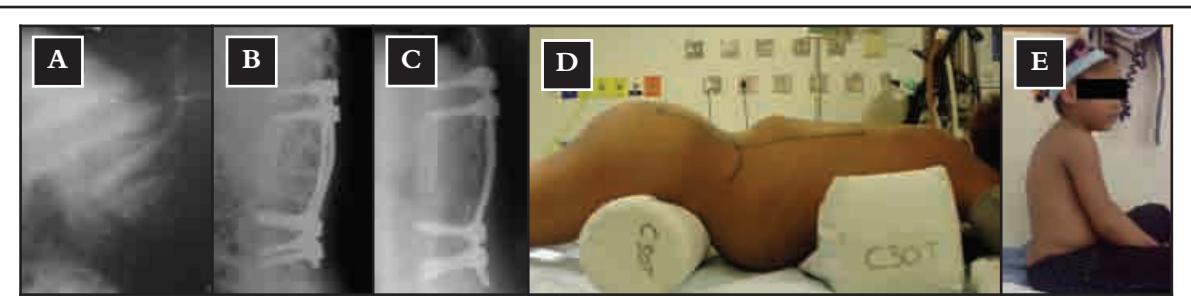
The 45° kyphosis was improved to 20° postoperatively but the deformity recurred and at 1-year follow-up union was confirmed, but with 40° kyphosis. There were five patients with severe deformities who had had *in situ* posterior onlay fusions only. These were young patients without neurological deficit where anterior debridement was not performed, acute correction was not attempted and improvement in deformity with growth was anticipated. We do not have long-term follow-up on these patients yet but intermediate term results have not shown a favourable trend.

When comparing un-instrumented and instrumented anterior and posterior fusions, thus excluding posterior only *in situ* fusions and the anterior only fusion, the correction and loss of correction is as follows: The instrumented group had an average correction at last follow-up of 15° which was on average 2.5° less than the initial post-operative correction. The un-instrumented group had an average of 7° correction at last follow-up, 5° less than the average post-operative correction in this group *(Table II)*.

Neurological recovery

In our series 20 patients had surgery for neurological compromise. Eighteen of these patients had a pre-operative Frankel grading of C or worse. No patients had any neurological deterioration following surgery and only two patients did not become ambulant. Both of these patients presented late to the spinal unit after not recovering neurological deficit on medical management. After surgery the one improved from a Frankel grade A to B, the other had a Frankel grading of B pre-operatively and remained unchanged post-operatively. Of the four patients in our series who had a pre-operative Frankel grading of A, two started showing some neurological recovery within the first week post surgery and three became ambulant *(Table III)*.

> When fusing a growing spine it is essential to fuse both anteriorly and posteriorly to prevent deformity with growth unless the surgeon plans to utilise remaining growth to assist with deformity correction

Figure 3: Anterior strut bone graft and posterior instrumented fusion for thoracolumbar TB spine. Lateral X-rays taken pre-op (A), post-op (B), and at 3 months follow-up (C). The patient positioned on the operating table (D), and at 3 months follow-up (E)

Table I: Pre-op, post-op and follow-up kyphotic angle of 24 patients who had surgery for deformity correction

Operative technique	Number of patients	Pre-op kyphosis	Post-op kyphosis	Last F/U (1y+) kyphosis
Ant: BG Post: BG	12	54°	42°	47°
Ant: BG Post: Inst	3	50°	33°	35°
Ant: BG & Inst Post: Inst	2	50°	35°	35°
Ant: BG & Inst Post: BG	1	55°	20°	30°
Ant: BG & Inst	1	45°	20°	40°
Post: BG *(in situ)*	5	82°	82°	87°

Ant - Anterior   Post - Posterior   BG - Bone graft
Inst - Instrumentation   F/U - Follow-up   y – year

Table II: Correction and loss of correction of instrumented vs un-instrumented fusions

	No. of patients	Final correction	Loss of correction
Instrumented	6	15°	2.5°
Un-instrumented	12	7°	5°

Table III: Frankel gradings of all patients pre-op, and at 3 months follow-up

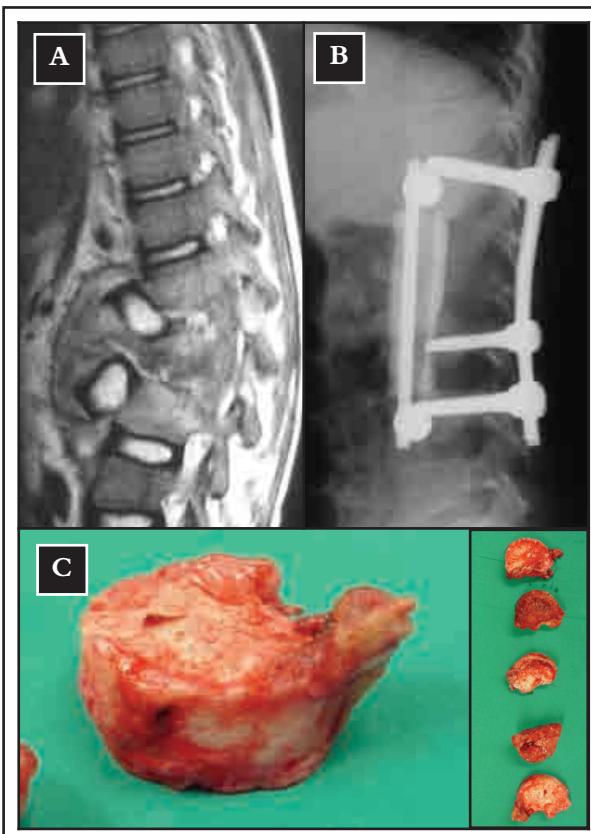| Pre-op	At follow-up				
	A	B	C	D	E
A (4)		1		2	1
B (8)		1		3	4
C (6)				4	2
D (6)				1	5
E (15)					15

Complications

Five revisions were performed for strut graft failure. All strut failures occurred in un-instrumented fusions *(Figure 4)*. Two of the revisions were done in the same patient who was an exceptionally active boy who kept on jumping up and down in his cot once his neurological deficit had recovered. One strut displacement occurred in a cervicothoracic fusion. After revision the patient was placed in a halo vest and subsequently recovered uneventfully. It is now our standard practice to use haloes following cervicothoracic fusion. There was one fracture of rib autograft. We no longer use rib autograft as a stand-alone strut. Resorption of one strut graft occurred in a patient that eventually cultured an MDR strain. The patient recovered well after revision on MDR TB treatment.

Figure 4: 3D reconstructed CT-scan images showing union of un-instrumented posterior fusion but displacement of anterior strut grafts (fibula allograft and rib autograft)

Figure 5: Posterior element involvement. MRI showing pedicle involvement (A). Posterior instrumentation was performed first followed by anterior strut grafting and instrumentation. Post-op x-rays show good correction but the superior pedicle screws cut out of the T12 body when the deformity was corrected (B). The inter-vertebral discs of the involved levels were floating free in the abscess cavity, but were relatively intact (C).

Other complications included ankle valgus in one patient following harvesting of fibula autograft, and recollection of psoas abscesses (twice) in a patient who also cultured an MDR strain from a specimen collected at the third procedure.

Discussion

The goals of treatment of TB spine are to eradicate the disease, to recover or prevent neurological compromise and to prevent or correct unacceptable deformity. Antituberculous chemotherapy is the cornerstone of management and it can be employed as stand-alone treatment in many cases.[6,7]

The biggest challenge posed by TB spine in younger patients is addressing kyphotic deformity. Progression of deformity of the growing spine occurs both during the active phase and after the disease is cured.[8] Complications arising from persisting kyphosis may include late onset paraplegia, cardiorespiratory compromise, pain and unacceptable cosmesis. Correction of established deformity is difficult and is associated with a high complication rate.[9] It is therefore very important to identify patients with unacceptable deformity and those at risk of progressing to an unacceptable deformity. As yet there are no universally accepted guidelines aiding the spinal surgeon in making these decisions.

Progression of the kyphotic deformity depends on the severity of the kyphosis at presentation, the number of vertebral bodies involved and the anatomical level of the lesion. Thoracic lesions often present with a severe deformity but show a lesser tendency to progress, possibly because the rib cage contributes to stability. Thoracolumbar lesions show the greatest tendency to progress. Lumbar lesions are associated with the least pre-treatment deformity.[10] A kyphosis of 30° to 35° over 5 years is expected for every whole vertebral body involved.[11] Most authors would consider a kyphotic angle of greater than 40° an indication for surgery but many others feel that a kyphosis of more than 30° is likely to progress and that surgery is indicated. Jutte et al[12] found that loss of vertebral height and the anatomical level were the most powerful predictors of a favourable outcome in patients who had a kyphosis of between 30° and 40°. Their recommendation was that non-operative treatment can be started in patients with kyphotic angles of less than 40° if there was initial bone loss of more than 0.3 (of the expected body height of affected vertebra) but that thoracolumbar lesions should be monitored carefully. Excluded from their study were children under 15 and those with cervical and lumbar lesions.

Tuberculosis mainly affects the anterior elements of the spine, and although posterior involvement is rare, these lesions may render the spine unstable and necessitate operative stabilisation *(Figure 5)*. Rajasekaran[10] described radiological signs identifying the 'spine at risk'. Separation of the facet joints at the apex of the deformity, posterior retropulsion of the diseased vertebral segments and the 'toppling sign' are assessed on the lateral plain films.

Toppling is said to occur when separation of the facet joint allows the superior normal vertebra to tilt or topple so that the anterior surface of the vertebra comes into contact with the superior surface of the vertebra below the level of the lesion. Lateral translation is assessed on the AP film. The recommendation is that surgery is indicated if two or more of the signs are present. Axial CT is the most accurate method for visualising the posterior elements.[13] MRI can now define bony anatomy almost as well as CT with the advantage that extradural compression of the spinal cord and the extent of associated abscess formation are defined.

Paraplegia associated with TB spine (Pott's paraplegia) might occur in up to 30% of cases.[14] Patients can present with the neurological deficit or it may develop after chemotherapy is commenced. This should be distinguished from Pott's paraplegia of late onset that is associated with persistent severe deformity. Several authors have reported good outcomes on either chemotherapy alone or in combination with surgery but there are no randomised studies comparing outcomes of operative and non-operative management. Pattinson[15] reported on 89 patients treated for Pott's paraplegia. Only four had surgical debridement of which only one was in the first month of treatment. Eighty-four per cent became ambulant. There was no noticeable benefit gained from delayed surgery but possible benefit was gained from early surgery. Moon *et al*[16] compared outcomes of patients with Pott's paraplegia who were treated surgically with those who were treated non-surgically. This was a retrospective study and the surgical group included patients with late-onset paraplegia in healed disease, who had poor outcomes. Non-operative management was reserved for patients in poor general condition, with minimal deformity, less severe paralysis and a normal spinal cord on MRI. All of the children in their study (9) were treated non-operatively and became ambulant. They comment that patients who had surgery for early active disease recovered more rapidly than those who were managed non-operatively and that when anterior debridement was combined with posterior instrumentation, patients could be mobilised earlier than with anterior surgery only. Louw[17] reports on 19 patients with Pott's paraplegia in whom anterior debridement and vascularised rib bone graft was combined with posterior osteotomies and instrumentation. Eighteen patients became fully ambulant and one required crutches for ambulation. In our series 20 patients had surgery for neurological compromise, 18 of whom had a Frankel grading of C or worse. Two patients did not become ambulant. In both cases surgery was performed only after no neurological recovery was noted on chemotherapy for at least 2 months.

The Medical Research Council recommended that 'where facilities are lacking' reliance should be placed on ambulant chemotherapy alone.[1]

We suggest the following indications for surgery in paediatric and adolescent patients with TB spine if the facilities and expertise are available:

1. Deformity: Kyphus angle of ≥ 40° or predicted deformity of ≥ 60° (two or more whole bodies involved).
   A kyphus angle of 30°-40° in a thoraco-lumbar lesion requires close monitoring for progression.
   Kyphosis of ≥ 20° in cervical or cervico-thoracic lesions is an indication for surgery.
2. Instability: Involvement and collapse of the pedicles/facets as assessed on plain film, CT scan or MRI.
3. Neurological compromise: This remains the most controversial of indications and up to 90% of patients with paraplegia will recover on chemotherapy alone.[15,16] For the minority of patients who do not recover, this is however a catastrophic complication. It is difficult to predict which patients will not recover on chemotherapy alone, and once it has become apparent, it is unlikely that delayed surgery will be of benefit. It has also been suggested that surgically managed patients have a more rapid recovery and rehabilitation with a shorter hospital stay.[16] It is therefore our recommendation that paraplegia, defined as an inability to walk across a room unaided, or change in bladder and bowel control, are indications for surgery. If the patient has not reached walking age yet, then myelopathy becomes an indication for surgery. Surgery should be performed on the earliest available elective theatre slate after onset of neurological symptoms and should not be delayed by more than 2 weeks. Neurological compromise that develops after chemotherapy has been commenced should be managed in the same manner as when a patient presents with neurological compromise. The management of late onset paraplegia is not discussed here.
4. Pain: In a patient with persistent pain due to a large abscess, in the absence of another indication that might necessitate a more invasive procedure, a costotransversectomy or drainage of a psoas abscess should be performed.
5. Diagnosis: In areas where TB is endemic, the diagnosis can be based on a combination of radiological findings (of the affected area and a chest radiograph), a positive Mantoux skin test, sputum microscopy and culture, and response to treatment.[13] The author believes biopsy to be mandatory due to the rising incidence of drug resistance. In our series multi-drug-resistant strains were cultured on specimens from three patients (7.5%). Biopsy can be performed percutaneously under CT or fluoroscopy guidance, or as an open procedure in theatre. We prefer a percutaneous transpedicular biopsy in theatre under fluoroscopy guidance for patients who do not require open surgery for another indication.

In our experience the surgical procedure of choice for deformity, instability or neurological compromise is an anterior debridement, strut allograft and a posterior fusion. Posterior instrumentation is required for the thoracolumbar area due to the biomechanics of the region.

> **We recommend the routine use of a halo vest for at least 6 weeks postoperatively for cervicothoracic lesions**

Anterior surgery and posterior surgery are preferentially performed during the same theatre episode. Anterior surgery is usually performed first, and the cord is visualised while the deformity is corrected. The exception is when there is posterior element involvement causing instability in which case it might be advisable to stabilise the spine with posterior instrumentation first, before performing anterior debridement.[18] Cervical or cervicothoracic lesions can be managed in the same fashion as thoracic lesions, or an anterior spinal locked plate can be employed in combination with a strut graft and posterior fusion. We recommend the routine use of a halo vest for at least 6 weeks postoperatively for cervicothoracic lesions.

In very small children the pedicles may be too small for standard pedicle screws. We have used adult cervical instrumentation (3.5 mm) for this purpose.

Conclusion

Surgery for spinal TB in the paediatric and adolescent groups can be safe in terms of a low complication rate, and effective with good correction of deformity that is well maintained with instrumentation.

This article is the sole work of the authors.
No benefits of any form are to be received from a commercial party related directly or indirectly to the subject of this article.

References

1. Medical Research Council. A 10-year assessment of a controlled trial comparing debridement and anterior spinal fusion in the management of tuberculosis of the spine in patients on standard chemotherapy in Hong Kong. *J Bone Joint Surg (Br)* 1982;**64-B**:393-8.
2. WHO 2009 report on TB.
3. Naim-ur-Rahman. Atypical forms of spinal tuberculosis. *J Bone Joint Surg (Br)* 1980;**62-B**(2):162-5.
4. Harries AD. WHO HIV/TB clinical manual 1996.
5. Fountain SS, Hsu LCS, Yau ACMC, Hogdson AR. Progressive kyphosis following solid anterior spine fusion in children with tuberculosis of the spine. *J Bone Joint Surg (Am)* 1975;**57-A**:1104-7.
6. Konstam PG, Blesovsky A. The ambulant treatment of spinal tuberculosis. *Br J Surg* 1962;**50**:26-8.
7. Medical Research Council. A five-year assessment of controlled trials of in-patient and out-patient treatment and of Plaster-of-Paris jackets for tuberculosis of the spine. *J Bone Joint Surg (Br)* 1976;**58-B**:399-411.
8. Rajasekaran S. The problem of deformity in spinal tuberculosis. *Clin Orthop* 2002;**398**:85-92.
9. Yau ACMC, Hsu LCS, O'Brien JP, Hodgson AR. Tuberculosis kyphosis-correction with spinal osteotomy, halo-pelvic distraction and anterior and posterior fusion. *J Bone Joint Surg (Am)* 1974;**56-A**:1419-34.
10. Rajasekaran S. The natural history of post-tubercular kyphosis in children. *J Bone Joint Surg (Br)* 2001;**83**:954-62.
11. Rajasekaran S, Shanmugasundaram M.S. Prediction of the angle of gibbus deformity in tuberculosis of the spine. *J Bone Joint Surg (Am)* 1987;**69-A**:503-9.
12. Jutte P, Wuite S, The B, Van Altena R, Veldhuizen A. Prediction of deformity in spinal tuberculosis. *Clin Orthop* 2006;**455**:196-201.
13. Hoffman EB, Crosier JH, Cremin BJ. Imaging in children with spinal tuberculosis. A comparison of radiography, computed tomography and magnetic resonance imaging. *J Bone Joint Surg (Br)* 1993;**75-B**:534-8.
14. Tuli S. Treatment of neurological complications in tuberculosis of the spine. *J Bone Joint Surg (Am)* 1969;**51-A**:680-92.
15. Pattinson PRM. Pott's paraplegia: An account of the treatment of 89 consecutive patients. *Paraplegia* 1986;**24**:77-91.
16. Moon M, Ha K, Sun D, Moon J, Moon Y, Chung J. Pott's paraplegia 67 cases. *Clin Orthop* 1996;**323**:122-8.
17. Louw JA. Spinal tuberculosis with neurological deficit. *J Bone Joint Surg (Br)* 1990;**72-B**:686-93.
18. Travlos J, Du Toit G. Spinal tuberculosis: Beware the posterior elements. *J Bone Joint Surg (Br)* 1990;**72-B**:722-3.