Eur Spine J (2003) 12 : 224–234
DOI 10.1007/s00586-002-0403-0

ORIGINAL ARTICLE

İ. Teoman Benli
Emre Acaroğlu
Serdar Akalin
Mahmut Kiş
Evrim Duman
Ahmet Ün

Anterior radical debridement and anterior instrumentation in tuberculosis spondylitis

Received: 29 August 2001
Revised: 28 December 2001
Accepted: 14 February 2002
Published online: 13 September 2002

İ. T. Benli (✉) · S. Akalin · M. Kiş
E. Duman · A. Ün
1st Department of Orthopaedics
and Traumatology,
Ankara Social Security Hospital,
Ankara, Turkey
e-mail: cutku@ada.net.tr,
Tel.: +90-312-4350914

İ. T. Benli
Mithatpaşa Cad., 59/2, Kızılay, 06420,
Ankara, Turkey

E. Acaroğlu
Department of Orthopaedics
and Traumatology,
Hacettepe University Medical School,
Ankara, Turkey

Abstract The conventional procedure in the treatment of vertebral tuberculosis is drainage of the abscess, curettage of the devitalized vertebra and application of an antituberculous chemotherapy regimen. Posterior instrumentation results are encouraging in the prevention or treatment of late kyphosis; however, a second-stage operation is needed. Recently, posterolateral or transpedicular drainage without anterior drainage or posterior instrumentation following anterior drainage in the same session has become the preferred treatment, in order that kyphotic deformity can be avoided. Information on the use of anterior instrumentation along with radical debridement and fusion is scarce. This study reports on the surgical results of 63 patients with Pott's disease who underwent anterior radical debridement with anterior fusion and anterior instrumentation (23 patients with Z-plate and 40 patients with CDH system). Average age at the time of operation was 46.8±13.4 years. Average duration of follow-up was 50.9±12.9 months. Local kyphosis was measured preoperatively, postoperatively and at the last follow-up visit as the angle between the upper and lower end plates of the collapsed vertebrae. Vertebral collapse, destruction, cold abscess, and canal compromise were assessed on magnetic resonance (MR) images. It was observed that the addition of anterior instrumentation increased the rate of correction of the kyphotic deformity (79.7±20.1%), and was effective in maintaining it, with an average loss of 1.1°±1.7°. Of the 25 patients (39.7%) with neurological symptoms, 20 (80%) had full and 4 (16%) partial recoveries. There were very few intraoperative and postoperative complications (major vessel complication: 3.2%; secondary nonspecific infection: 3.2%). Disease reactivation was not seen with the employment of an aggressive chemotherapy regimen. It was concluded that anterior instrumentation is a safe and effective method in the treatment of tuberculosis spondylitis.

Keywords Pott's disease · Surgical treatment · Anterior instrumentation

Introduction

The most frequent site for extra pulmonary involvement of tuberculosis infection is the vertebral column. Percival Pott described tuberculosis of the vertebral column in 1877 as a kyphotic deformity of the spine associated with paraplegia [36]. Menard in 1894 described a series of patients with Pott's paraplegia successfully treated with decompression via costatransversectomy [21, 36]. Pott's disease is now infrequent in developed countries, but still constitutes a public health problem in underdeveloped countries [1, 5, 6, 8, 18, 43].

Prior to the era of antibiotics and improvements in general health, multisegmental involvement was thought to be the norm, usually diagnosed at autopsy. Today, however, involvement of more than one noncontiguous region of the spine is very rare [36]. The true incidence of primary posterior involvement is virtually unknown; however, the introduction of computerized tomography (CT) and magnetic resonance imaging (MRI) have probably increased the rate of identified cases to up to 10% of the cases with extensive disease [3, 37].

Chemotherapy appears to be the mainstay in the treatment of tuberculosis. Only by the introduction of effective chemotherapy regimens can the mortality associated with the disease be controlled, and morbidity has been substantially decreased. Surgery in tuberculosis spondylitis is generally considered to be an adjuvant of effective chemotherapy. Indications for surgical treatment include (1) neurological involvement, (2) deformity and/or impending increase in deformity, and (3) the presence of large tuberculosis abscess and/or abundant necrotic tissue [27, 36].

Drainage and debridement of cold abscess has become popular since this treatment was first reported by Hodgson and co-workers in 1960 [12]. The gold standard in practice today is probably radical debridement with anterior approach and anterior fusion with anterior strut grafts [36]. As spinal cord compression is usually located anteriorly, anterior approach and decompression is the preferred route for neural decompression [15, 36]. Satisfactory fusion rates have been reported with only posterior or anterior approaches [11, 12, 16, 36, 42]. However, albeit in low rates, graft resorption has been reported in patients who had undergone anterior or posterior fusion only, and kyphotic deformity due to asymmetric growth is probable in children [11, 29, 30, 32, 35]. Recently, posterolateral or transpedicular drainage without anterior drainage, or posterior instrumentation following anterior drainage in the same session is offered as an alternative in attempts to avoid kyphotic deformity [11, 12, 20, 32, 33]. Posterior instrumentation in addition to anterior fusion, sequential or staged, is associated with increased morbidity [25, 35]. Use of anterior instrumentation has been reported in a limited number of series. Oga and co-workers evaluated the adherence capacity of *Mycobacterium tuberculosis* to stainless steel, and demonstrated that adherence was negligible, and the use of implants in regions with active tuberculosis infection is safe [31]. Kostuik reported his experience on cases with healed or inactive disease [19]. Anterior plate fixation along with debridement and fusion of the active disease has been reported for a limited number of patients with active disease by the present authors [5, 6].

The objective of this study was to evaluate the clinical and radiographic results of 63 patients with active tuberculosis spondylitis, who were surgically treated by anterior instrumentation along with anterior fusion.

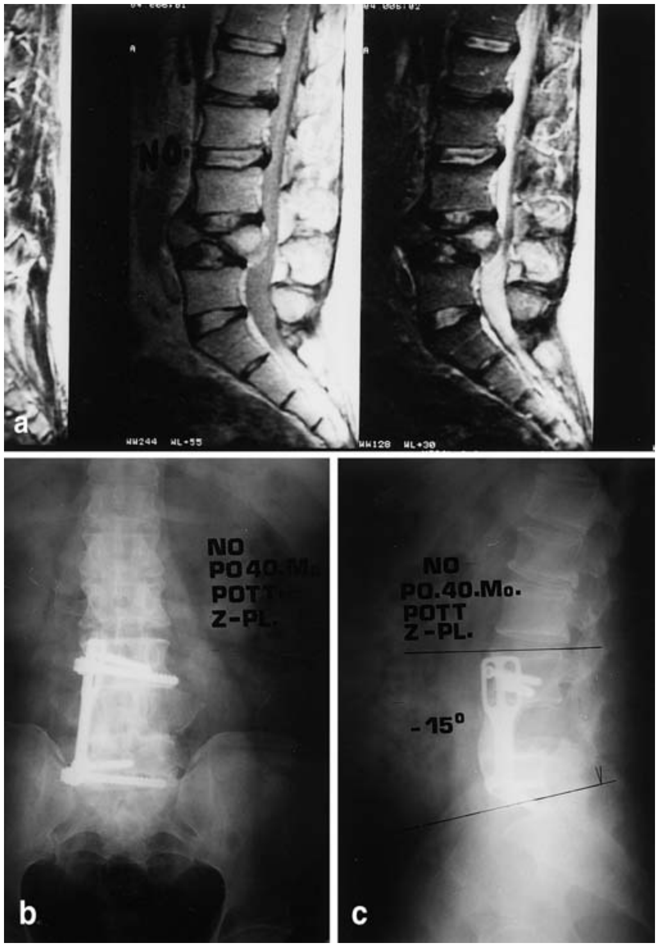

Fig. 1A–C A 36-year-old man (N.O.) with Pott's disease in the L4 vertebra. Two mobile segments were instrumented with anterior Z-plate and a 100% correction rate was obtained after anterior radical debridement and strut grafting. There was a 5° loss of correction and solid fusion mass was observed at the last visit. **A** Preoperative magnetic resonance (MR) image, sagittal view, and **B** posteroanterior and **C** lateral radiographs, 40 months after surgery

Materials and methods

Sixty-three patients with a minimum follow-up of 2 years were included in this study. All were 19 years old or older; the average age at the time of operation was 46.8±13.4 years. Average follow-up was 51.1±12.8 (range 24–81) months. Almost all patients had general tuberculosis symptoms such as weight loss, moderate fever, fatigue and predominantly back pain in their histories. Twenty-five patients (39.7%) presented with partial or complete neural deficits. Seven patients (11.1%) had active pulmonary system tuberculosis, and one patient (1.6%) had active gastrointestinal tuberculosis at the time of presentation. Overall, eight patients (12.7%) had active primary tuberculosis. The patients were assessed clinically and radiologically following hospitalization (Fig. 1, Fig. 2, Fig. 3, Fig. 4). In general, these patients were notable for mild increases in erythrocyte sedimentation rate (ESR) and relative lymphocytosis. Radiology revealed kyphotic deformities due to vertebral collapse and paravertebral abscess formation. The levels of involvement, numbers of affected levels, and local kyphosis angles were assessed radiologically and the sagittal contours were measured independently for cervical, thoracic, thoracolumbar or lumbar segments. Twenty-three patients had ^{99m}Tc bone scans, which were suggestive of infection prior to referral to our center. We evaluated all patients with CT and MRI. CT scans mostly revealed bony destruc-

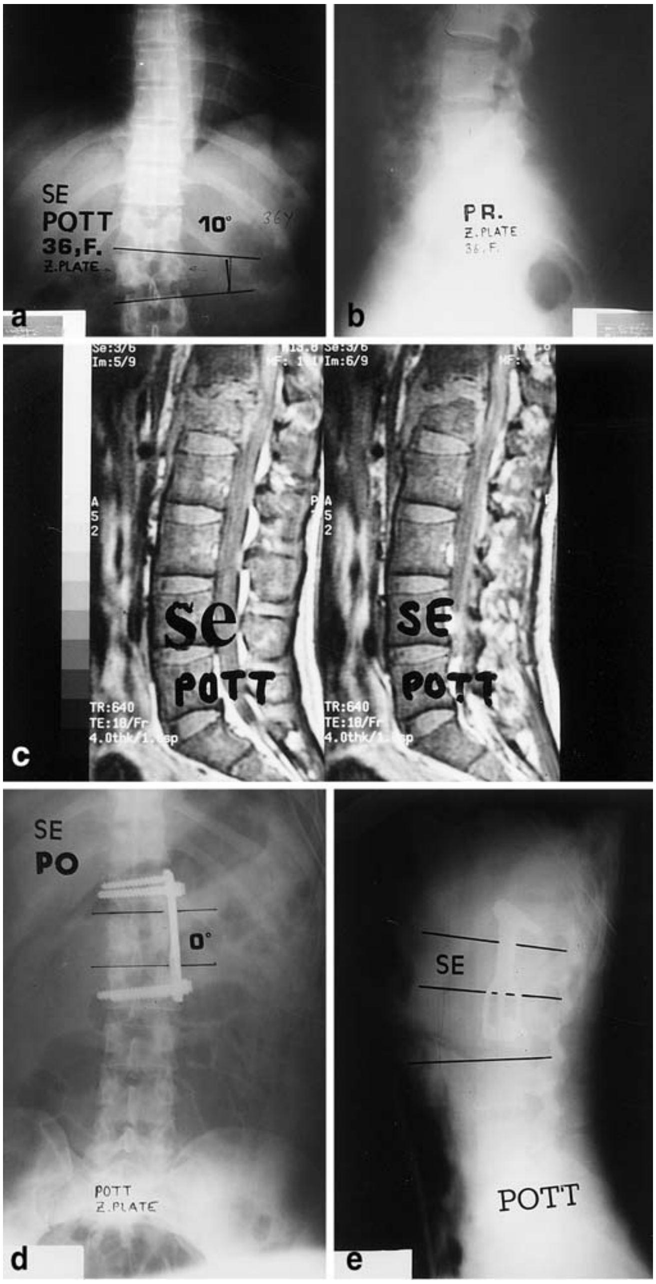

Fig. 2A–E A 36-year-old woman (S.E.) with Pott's disease in the T12–LI vertebrae. Two mobile segments were instrumented with anterior Z-plate, and a 100% correction rate was obtained after anterior radical debridement and strut grafting and instrumentation in both the frontal and sagittal planes. **A** Preoperative posteroanterior (**A**) and lateral (**B**) graphics, and sagittal MR image (**C**), and postoperative posteroanterior (**D**) and lateral (**E**) radiographs

tion and the lack of any soft tissue masses. Vertebral collapse, destruction, paravertebral and/or psoas abscess, and spinal cord compression due to abscess or bony debris were evident on MRI. Sixty-one patients (96.8%) were diagnosed with tuberculosis spondylitis pre-operatively in this prospective series. Only two patients (3.2%) were misdiagnosed initially, as their radiology was notable for soft

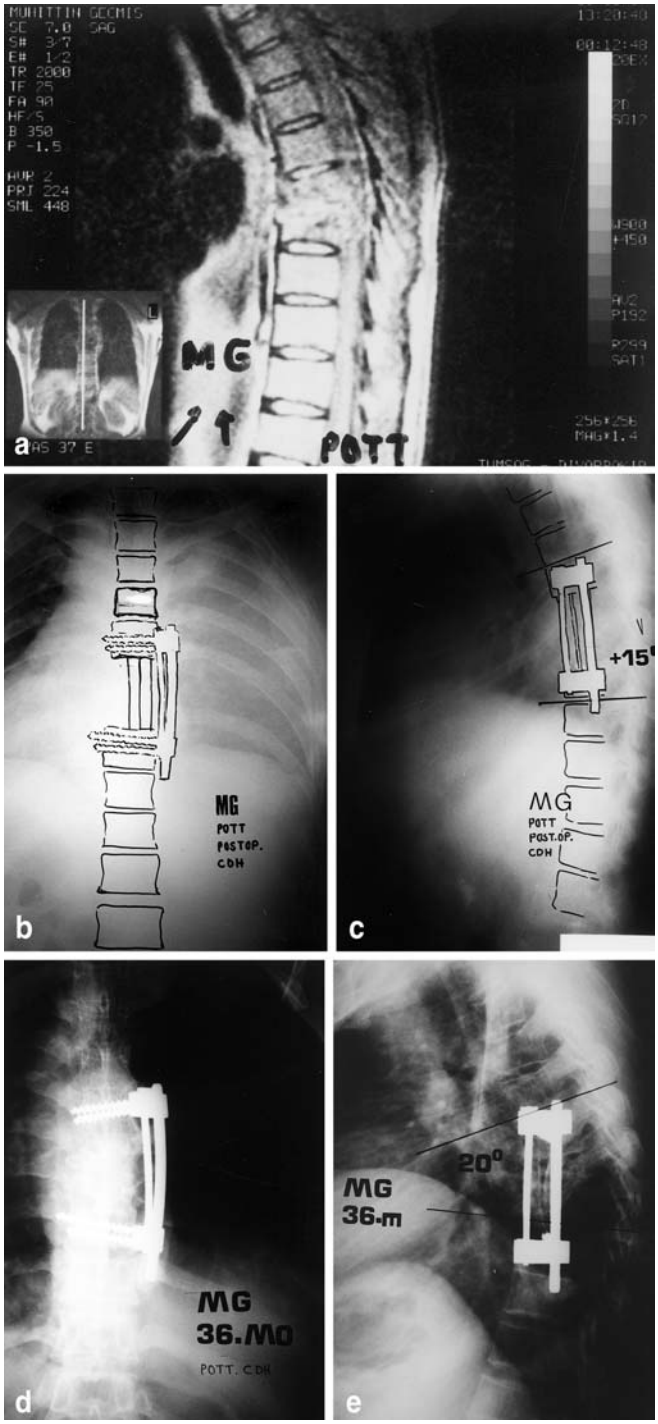

Fig. 3A–E A 37-year-old man (M.G.) with Pott's disease in the T8–9 vertebrae. Two mobile segments were instrumented with anterior Cotrel-Dubousset-Hopf (CDH) instrumentation, and a 66.7% correction rate and complete neurologic impairment was obtained after anterior radical debridement and strut grafting. There was a 5° loss of correction in local kyphosis angle at the last visit. Preoperative sagittal MR image (**A**) and postoperative posteroanterior (**B**) and lateral (**C**) radiographs, and 36-month control posteroanterior (**D**) and lateral (**E**) radiographs

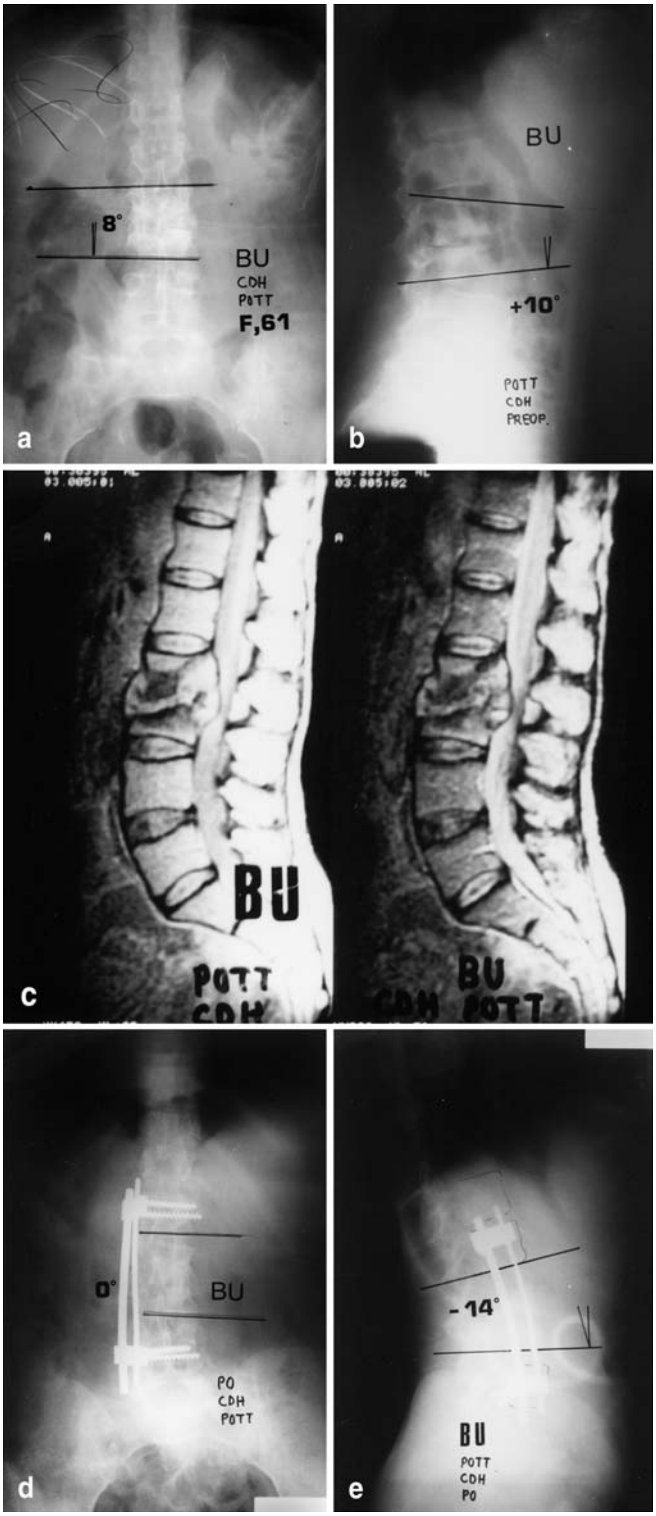

Fig. 4A–E A 61-year-old man (B.U.) with Pott's disease in the L2–3 vertebrae. Three mobile segments were instrumented with anterior CDH and a 66.7% correction rate in the sagittal plane and 100% correction rate in the frontal plane were obtained after anterior radical debridement and strut grafting. There was no loss of correction and solid fusion mass was observed at the last visit. Preoperative posteroanterior (**A**) and lateral (**B**) radiographs and sagittal MR image (**C**), and postoperative posteroanterior (**D**) and lateral (**E**) radiographs

tissue masses; however, they were treated by anterior vertebrectomies along with anterior instrumentation anyway.

All patients, with the exception of those who had recently developed or demonstrated progressive neurologic deficits that required urgent decompression, underwent three-drug antituberculous chemotherapy prior to surgery for 3 weeks. Presence of a large abscess, vertebral collapse and spinal instability, local kyphotic deformity with impending increase and neurological compromise constituted the surgical indications.

Access to the involved vertebrae was gained by means of thoracotomy in the thoracic region and thoracophrenolumbotomy in the thoracolumbar and lumbar region. The abscess was drained if present, and neural decompression was carried out with complete corpectomy of the destroyed vertebra. Anterior fusion was accomplished with tricortical autologous graft from the iliac crest, and at least three costal parts were obtained by the thoracotomy. Anterior instrumentation at the levels just above and below the fused segments was performed using titanium Z-plate instrumentation [44] in 23 patients and Cotrel-Dubousset-Hopf (CDH) instrumentation [14] in 40 patients. After radical debridement, two bolt screws were attached to the vertebrae above and below the corpectomy area in patients treated with Z-plate instrumentation. Afterwards, the Z-plate was fitted to these bolt screws and security bolts were screwed tightly. Spongious screws were then fixed. In the thoracic region, titanium thoracic Z-plates, and in the lumbar region standard titanium Z-plates, were used. In patients treated with CDH, vertebral implants were first attached by two spongious screws. The 6-mm rod, bent according to the curve, was then inserted in plates. Derotation maneuver followed distraction. The other rod (4 mm) and drawers were positioned and the locking screws screwed. Average operation time was 1.6±0.7 h. For all patients in this study, somatosensory evoked potentials (SSEP) and transcranial cortical magnetic stimulation-motor evoked potentials (TkMMEP) were combined for intra-operative neurologic monitoring. The mean blood loss was 670±110 cc, and an average of 2.3±1.1 units of banked blood was transfused.

Patients were allowed to turn in bed on the 1st postoperative day, sitting on the 2nd, and they were encouraged to stand and walk on the 3rd postoperative day. Active rehabilitation was started immediately for patients who had neural deficits. No cast immobilization or bracing was used in patients with satisfactory bone quality. Light braces were used for 4 months in 13 osteoporotic patients.

Diagnosis was confirmed by histopathological examination. Postoperative chemotherapy regimen consisted of rifampicin (R) 15 mg/kg (maximum 600 mg/day), isoniasid (INH) 6 mg/kg (maximum 300 mg/day), and streptomycin 1 g daily for a month. Thereafter, ethambutol (EMB) 25 mg/kg/day (maximum 2.5 g/day) replaced streptomycin for 6 months. EMB, in turn, was replaced by piranizamid 25 mg/kg daily (maximum 2 g/day) on the 6th month, and chemotherapy was discontinued after 1 year.

Patients with neural deficits were graded according to the Frankel scale [9]. Local kyphosis was measured as the angle between the upper and lower end plates of the collapsed levels postoperatively and at the last follow-up visit. These values were corrected by subtracting 5° per level from the thoracic values and by adding 10° per level to the lumbar angles. On lateral radiographs, sagittal contours between the T2 and T12 vertebrae and the L1 and L5 vertebrae were measured by the Cobb method. Normal thoracic physiological kyphosis and physiological lumbar lordosis were accepted as 30°–50° and 40°–60° respectively [4]. All measurements were made in cooperation with a radiologist. Sagittal contours were given (+) and (–) angle values if they had kyphotic and lordotic patterns, respectively. Presence of significant consolidation, along with the absence of implant failure or correction loss and pain relief, was considered a sign of fusion. At the last follow-up, implant failure and other complications were also evaluated. The last follow-up visits were made in January 2001, and patients who had more than 2 years follow-up were included in the study. The tests used for statistical assessment were the Wilcoxon matched-pair signed-ranks test, and the Mann-Whitney-U test (SPSS for MS Windows), with confidence intervals of 95%.

Results

Tuberculosis infection was found in 102 vertebrae of 63 patients. The thoracic region was the leading site for infection, with 38 vertebrae involved in 25 patients. The thoracolumbar region was the second most common site for infection, with 34 vertebrae involved in 21 patients, followed by the lumbar region, with 30 vertebrae involved in 17 patients. The most commonly affected vertebra was L1, with 18 cases (17.6%). This was followed by 16 cases of T12 affection, 14 cases of L3, 9 of T11 and 9 of T10.

Age, sex, involved vertebral segment, follow-up period, instrumented mobile segments, preoperative and postoperative local kyphosis angles at the involved vertebra, postoperative and final correction percentages at the local kyphosis angles and their rates of correction loss at the last follow-up are illustrated in Table 1 and Table 2. Overall, an average of 2.4±0.7 mobile segments was included in the instrumentation and fusion area. Involvement was seen in 1.6±0.5, 1.7±0.5 and 1.6±0.5 levels for the thoracic, thoracolumbar and lumbar regions respectively, and 2.3±0.6, 2.6±0.7 and 2.2±0.8 mobile segments were instrumented in each respective region.

It was possible for all patients in this series to be followed closely because of the way the social security system operates, so no patients were lost to follow-up. The preoperative local kyphosis angle was 23.4°±10.9° (10°–80°), and this was corrected to 5.4°±6.3° (0°–22°), with a correction rate of 79.7±20.2% (42.3–100%) for the entire study population (Table 3, Table 4). This correction rate was statistically significant (*t*: 18.02, $P<0.05$). On average, 1.1°±1.7° of correction loss was noted in the local kyphosis angle, and the final correction was measured to be 74.2±23.3%. Values for the correction and loss of correction parameters for the regions of involvement can be seen in Table 3. A comparison of the average values of these groups showed that they were nearly the same, but the highest correction rates were obtained in the thora-

Table 1 Data on the 23 patients treated with Z-plate instrumentation (*LK* local kyphosis)

Patient	Age	Sex	Follow-up period (months)	Affected level	No. of affected vertebrae	No. of instru-mented mobile segments	Preop. LK (degrees)	Postop. LK (degrees)	Postop. LK correction (%)	Loss of LK correction (degrees)	Final LK correction (%)
S.D.	35	F	48	T7–8	2	2	14	6	57.1	0	57.1
U.A.	60	M	50	T7–8	2	2	20	8	60	0	60
G.M.	66	M	51	T10–11	2	2	13	7	46.2	2	30.8
Y.M.	69	F	49	T10–11	2	3	14	0	100	0	100
K.K.	48	M	49	T10–11	2	2	30	8	73.3	5	56.7
C.H.	37	M	52	T10–11	2	2	23	0	100	0	100
A.M.	32	M	54	T11–12	2	3	14	0	100	0	100
S.E.	36	M	74	T12–L1	2	3	30	5	83.3	2	76.6
S.A.	54	F	46	T12-L1,2	3	3	57	22	61.4	4	54.4
S.R.	61	M	79	T12–L1	2	1	10	0	100	0	100
B.F.	43	F	48	T12–L1	1	2	15	0	100	0	100
S.S.	48	M	62	T12–L1	2	3	22	12	45.5	0	45.5
E.M.	22	M	81	T12–L1	2	2	18	8	55.6	0	55.6
T.L.	57	M	51	L1	1	2	20	0	100	2	90
Y.S.	27	M	59	L2–3	2	1	30	10	66.7	0	66.7
Y.A.	50	M	76	L2–3	2	3	20	10	50	0	50
K.V.	51	M	68	L2–3	2	1	18	0	100	0	100
K.N.	49	M	53	L3	1	2	14	0	100	2	85.7
S.L.	59	F	61	L4	1	2	26	10	61.5	0	61.5
N.O.	36	M	40	L4	1	1	15	0	100	5	66.7
Y.G.	20	F	55	L3–4	2	3	19	4	78.9	0	78.9
A.I.	67	M	50	L3–4	2	2	32	10	68.8	0	68.8
M.A.	53	F	76	L3–4	2	3	20	0	100	4	80

Table 2 Data on the 40 patients treated with Cotrel-Dubousset-Hopf instrumentation

Patient	Age	Sex	Follow-up period (months)	Affected level	No. of affected vertebrae	No. of instru-mented mobile segments	Preop. LK (degrees)	Postop. LK (degrees)	Postop. LK correction (%)	Loss of LK correction (degrees)	Final LK correction (%)
Y.S.	32	M	50	T5	1	2	30	15	50	0	50
T.C.	64	M	24	T5–6	2	3	20	8	75	0	75
M.G.	37	M	36	T6–7	2	4	15	5	66.7	5	33.3
S.H.	44	F	48	T7	1	2	14	0	100	0	100
B.U.	29	M	49	T7–8	2	3	15	0	100	0	100
A.S.	45	F	51	T8	1	2	17	5	70.6	1	64.7
G.N.	66	M	50	T8–9	2	2	26	15	42.3	0	42.3
C.D.	61	M	26	T8–9	2	3	28	0	100	2	92.9
V.T.	52	M	44	T8–9	2	3	24	4	83.3	4	66.7
Y.E.	44	F	59	T9	1	2	36	15	58.3	0	58.3
E.K.	58	F	25	T9	1	2	20	0	100	0	100
K.V.	42	M	54	T10	1	2	22	12	45.6	3	31.8
D.Z.	32	F	58	T10	1	2	39	22	43.6	0	43.6
A.R.	62	F	46	T10	1	2	30	0	100	0	100
S.S.	44	M	38	T10	1	2	18	0	100	0	100
O.G.	21	F	51	T10–11	2	2	34	18	47.1	3	38.2
G.B.	19	M	38	T10–11	2	3	26	4	84.6	0	84.6
M.C.	36	M	51	T11	1	2	20	0	100	0	100
K.L.	40	F	32	T11	1	2	16	4	75	2	62.5
V.B.	43	F	51	T11–12	2	4	80	22	72.5	0	72.5
K.Z.	60	F	50	T12	1	2	34	0	100	2	94.1
Y.C.	38	M	54	T12-L1	2	3	15	0	100	0	100
I.O.	58	F	57	T12-L1	2	2	12	0	100	0	100
U.B.	61	F	54	T12-L1	2	3	20	0	100	2	90
I.N.	58	F	54	T12-L1	2	3	10	0	100	0	100
T.B.	45	M	50	T12-L1	2	3	25	10	60	5	40
A.A.	38	M	49	T12-L1	2	3	18	2	88.9	0	88.9
E.S.	56	M	28	T12-L1	2	3	24	0	100	0	100
N.C.	53	F	54	L1	1	2	22	8	63	2	54.5
S.K.	62	F	28	L1	1	2	24	0	100	0	100
B.B.	60	F	24	L1	1	2	16	0	100	0	100
G.S.	60	M	56	L1–2	2	3	18	5	72.2	0	72.2
T.R.	40	F	50	L2	1	2	24	6	75	2	66.7
B.U.	61	F	58	L2–3	2	3	20	4	66.7	0	66.7
A.C.	46	F	44	L2–3	2	2	24	8	66.7	2	58.3
A.D.	22	M	42	L2–3	2	3	34	12	64.7	0	64.7
D.A.	30	F	64	L3	1	2	18	0	100	0	100
R.B.	58	M	54	L3	1	2	20	0	100	0	100
V.A.	39	M	83	L3–4	2	3	32	5	84.4	5	68.8
T.U.	52	M	50	L3–4	2	3	34	14	58.8	4	47.1

columbar region, followed by lumbar and thoracic involvement.

When the sagittal contours of the involved areas were analyzed, the preoperative average kyphosis angle was found to be 43.7°±11.5° for the thoracic and 24.0°±16.3° for the thoracolumbar regions, and the preoperative average lumbar lordosis angle was found to be –20.5°±8.9°. Postoperatively, these angles were found to have been corrected to 35.9°±9.0°, 4.5°±6.9° and –33.0°±4.5° respectively. Correction rates for the global sagittal contour angles were statistically significant (thoracic t: 5.68; thoracolumbar t: 7.83; lumbar t: 7.61; $P<0.05$).

Of the 25 patients with neurologic deficits, 5 were Frankel A, 4 Frankel B, 10 Frankel C and 6 Frankel D. Postoperatively, four patients (16.0%) had partial recovery; two patients with Frankel A and one patient with Frankel B involvement improved to Frankel D, while one patient with Frankel A improved to Frankel C. One pa-

Table 3 Average preoperative local kyphosis postoperative and final correction rates, and loss of correction values according to vertebral regions (*n* number of patients)

	Preop. LK	Postop LK correction (%)	*t*	*P*	Final LK correction (%)	Loss of LK correction
Thoracic (*n*=25)	22.6°± 7.5°	75.1±22.4	13.5	<0.05	69.8±25.6	1.2°±1.8°
Thoracolumbar (*n*=21)	24.0°±16.4°	85.8±18.9	7.8	<0.05	81.2±24.7	0.9°±1.5°
Lumbar (*n*=17)	23.5°± 6.6°	78.9±12.7	19.3	<0.05	72.4±16.3	1.4°±1.9°
Total (*n*=63)	23.4°±10.9°	79.7±20.2	18	<0.05	74.2±23.3	1.1°±1.7°

Table 4 Average preoperative and postoperative local kyphosis, loss of correction values and postoperative and final correction percentages of the patients treated with Z-plate or CDH instrumentation (*n* number of patients)

	Preop. LK	Postop. LK	*t*	*P*	Postop. LK correction (%)	Final LK correction (%)	Loss of correction
Z-plate (*n*=23)	21.5°± 9.9°	5.2°±5.7°	11.9	<0.05	78.6±21.1	73.3±20.8	1.1°±1.8°
CDH (*n*=40)	24.4°±11.5°	5.6°±6.6°	14	<0.05	80.4±19.9	74.9±24.9	1.2°±1.7°
Total (*n*=63)	23.4°±10.9°	5.4°±6.3°	18	<0.05	79.7±20.2	74.3±23.3	1.1°±1.7°

tient, who had been treated for active pulmonary tuberculosis and referred to our hospital 38 days after the onset of the neurological symptoms had no change. The remaining 20 patients (80.0%) had complete recoveries.

No apparent pseudoarthrosis or implant failures could be demonstrated at the latest follow-up. All patients demonstrated clinical healing of the tuberculosis infection. No recurrences, reactivation or draining sinuses were encountered. Two patients among the earlier cases of our series suffered major vascular complications. One patient with T9 involvement developed an aortic aneurysm, which was diagnosed at the 20th postoperative day, and the patient was immediately operated. The other patient had L4–L5 destruction, and the iliac vein, which had adhered to the L5 corpus, was torn during the dissection, and had to be repaired using a Teflon graft during operation.

Secondary late non-specific infection developed in two patients, whose implants were removed at 14th and 16th postoperative months, and the infected area debrided. Both were confirmed to be positive for acid-fast staining on retrospective evaluation, and it was considered that the staphylococcal infections in these patients were secondary. Fortunately, both could be treated by debridement and IV antibiotics (sulbactam ampicillin 1 g two times daily, for 6 weeks), amid sagittal correction losses of 4°.

Patients were also divided in two groups according to the type of instrumentation (Table 1, Table 2). In the 23 patients treated with Z-plate instrumentation and 40 patients treated with CDH instrumentation, the respective mean ages were 46.9±14.2 and 46.7±13.0 years, average numbers of involved levels were 1.8±0.5 and 1.6±0.5, and average preoperative local kyphosis angles at the involved vertebral levels were 21.5°±9.9° and 24.4°±11.5°. When these groups were compared with regard to these preoperative parameters, no statistically significant differences were noted (age *t*: –0.73; number of involved vertebrae *t*: –2.11; local kyphosis *t*: 1.0; $P>0.05$). The mean numbers of mobile segments that were instrumented in patients undergoing Z-plate and CDH instrumentation were 2.2±0.7 and 2.5±0.6 respectively. Postoperative local kyphosis angles were corrected to 5.2°±5.7° and 5.6°±6.6°, and 78.6±21.1% and 80.4±19.9% correction rates were obtained respectively. These correction rates were statistically significant (Z-plate *t*: 11.9; CDH *t*: 14.0; $P<0.05$) (Table 3). They were not significantly different when compared with one another (*t*: 0.33, $P>0.05$). At the last control visit, correction loss rates in Z-plate and CDH groups were 1.1°±1.8° and 1.2°±1.7° and final correction rates were 73.2±20.8% and 74.9±24.9% respectively. In the CDH group, an average scoliotic curve of 9.4°±5.6° was seen in 18 patients, and was completely corrected postoperatively. In five patients with Z-plate instrumentation, a mean scoliotic curve of 6.7°±5.4° was seen; in one patient this was corrected to 5° and persisted, in three patients it was entirely corrected, and in the remaining patient it increased from 6° to 10°. Additionally, in five patients without any scoliotic deformity preoperatively, an average of 5.2°±2.6° of scoliotic curves developed. Postoperatively, therefore, seven patients (30.4%) of this group had scoliotic curves.

Discussion

A prospective series of 63 patients with tuberculosis spondylitis was treated with anterior instrumentation along with anterior debridement and fusion. Analysis of the clinical and radiological results of these patients revealed that this procedure was associated with a very satisfactory rate of deformity correction as well as the maintenance of correction. A very high rate of fusion was achieved, with a negligible number of complications.

Anterior instrumentation in active tuberculosis infection is a relatively new concept, and the results of this study should probably be compared to those achieved with other modalities of surgical treatment as well as other reports on anterior instrumentation.

Indications for surgery in spinal tuberculosis are reported to include the presence of a large paraspinal abscess, the presence of severe bone destruction and kyphotic deformity, neurologic deficit with spinal cord compression, and lack of response to conservative treatment [33]. Posterior fusion had been the standard surgical procedure for the limited correction and prevention of progression of deformity in many centers before the safe and liberal use of anterior spinal surgery became feasible. However, posterior fusion does not appear to alter the natural course of the disease process; pseudoarthrosis and bending of the fusion mass very frequently leads to a substantial increase in the kyphotic deformity [1, 11, 40].

Anterior debridement without fusion in the treatment of spinal tuberculosis has been evaluated in Medical Research Council (MRC) studies performed in Hong Kong and Bulawayo. The findings showed that the magnitude and rate of progression of the kyphotic deformity in patients who underwent this treatment were similar in patients who underwent no surgery, and were significantly worse than in patients treated with anterior debridement and fusion [22]. Longitudinal follow-up of the same group of patients revealed that bony fusion occurred later in those who were treated with anterior grafting compared to patients treated with debridement only, but the rates of fusion were similar at 5 years [23]. Over 10 years, the debridement group exhibited mean increases in kyphosis of 9.8° for thoracic and thoracolumbar lesions and 7.6° degrees for lumbar lesions, compared with minor changes in the fusion group [24]. Upadhyay and co-workers reported the latest follow-up of the same group of patients, concluding that the debridement group demonstrated increases in kyphotic deformity for up to 6 months. Adult patients demonstrated an arrest in progression, while some spontaneous correction of the deformity occurred in the pediatric patients [38, 39, 40, 41]. Aksoy et al. reported a series of 100 patients with either posterior or anterior fusion only, and demonstrated that kyphotic deformity developed less frequently after anterior fusion [1]. Rajasekaren and Soundarapandian reported a 59% rate of kyphotic deformity with anterior fusion [32].

With anterior debridement and fusion, the MRC trials demonstrated that an increase in kyphotic deformity occurred in only 17% of patients compared to 39% of patients treated with chemotherapy. In contrast to patients treated with only anterior debridement, the progression of the kyphotic deformity was considerably less, especially during the first 6 months of the treatment [22, 23, 24, 25]. Kyphotic deformity did not significantly increase in these patients after 6 months regardless of the treatment method. In another study, 59% of patients had favorable results (excellent or good), 19% were rated as fair, and 22% as poor [32].

The necessity of prolonged immobilization following anterior procedures, and the relatively high rates of progression of kyphosis frequently related to the problems with strut grafts, prompted the idea that tuberculosis spondylitis may be stabilized by posterior instrumentation [10, 36]. Oga and co-workers obtained good clinical results, but the instrumentation was extended to an alarming average of 8.5 levels, in spite of the fact that only 3.5 levels on average were involved by the disease [31]. Moon et al. reported very good rates of correction and good maintenance of correction for both children and adults; fusion occurred in 4 months in single-level spondylodesis cases and in 6 months in two-level [28] cases.

Several studies have demonstrated satisfactory results using posterior instrumentation along with anterior debridement and fusion [25, 27, 31, 37]. Güven et al. reported a series of ten cases with posterior instrumentation, in which there was a 3.4° loss in the correction of local kyphosis [10]. Domaniç et al. reported that, in their series with anterior debridement, correction of the kyphosis was more successful in patients who underwent additional posterior CD instrumentation [8]. Yau et al. reported higher success rates with anterior fusion and posterior instrumentation in the same session [42]. In a recent series, 72 adult patients with different surgical procedures were assessed. Eight patients underwent only anterior debridement and fusion, leading to an 8.6% correction rate and an average correction loss of 23.6° during follow-up. This compares to 76.8% average correction and 2.5° correction loss in 11 patients who had posterior instrumentation following anterior radical surgery [6].

Kostuik reported a series of 79 patients who underwent anterior decompression and anterior internal fixation in 1983, among whom 51 had neurologic deficits. He reported two patients developing deformity because of spinal tuberculosis [19]. There has been very limited experience with anterior instrumentation following anterior radical debridement and fusion, especially in the early cases with active disease [5]. The reluctance to use this procedure probably arises from an assumption that placing the instrumentation in an area with active infection would lay the patient open to complications like disease reactivation or secondary infection [17]. This assumption, however, is not supported by the results of the present study, which demonstrate that anterior instrumentation in the presence of active infection does not cause any major complications, probably because of the poor adherence capacity of the tuberculosis bacilli to metals.

This series is not the first in the literature reporting the use of anterior instrumentation. We reported our first nine cases in 1996 [5]. Yılmaz and co-workers reported on 22 patients with single- or two-level and 16 with multilevel involvement, treated with anterior instrumentation. Their rates of correction were 64% and 81% for short and long fusions respectively; an overall average of 3° of correction loss was encountered and there were no major complications [43]. In another study, comparing the results of 45 patients treated with anterior radical debridement and anterior instrumentation with those treated with posterior instrumentation, we reported that, with anterior instrumentation, statistically similar correction rates can be obtained, but this procedure required fewer mobile segments to be instrumented. Also in this study, we suggested that posterior instrumentation may be preferable if there were various regions of involvement, more than two vertebrae were involved and if involvement included the lumbosacral junction [6]. In the present study, the results of 63 patients with 50.9 months of follow-up were evaluated, and our correction rates in local kyphosis angle (79.7±20.2%), our correction loss at the last control visit (1.1°±1.7°) and our final correction rate (74.3±23.3%) were compatible with the results reported in the literature. Evaluation of the effect on sagittal global contours showed a statistically significant correction rate in the thoracic, thoracolumbar and lumbar regions; correction loss rates at the last control visit were found to be very low. The normal physiological sagittal contours were maintained in the thoracic and thoracolumbar regions in 88% and 71.4% of the patients respectively, but physiological normal lumbar lordosis was restored in five patients. It is noted that carrying out a distraction for correction of the local kyphosis deformity in thoracic region resulted in a decrease in the global kyphosis angle, but despite this effect, neither hypokyphosis nor lordosis was noted in the thoracic region. The procedure played a positive role in the lumbar region by increasing lordosis. Implant failure and pseudoarthrosis were not noted, and a solid fusion mass was obtained in all patients. Tuberculosis reactivation was not noted.

Therefore, based on our results and those reported with the use of posterior instrumentation, it can be stated that instrumentation in active tuberculosis spondylitis can be performed safely with few complications, and is effective in obtaining and maintaining the correction of the deformity as well as obviating the need for external support. The two major advantages of anterior over posterior instrumentation are (1) the operation can be performed with a single approach, and (2) the inclusion of unnecessarily large number of levels into fusion can be avoided.

It should be noted that all patients included in this study have undergone a very aggressive alternating three-drug antibiotic regimen for 12 months, which has been the standard protocol at our center over the years, despite recent reports suggesting that shorter and less aggressive chemotherapy may be as effective. The 14th report of the MRC demonstrated that the clinical results at 3 years were excellent in patient groups receiving INH and R for 6 months and in those receiving the same drugs for 9 months, but only in those receiving INH and PAS or EMB for 18 months [26]. In 1998, the MRC Working Party on Tuberculosis of the Spine published the findings of a 15-year follow-up study of a series of patients with spinal tuberculosis who received a variety of treatments. They found anterior radical debridement and anterior strut grafting to be the most successful procedure for neurologic recovery, fusion and preventing kyphotic deformity, when compared against ambulatory chemotherapy, nonambulatory chemotherapy with debridement, and chemotherapy with Hong-Kong procedure [25]. Likewise, Upadhyay and co-workers have found that a regimen consisting of INH, R and streptomycin given for as short as 6 months yielded comparable results with a regimen of INH, PAS and streptomycin, in a group of patients who underwent surgical debridement and grafting [41] .The use of a more aggressive regimen for longer periods might have been effective for a better control of the disease in our series, eventually leading to uneventful healing. Shorter and less aggressive regimens in the presence of anterior internal fixation material needs to be tested further.

Finally, it may be argued that in patients with suspected tuberculosis spondylitis, the diagnosis, as well as the absence of secondary non-specific infection, needs to be confirmed before starting the process of surgical decision making. However, in areas where tuberculosis is an endemic problem, the rate of correct pre-operative diagnosis may be very high.

In addition to classical radiographs and laboratory tests, MRI is the best method for diagnosing tuberculosis [36]. Radionuclide imaging is not very helpful in these cases. There are high false-negative rates with technetium (33%) and gallium (70%) scans. CT imaging reveals the extent of bony destruction better than MRI [36]. An and co-workers reported a diagnostic accuracy of 97% with MRI in a series of patients with spinal tumors or infectious diseases [2]. In his series of 24 patients, Desai reported that diagnosis of the disease was possible in the very early stages with MRI [7]. Hoffmann et al. reported that MRI was necessary and very useful for surgical planning and diagnosing the canal compromise [13]. In the present study, our pre-operative rate of diagnosis was 96.8% (61 out of 63 patients) when a combination of MRI, CT and laboratory studies was used. The two patients diagnosed with solid tumors pre-operatively constitute the false-negative cases of this series. It should be noted, however, that these figures may be misleading. The probable false-positive cases who turned out not to be cases of tuberculosis spondylitis at surgery were not included in this database; hence, it cannot be claimed that the diagnostic accuracy of these methods combined is as high as 96.8%. Schmitz and co-workers have demonstrated that fluorine-18 flouro-2-deoxy-D-glucose positron emission tomography is more sensitive and accurate in the diagnosis of tuberculosis spondylitis than MRI, especially in the presence of metallic implants [34]. This technique may be used to achieve a higher rate of diagnostic accuracy in the future.

Conclusion

In patients without vertebral instability and deformity, we prefer conservative management, and in those who have abscess formation in addition, we use invasive radiological techniques in combination with abscess drainage and chemotherapy. It is our contention that, in patients with vertebral destruction and collapse, moderate to severe kyphotic deformity and large abscess formation, vertebral instability and neurological deficits and instability, anterior radical debridement, anterior strut grafting and anterior instrumentation is an optimal method. In patients with involvement in different vertebral regions and multiple levels and in those whose global sagittal contours are markedly deformed owing to local kyphosis, and in patients who have difficulty in undergoing anterior instrumentation due to lumbosacral junction involvement, posterior instrumentation may be preferred, after anterior radical debridement and anterior strut grafting at the same or a subsequent session.

In conclusion, based on the results of this study on the treatment of active tuberculosis spondylitis with anterior instrumentation along with anterior debridement and fusion, it can be stated that this procedure provides a very high and effective rate of deformity correction and maintenance. Furthermore, as demonstrated by several other studies, the use of metallic implants in the presence of active tuberculosis infection appears to be a safe procedure associated with a very low rate of complications.

References

1. Aksoy MC, Acaroglu RE, Tokgozoglu AM, Ozdemir N, Surat A (1995) Retrospective evaluation of treatment methods in tuberculosis spondylitis. Hacettepe J Orthop Surg 5:207–209
2. An HS, Vaccaro AR, Dolinkas CA, Cotler JM, Balderston RA, Bauerle WB (1991) Differentiation between spinal tumors and infections with magnetic resonance imaging. Spine 16 [8 Suppl]:333–338
3. Arthornthurasook A, Chongpieboonpatana A (1990) Spinal tuberculosis with posterior element involvement. Spine 15:191–194
4. Benhardt M (1997) Normal spinal anatomy: normal sagittal plane alignment. In: Bridwell KH, DeWald RL (eds) The text book of spinal surgery. Lippincott Raven, Philadelphia, pp 188–189
5. Benli IT, Aydın E, Kıs M, Akalın S, Tuzuner M, Baz AB (1996) The results of anterior instrumentation in vertebral tuberculosis. J Turkish Spine Surg 7: 98–101
6. Benli IT, Kıs M, Akalın S, Cıtak M, Kanevetci S, Duman E (2000) The results of anterior radical debridement and anterior instrumentation in Pott's disease and comparison with other surgical techniques. Kobe J Med Sci 46: 39–68
7. Desai SS (1994) Early diagnosis of spinal tuberculosis by MRI. J Bone Joint Surg Br 76:863–869
8. Domanic U, Hamzaoglu A, Sar C, Yavuzer Y (1993) Posterior fusion and instrumentation after anterior radical debridement and fusion in the surgical treatment of Pott's disease. J Turkish Spine Surg 4:16–19
9. Frankel HL, Hancock DO, Hyslop G, Melzah J, Michaelis LS, Ungar GH, Vernon JD, Walsh JJ (1969) The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. Paraplegia 7:179–192
10. Guven O, Kumano K, Yalş in S, Karahan M, Tsuji S (1994) A single stage posterior approach and rigid fixation for preventing kyphosis in the treatment of spinal tuberculosis. Spine 19:1039–1043
11. Hodgson AR, Stock FE (1994) Anterior spinal fusion. A preliminary communication on the radical treatment of Pott's disease and Pott paraplegia. Clin Orthop 300:16–23
12. Hodgson AR, Stock FE, Forg HSY, Ong GB (1960) Anterior spinal fusion: the operative approach and pathological findings in 412 patients with Pott's disease of the spine. Br J Surg 48:172–178
13. Hoffman EB, Crusier JH, Cremin BJ (1993) Imaging in children with spinal tuberculosis. A comparison of radiography, computed tomography and magnetic resonance imaging. J Bone Joint Surg Br 75:233–239
14. Hopf C, Eysel P, Dubousset J (1995) CDH: preliminary report on new anterior spinal instrumentation. Eur Spine J 4:194–199
15. Hsu LC, Cheng CL, Leong JC (1988) Pott's paraplegia of late onset: the cause of compression and results after anterior decompression. J Bone Joint Surg Br 70:534–538
16. Kemp HBS, Jackson JW, Jeremiah JD, Cook J (1973) Anterior fusion of the spine for infective lesions in adults. J Bone Joint Surg Br 55:715–734
17. Kim NH, Lee DHM, Choi CH, Park SJ (1994) The comparison of the fusion rate in anterior interbody fusion between noninfectious and infectious disease of the spine. J Turkish Spine Surg 5:49–58
18. Korkusuz F, Islam C, Korkusuz Z (1997) Prevention of postoperative late kyphosis in Pott's disease by anterior decompression and intervertebral grafting. World J Surg 21:524–528
19. Kostuik JP (1983) Anterior spinal cord decompression for lesions of the thoracic and lumbar spine: techniques, new methods of internal fixation. Spine 8:512–531
20. Loembe PM (1995) Medical-surgical treatment of progressive tuberculous (Pott's) paraplegia in Gabon. Paraplegia 33:579–584
21. Menard V (1894) Causes de paraplegia dans le mal de Pott. Son traitement chirurgical par l'ouverture directe du foyer tuberculeux des vertebres. Rev Orthop 5:47
22. Medical Research Council Working Party on Tuberculosis of the Spine (1974) A controlled trial of anterior spinal fusion and debridement in the surgical management of tuberculosis of the spine in patients on standard chemotherapy. A study in Hong Kong. Br J Surg 61:853–866
23. Medical Research Council Working Party on Tuberculosis of the Spine (1978) Five-year assessments of controlled trials of ambulatory treatment, debridement and anterior spinal fusion in the management of tuberculosis of the spine: Studies in Bulawayo (Rhodesia) and in Hong Kong. J Bone Joint Surg Br 60:163–177
24. Medical Research Council Working Party on Tuberculosis of the Spine (1982) A ten-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 64: 393–398

25. Medical Research Council Working Party or Tuberculosis of the Spine (1998) A 15-year assessment of controlled trials of the management of tuberculosis of the spine in Korea and Hong Kong. Thirteenth Report of the Medical Research Council Working Party on Tuberculosis of the Spine. J Bone Joint Surg Br 80:456–462
26. Medical Research Council Working Party on Tuberculosis of the Spine (1999) Five-year assessment of controlled trials of short-course chemotherapy regimens of 6, 9 or 18 months' duration for spinal tuberculosis in patients ambulatory from the start or undergoing radical surgery. Fourteenth report of the Medical Research Council Working Party on Tuberculosis of the Spine. Int Orthop 23:73–81
27. Moon MS (1997) Spine update: tuberculosis of the spine. Spine 22:1791–1797
28. Moon MS, Woo YK, Lee KS, Ha KY, Kim SS, Sun DH (1995) Posterior instrumentation and anterior interbody fusion for tuberculosis kyphosis of dorsal and lumbar spines. Spine 20:1910–1916
29. Moula T, Fowles JV, Kassab MT, Sliman N (1981) Pott's paraplegia: a clinical review of operative and conservative treatment in 63 adults and children. Int Orthop 5:23–29
30. Nemir RL, Krasinski K (1988) Tuberculosis in children and adolescents in the 1980s. Pediatr Infect Dis J 7:375–379
31. Oga M, Arizono T, Takasita M, Sugioka Y (1993) Evaluation of the risk of instrumentation as a foreign body in spinal tuberculosis: clinical and biologic study. Spine 18:1890–1894
32. Rajasekaran S, Soundarapandian S (1989) Progression of kyphosis in tuberculosis of the spine treated by anterior arthrodesis. J Bone Joint Surg Am 71:1314–1323
33. Rezai AR, Lee M, Cooper PR, Errico TJ, Koslow M (1995) Modern management of spinal tuberculosis. Neurosurgery 36:87–97
34. Schmitz A, Kalicke T, Willkomm P, Grunwald F, Kandyba J, Schimitt O (2000) Use fluorine-18 flouro-2-deoxy-D-glucose positron emission tomography in assessing the process of tuberculous spondylitis. J Spinal Disord 13: 541–544
35. Schulitz KP, Kothe R, Leong JCY, Wehling P (1997) Growth changes of solid fusion kyphotic bloc after surgery for tuberculosis. Spine 22:1150–1155
36. Slucky AV, Eismont FJ (1997) Spinal infections. In: Bridwell KH, DeWald RL (eds) The textbook of spinal surgery. Lippincott Raven, Philadelphia, pp 2141–2183
37. Tuli SM (1995) Current concept. Severe kyphotic deformity in tuberculosis of the spine. Int Orthop 19:327–331
38. Upadhyay SS, Saji MJ, Sell P, Sell B, Hsu LCS (1994) Spinal deformity after childhood surgery for tuberculosis of the spine. A comparison of radical surgery and debridement. J Bone Joint Surg Br 76:91–98
39. Upadhyay SS, Sell P, Saji MJ, Sell B, Hsu LC (1994) Surgical management of spinal tuberculosis in adults: Hong Kong operation compared with debridement surgery for short and long term outcome of deformity. Clin Orthop 302:173–182
40. Upadhyay SS, Saji MJ, Sell P, Yau ACMC (1994) The effect of age on the change in deformity after radical resection and anterior arthrodesis for tuberculosis of the spine. J Bone Joint Surg Am 76:701–708
41. Upadhyay SS, Saji MJ, Yau ACMC (1996) Duration of antituberculous chemotherapy in conjunction with radical surgery in the management of spinal tuberculosis. Spine 21:1898–1903
42. Yau ACMC, Hsu LCS, O'Brein JP, Hodgson AR (1974) Tuberculosis kyphosis: correction with spinal osteotomy halopelvis distraction and anterior and posterior fusion. J Bone Joint Surg Am 56:1419–1434
43. Yilmaz C, Selek HY, Gurkan I, Erdemli B, Korkusuz Z (1999) Anterior instrumentation for the treatment of spinal tuberculosis. J Bone Joint Surg Am 81:1261–1267
44. Zdeblick TA (1996) Thoracolumbar fractures. New anterior instrumentation. American Academy of Orthopaedic Surgeons Annual Meeting, February 22–26, Atlanta