A single-stage single-surgical approach for the treatment of pyogenic spinal infection

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Background
Pyogenic spinal infection (PSI) is the most common cause of spinal infection, affecting mainly the vertebral body. Nonoperative treatment is associated with high failure and mortality rates, especially in patients with impaired immune system. There is debate as regards the most appropriate approach and whether to use an implant at the infected site immediately or to wait for a second stage after a period of antibiotic coverage and whether to use one or combined anteroposterior approaches.

Objective
The aim of this work was to study the results of single-stage debridement, bone graft and immediate internal fixation for PSI cases through one approach.

Study design
This study was a retrospective review of 23 cases of PSI.

Patients and methods
The medical records, haematological results, radiological imaging, bacteriology and biopsy results of 23 patients of PSI were reviewed. The posterior approach was used in cases of thoracolumbar infection and the anterior approach was used in cervical spinal cases. Patients were treated with single-stage debridement, bone autograft and immediate internal fixation through the same approach, followed by parenteral antibiotics for 4–6 weeks and oral antibiotics until normalization of the inflammatory markers with good clinical and radiological response. Functional results were assessed using the Oswestry disability index questionnaire and the physical function domain score of SF-36 questionnaire.

Results
All patients showed complete resolution of infection and achieved solid bony fusion in a sound position without chronicity, relapse or persistence of infection. All patients showed neurological recovery and returned to their preoperative activity with good functional outcome as evidenced by significant improvement in the preoperative Oswestry disability index mean score and the physical function domain score of SF-36 questionnaire.

Conclusion
Single-stage single-approach surgical debridement, interbody fusion using bone graft and immediate internal fixation, is a safe and effective treatment for PSI.

Keywords:
immediate internal fixation, pyogenic spinal infection, single-surgical approach

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Introduction

Pyogenic spinal infection (PSI) is the most common cause of spinal infection and these include spondylodiscitis, septic discitis, vertebral osteomyelitis and epidural abscess. It represents 2–7% of all cases of osteomyelitis [1,2] and the incidence is rising. This may be due to the longer life expectancy for patients with chronic debilitating diseases, immunocompromise, steroid use, HIV, intravenous drug use and recent spinal surgery [3,4]. The male population is affected twice as the female population. It is primarily a disease of adults in their fifth decade of life. The vertebral body is the most common site of infection (95%) with only 5% affecting the posterior elements, including the facet joints. *Staphylococcus aureus* is the most common causative organism. The diagnosis is often delayed, as symptoms are often nonspecific. Inadequately treated or nontreated cases may lead to sepsis, bone destruction, spinal instability, deformity, neurological deficit and relapse of infection.

Nonoperative treatment has a high failure rate in patients with impaired immune system [5]. The mortality rate is 5–16% depending on the average age and comorbidities of patients. Death is much more likely in the elderly and in those with an underlying disease [5–8]. *S. aureus* infection is associated with a

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higher mortality rate compared with infection with other pathogens [9]. The main goal of treatment is to establish tissue and bacteriologic diagnosis, prevent reverse neurologic deficits, control infection, establish spinal stability, correct symptomatic deformity and prevent relapse by having solid bony fusion. There is debate as regards the most appropriate approach to treat septic spondylitis [10] and whether to use immediate implant at the infected site after debridement or to wait for a second stage after debridement for a period of antibiotic coverage and whether to use one approach or combined anteroposterior approaches.

The aim of this study was to evaluate the outcome of surgical treatment of PSI cases with single-stage debridement, bone autograft and immediate internal fixation through one approach and to show whether the use of immediate internal fixation is associated with persistence or relapse of infection.

Patients and methods

This was a retrospective study of 23 patients with PSI operatively treated at Mansoura University Hospital, Mansoura, Egypt. Patients were operatively treated using a single-stage, debridement, autograft and instrumentation using a single approach – the anterior approach in cervical spine cases and the posterior approach in thoracolumbar cases. The medical records, laboratory findings, radiologic imaging and bacteriology results of the 23 patients during the period from February 2006 to October 2008 were reviewed.

Preoperative diagnosis of vertebral pyogenic osteomyelitis was based on clinical presentation, radiographic findings and haematologic examination. Radiographic imaging included plain radiography, MRI and computed tomographic (CT) scan. Haematologic examination included white blood cell (WBC) count, erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP) titre. The biopsy and bacteriology results were diagnosed postopertively from the material taken from the operative debridement. Neurologic impairment was graded according to the American Spinal Injury Association (ASIA) classification [11]. The collected data included demographic data (age, sex, and occupation), systemic illnesses or any debilitating diseases, initial clinical presentation, neurologic deficit (Table 1), presenting inflammatory markers (WBC count, ESR and CRP titre), site of infection, vertebral levels involved, hospital stay and duration of antibiotic therapy. Functional assessment was carried out using the Oswestry disability index (ODI) questionnaire score [12], visual analogue scale for pain from 0 to 10 and the physical function domain score of SF-36 questionnaire [13]. This study approved by the Ethical committee of El-Mansoura University.

Radiographic evaluation included the local kyphosis angle as measured from the upper endplate of the vertebra to the lower endplate of the vertebra and the sagittal index as described by Farcy *et al.* [14]. Bony fusion was diagnosed from radiographic film as a continuous bony bridging between the graft and the endplates with absence of any radiolucencies. CT scan was used in suspected cases of radiolucencies at the graft endplate interface.

The indications for surgical treatment included one or more of the following: vertebral endplate destruction and vertebral collapse, local kyphosis, instability associated with intractable pain, neurological affection and failed medical treatment. Cases of psoas abcess requiring anterior drainage, tuberculous spondylitis and postoperative discitis were excluded from the study.

Operative procedures

Cervical spine cases were treated with debridement, tricortical bone graft and locked titanium anterior cervical plate fixation using the anterior approach. Other regions were treated using the posterior approach. In thoracic spinal infections, debridement and graft were performed by means of costotransversectomy and through the transforaminal and far lateral posterior approach in those with lumbar and lumbosacral infection together with posterior instrumentation. The instrumentation used was top-loading titanium pedicular screws and rod system.

Postoperative procedures

Patients were on empirical intravenous antibiotics until the results of biopsy and culture sensitivity tests. In negative cultures, empirical antibiotics were continued. In all cases, parenteral antibiotics were given for 4–6 weeks according to the clinical and laboratory response and then oral antibiotics were given until the infection profile returned to normal limits, with good clinical and radiological response. Patients started postoperative rehabilitation program early postoperatively (Figs. 1 and 2).

Results

A total of 23 patients with PSI were operatively treated between February 2006 and October 2008 at Mansoura University Hospital, Egypt. There were 18 male and five female patients. Their ages ranged from 18 to 65 years (mean ± SD: 48 ± 13.43 years).

Table 1 Patient data, causative organism, follow-up and neurological status

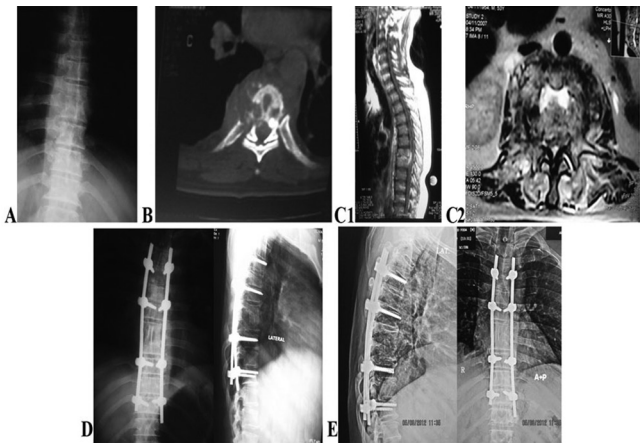
Patient number	Age (years)	Sex	Presentation	Level	Predisposing condition	Causative organism	Follow-up (months)	Neurological status	
								Admission	Follow-up
1	45	Male	Pain (B and L)	L5–S1		No growth	65	E	E
2	25	Male	Pain (B and L)	L4–L5		*Staphylococcus aureus*	60	E	E
3	40	Male	Pain (B and subcostal) and neurologic deficit	D10–D11		*Staphylococcus aureus*	56	D	E
4	60	Female	Pain (back)	L2–L3	Diabetes mellitus	No growth	56	E	E
5	57	Male	Pain (B and L) and neurologic deficit	L2–L3	Head trauma and ICU admission	*Staphylococcus aureus*	55	C	E
6	47	Male	Neurologic deficit and intractable pain	D7–D8		*Staphylococcus aureus*	54	D	E
7	42	Male	Pain and neurologic deficit	D7–D8		*Staphylococcus aureus*	53	D	E
8	36	Male	Neurologic deficit and pain (B and intractable)	D7–D8	Addiction and intravenous drug user	*Staphylococcus aureus*	50	C	E
9	65	Male	Pain (B and L)	L4–L5	Diabetes mellitus	Streptococci	48	E	E
10	50	Female	Pain (back)	L3–L4		No growth	48	E	E
11	55	Male	Pain (back)	L1–L2	Diabetes mellitus	*Staphylococcus epidermidis*	40	E	E
12	45	Female	Pain (back)	L3–L4		No growth	40	E	E
13	50	Female	Pain (back)	L3–L4		No growth	38	E	E
14	18	Female	Pain (neck)	C3–C4		*Staphylococcus aureus*	36	E	E
15	65	Male	Pain (B and L) and neurologic deficit	L1–L2	Diabetes mellitus	No growth	36	D	E
16	58	Male	Pain (B and L)	L4–L5	Liver cirrhosis	No growth	34	E	E
17	57	Male	Pain (back)	D12–L1	Empayema	Streptococci (group B)	34	E	E
18	44	Male	Pain (back)	L4–L5		*Staphylococcus aureus*	33	E	E
19	63	Male	Pain (back)	D8–D9	Liver cirrhosis	*Pseudomonas*	32	E	E
20	56	Male	Pain (back)	L2–L3	Chronic renal failure on dialysis	*Staphylococcus aureus*	32	E	E
21	46	Male	Pain (B and L)	L5–S1	Diabetes mellitus	No growth	31	E	E
22	60	Male	Pain (B and intractable)	D10–D11	Liver cirrhosis	No growth	30	E	E
23	20	Male	Pain (neck and radicular) and neurologic deficit	C5–C6		*Staphylococcus aureus*	30	D	E

The mean follow-up period was 43.09 ± 11.08 months (range 30–65 months). The lumbar spine was the most commonly affected region in 10 patients (43.48%), followed by the thoracic spine in six patients (26.9%) and the thoracolumbar area in three patients. The cervical and lumbosacral regions were the least affected, in two patients for each level (Table 2). The most common presentation was (back/neck) pain in nearly all cases (Table 3). Radicular pain was present in 12 patients. Systemic signs and symptoms occasionally occurred. These included fever higher than 37.5, weight loss, nausea and vomiting. Dysphagia was observed in one patient with cervical spinal infection. Neurological deficits were present in seven patients, including five patients with ASIA D and two patients with ASIA C. Four (66.67%) out of six patients with thoracic spinal infection, one (50%) out of two patients with cervical affection and one (33%) out of three patients with thoracolumbar spinal affection had neurological deficits. The lumbar spine showed the least incidence of neurological affection, one (10%) out of 10 patients. Risk factors for spinal infection were identified in 12 (52.17%) out of 23 patients. The most commonly associated risk factor was diabetes mellitus in five patients, followed by liver cirrhosis

Figure 1

(a) Plain radiographs: anteroposterior and lateral views of a 55-year-old male patient, showing endplate destruction, disc-space narrowing, collapse and localized kyphosis at L2–L3 spinal segment due to spinal infection. (b) Axial, sagittal and coronal computed tomographic scan showing marked bone destruction and collapse of L2–L3 segment. (c) MRI: C1: sagittal T1; C2: sagittal T2-weighted image showing loss of the disc space, endplate destruction, anterior paraspinal soft tissue extension and posterior intraspinal abscess under the lamina of L2 with fluid level compressing the cord; C3: axial T2-weighted images showing enhancement after gadolinium injection with paraspinal and intraspinal extension, fluid inside the disc space, endplate destruction, and posterior epidural mass under the lamina of L2 compressing the cord. (d) Immediate postoperative anteroposterior and lateral views: a plain radiography after posterior debridement, decompression, iliac bone autograft and posterior titanium short-segment pedicular score fixation showing correction of kyphosis and restoration of normal lumbar lordosis. (e) Follow-up radiography in anteroposterior and lateral: a plain radiography showing solid bony fusion and resolution of infection with maintenance of correction and without implant failure.

Figure 2



(a) Anteroposterior view of a 45-year-old male patient, showing endplate destruction and collapse of D7–D8 spinal segment. (b) Axial computed tomographic scan showing bony erosion of the vertebra and rib with paraspinal and intraspinal soft tissue extension. (c) MRI of the thoracic spine showing D7–D8 discitis, vertebral osteomyelitis, epidural abscess and spinal cord compression. Sagittal (C1) T1-weighted MRI imaging with gadolinium enhancement showing fluid in the D7–D8 disc space, endplate erosion, associated endplate destruction and large epidural collection resulting in marked spinal cord compression. Axial (C2) T2-weighted MRI image showing paraspinal and intraspinal extension spinal cord compression and fluid in the disc space. (d) Immediate postoperative anteroposterior and lateral view plain radiography after posterior debridement, rib autograft through costotransversectomy with excision of the seventh and eighth rib on the right side (the side of the most severe pathology). Together with posterior long segment pedicular instrumentation with correction of the segmental kyphosis and the rib graft in position. (e) Final follow-up anteroposterior and lateral views: plain radiographic images 5 years after the operation showing complete resolution of infection, solid bony fusion and maintenance of correction without loss of correction.

in three patients. Other risk factors included chronic renal failure on dialysis, intravenous drug use, empayema and trauma with ICU admission, in one patient for each of these risk factors.

All patients had elevated ESR (range 35–110 mm) and CRP titre. Minor elevations of ESR was documented in eight out of 23 patients. Marked elevations greater than 100 mm/h were found in four out of 23 patients and marked elevations of 55–99 mm were found in 11 patients. Elevated WBC count (based on normal range of $4–11^{10}$/ml) was detected in only 10 out of 23 patients and returned to normal within 1.78 ± 0.45 weeks (range 1–4 weeks). The preoperative CRP titre range was 24 to 96 (average 47.57 ± 25.17) and it returned to normal within 4.83 ± 0.94 weeks (range 3–7 weeks). ESR range was 35–110 mm/h, and this returned to normal within 10.30 ± 1.66 weeks (range 6–12 weeks). Postoperative biopsy from the operative material of debridement revealed PSI with no evidence of granulomatous infection in all cases. Cultures yielded positive growth in 15 out of 23 patients. The most commonly isolated organism was *S. aureus* in 10 patients (43.48%). The incidence of negative cultures was 34.78% (8 out of 23). The mean duration of postoperative antibiotic therapy was 10.5 ± 1.55 weeks (range 8–13 weeks) until

Table 2 Regional distribution

Spinal level	Number of cases (% of total)
Cervical	2 (8.69)
Thoracic	6 (26.08)
Thoracolumbar	3 (13.04)
Lumbar	10 (43.47)
Lumbosacral	2 (8.69)

Table 3 Clinical presentation

Presentation	Number of cases (% of total)
Back/neck pain	22 (95.65)
Radicular pain	12 (52.17)
Neurologic deficit	7 (30.43)
Others	
Fever >37.5°C	3 (13.04)
Weight loss >1 stone	2 (8.69)
Anorexia, nausea and vomiting	2 (8.69)
Dysphagia	1 (4.34)

normalization of the ESR and CRP titre. Parenteral antibiotic duration was 4–6 weeks.

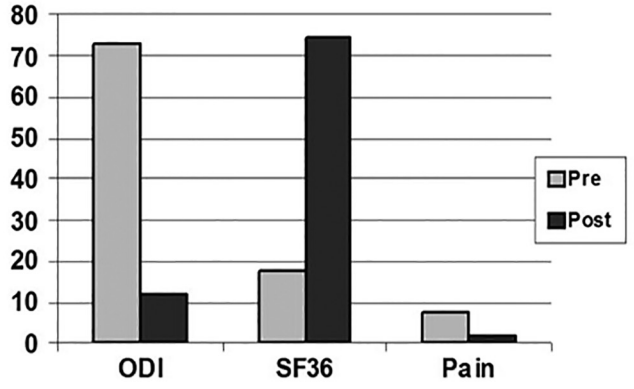
The mean duration of operation was 151.30 ± 21.22 min (range 110–180 min). The average amount of intraoperative blood loss was 765.22 ± 251.56 ml (range 350–1500 ml). The mean hospital stay lasted 8.48 ± 3.57 days (range 4–20 days). As regards graft, autogenous iliac bone graft was used in 21 patients and rib graft was used in only two patients. One patient developed early postoperative discharge that required second debridement on initial admission for drainage of seroma and closure of the dead space with complete resolution of infection. Pleural injury occurred in one patient treated with repair and chest tube for 3 days. All patients tolerated the operation well without any mortality or significant morbidity.

The segmental kyphosis angle and sagittal index were significantly corrected from 15.26 ± 5.26 (range 8–25) and 19.17 ± 3.75 (range 15–30) preoperatively to −3.17 ± 6.47 (range −10.00 to 6.5) and 74 ± 0.65 (range 0.00–2.00) postoperatively, respectively, without significant loss of correction at final follow-up (0.30 ± 0.49, range −0.50 to 1.50). Loss of correction was 0.78 ± 0.44 for thoracic and thoracolumbar cases and 0.00 ± 0.20 for the lumbar and cervical spinal cases, which is significantly lower. Solid interbody bony fusion was achieved in plain radiographs in all patients 6 to 8 months postoperatively.

All patients with incomplete neurological affection showed significant postoperative improvement and return to their full preoperative activity within 4 to 8 months. All neurologically free patients started early mobilization and rehabilitation program from the second or third postoperative day and returned to their full preoperative activity within 4–6 months. The average preoperative ODI score significantly improved from 76.30 ± 5.76 (range 67.00–85.00) to 12.26 ± 9.35 (range 0.00–27.00) postoperatively. The average preoperative visual analogue scale score of pain improved from 7.57 ± 1.41 (range 6–10) to 1.52 ± 1.27 (range 0–4). The average SF-36 (physical function score) improved from 17.61+5.97 (range 10.00–30.00) preoperatively to 74.83 ± 8.32 (range 65.00–85.00) postoperatively and correlated well with the average postoperative ODI score ($P = 0.000$) (Fig. 3).

At a mean follow-up period of 43.09 ± 6.75 months (range 30–65 months), all patients showed complete eradication of infection and had solid bony fusion in a sound position without relapse, persistence or chronicity of infection on clinical, laboratory and radiological basis.

Figure 3



Functional results: average preoperative and postoperative Oswestry disability index, SF-36 and pain scores.

Discussion

Although PSI is a highly treatable disease and conservative treatment with appropriate antibiotics and bracing is very successful in the majority of cases, it can lead to significant morbidity and even mortality, especially in developing countries because of the significant delay in diagnosis. However, with the advent of new diagnostic techniques allowing early diagnosis, multiple drug antimicrobial chemotherapy and improvements in surgical techniques, the prognosis has improved dramatically in recent years. The prognosis is dependent on host-immune defence, coexisting medical condition and severity of neurologic findings on first presentation. The lumbar spine is the most commonly affected region and the disease has a predilection for the elderly men, many of them are with medical comorbidities consistent with the results of this study but the median age was lower. Pain was the most common presentation for spinal infection in nearly all cases. Associated neurological deficits were present in seven patients, with higher incidence of neurological affection in thoracic than in cervical spine involvement, but the number of cervical spine involvement in this study was lower. Only three out of 12 patients with associated risk factors have neurological deficits. Hadjipavlou *et al.* [10] found a higher incidence of neurological deficits with thoracic spine than with cervical spine involvement. Eismont *et al.* [15] found a higher incidence of neurological deficits in cervical spine involvement, and Carragee [5] reported a higher incidence of neurological involvement in patients with impaired immune status. The higher incidence of neurological affection in thoracic spinal infection may be attributed to the narrow spinal canal, low cord/canal ratio, kyphotic angulation of the thoracic spine and the poor blood supply of the thoracic spinal cord [16].

Woertgen *et al.* [17], in their study on the functional outcome using SF-36, reported that surgical treatment particularly in conjunction with instrumentation may be beneficial compared with antibiotic therapy alone. The goals of surgical treatment of PSI are to establish tissue and bacteriologic diagnosis, prevent or reverse neurologic deficits, relieve pain, stabilize the destroyed unstable spinal segments, correct deformity, eradicate the infection and prevent relapses. Surgical treatment aims at preservation of neurologic function and facilitation of solid bony fusion without kyphosis. Surgical treatment comprises basically of good debridement of the infected focus, thus creating a clean vascular bed for bone grafting and stabilization of the spine.

Although the main pathology is mostly in the anterior column and the anterior approach appears to be the most direct approach, allowing direct decompression, debridement and anterior column reconstruction, other factors affect the decision-making about the approach in PSI [16]. These include the region involved, the amount of bone destruction, the presence of skip lesions in the spinal canal, the medical condition of the patient and obesity. The transthoracic approach in case of thoracic spinal infection is associated with significant morbidity, and instability is less common in the thoracic spine due to the rib cage. Therefore, combined approaches are not necessary in that region. Anterior infections in the cervical spine almost always require an anterior approach. Posterior thoracolumbar instrumentation has the advantages of being more stable, providing better deformity correction and preventing correction loss, allowing better control of infection with faster rates of solid bony fusion, allowing early mobilization and rehabilitation in these fragile patients, many of whom are with medical comorbidities, and decreasing the hospitalization time and cost. Posterior thoracolumbar instrumentation has been shown to be safe and effective after anterior debridement and fusion [5,18] and can be performed as a second stage either on the same day or later with good results. Posterior instrumentation should be considered in all patients with significant kyphosis or deformity and in cases of more than one level anterior corpectomy. Posterior instrumentation is also a relative indication in cases of surgery in the thoracolumbar or lumbar spine to achieve stability [16].

Historically, instrumentation was delayed until the surgeon is confident that the infection was eradicated. However, in recent times, instrumentation is usually performed at the same time as initial debridement, especially in the cervical or thoracolumbar lesions [19,20]. This retrospective study showed that sick patients with infective spondylitis can be safely and successfully treated using single-stage single-approach surgery and that using immediate instrumentation is not hazardous but controls the infection, stabilizes the destructed spine, achieves solid bony fusion, maintains spinal balance and allows early mobilization and easier rehabilitation of these sick patients. The anterior approach was used for cervical spine infection cases and the posterior approach for other regions of the spine. In the thoracic spine, we used the costotransversectomy approach and in the thoracolumbar, lumbar and lumbosacral regions, the transforaminal and far lateral approaches were used. With the posterior approaches, decompression of the neural elements was good and easy as the neural elements were identified and protected early in the procedure. Debridement was also accessible, allowing removal of all anterior necrotic tissues from the bodies or disc and epidural granulation tissues together with debridement of the posterior elements and paraspinal muscles in extensive cases of infection reaching posterior. Posterior thoracolumbar approaches are easier, simple, more familiar, achieve higher fusion rate, allow better correction of kyphosis and can be used in patients with poor general condition. The anterior approach is the most direct one that allows single-stage debridement, decompression, fusion and stabilization in the cervical spine. We used one approach because many of the patients did not have good general health conditions and some of them had medical comorbidities and could tolerate neither the combined nor the anterior approach. Some patients with lumbar and thoracolumbar spinal infections were hepatic and some of them had ascites and required long preoperative preparation, and the anterior or combined approaches are risky. With this single approach, the results were good, with lower surgical trauma, morbidity and mortality.

Despite debates and concerns, instrumentation has shown to be effective and safe in clinical studies in all types of spinal infections [20–24]. Bacterial adherence and multiplication and biofilm formation on the implant surface are dependent on the species and number of microorganisms and the type and physical characteristics of the biomaterial [25–29]. Bacterial adherence and glycocalyx biofilm formation that prevent the antibiotics and humoral immune system are less with titanium than with stainless steel implants [25,28–30] and this explains the good results with no surgical wound infections after titanium mesh cage implantation in spondylitis [22,31]. Good debridement decreases the number of microorganisms to the minimum possible at the site of infection. Unlike the long bone such as the tibia, the spine is highly vascular with good soft tissue coverage, and infection further increases the hyperaemia. Debridement removes all necrotic tissues harbouring the organism, thus creating a clean highly

vascular bed for delivery of the antibiotics and the humoral immune system and provides a more suitable bed for the graft to occur. Thus, glycocalyx formation is less with debridement and with the use of titanium instrumentation. Spinal instrumentation by providing stability achieves the final aim of surgical treatment of spinal infection – that is, control of the infection and facilitation of solid bony fusion with restoration of the normal balance of the spine. In addition, it allows rapid and easier rehabilitation of these fragile patients. The results of this study support this hypothesis. All patients showed solid bony fusion with good kyphosis correction without significant loss of correction at the final follow-up and returned early to their activity. There was no case with persistence, relapse or chronicity of the infection. Therefore, using instrumentation is not against the rule but it adds a very important factor for control of infection, which is stability. Anterior stability is provided through graft impaction, whereas posterior stability is provided through the posterior instrumentation in the thoracolumbar infection cases. In the cervical spine, the infection is usually limited anteriorly with intact posterior column and the stability provided by the locked anterior cervical plate was sufficient to achieve the good results, although the number of cervical spine infection cases in this study was low.

The nonvascularized bone autograft was earlier considered a foreign material similar to the instrumentation that increases bacterial adherence and biofilm formation. The graft used was autograft with good osteointegration, osteoinductivity and osteocoductivity. It is subjected to the favourable compression forces in the anterior column and protected from early collapse and absorption before consolidation by the instrumentation. There was no case of graft resorption or activation of infection, unlike the long bones. Therefore, the implant is similar to the bone graft in spinal infection, both are considered as dead foreign material initially but both do not exacerbate the infection.

In this study, neither preoperative needle biopsy nor blood cultures were used because all patients were referred and presented late in the course of the disease after a long period of antibiotic treatment and disappearance of the bacteraemic phase, when the diagnosis of spinal infection is evident and all patients are candidates for surgery. This makes the negative results of blood cultures high; moreover, the healing process according to Fraser's theory [32] makes the negative culture results of preoperative and operative biopsy high. In addition, some of the patients did not have good general health conditions to be anaesthetized in the radiology department for CT-guided biopsy. The reported incidence of positive blood cultures varies among studies ranging from 25 to 57% [33,34]. Sapico and Montgomerie [6] found that 30% of needle biopsy specimens and aspirates were sterile, compared with only 14% of surgical specimens. Hadjipavlou *et al.* [35] found positive cultures in 71% of the percutaneous biopsies. In this study, the incidence of negative cultures obtained from the operative material was 34.78% due to late presentation and prolonged antibiotic therapy before the operation. The most common isolated organism was *S. aureus* in 43.48%. Other studies reported an incidence of 42–84% [6,36–38] for *S. aureus* infection. Maintaining high serum level of prolonged antibiotics by means of the parenteral route after surgical debridement is the most important factor for controlled and successful treatment of spinal infection. Sapico and Montgomerie [6] reported a 25% relapse rate of infection in patients treated for less than 4 weeks' duration of parenteral antibiotics. In agreement with other studies, parenteral antibiotics were given for 4–6 weeks [10,33] to maintain high serum levels of prolonged antibiotics, or until the ESR reduced to 50% of its level at presentation [39] to be followed by oral antibiotics until the inflammatory markers were normal. Using this regimen controls and prevents the relapse and chronicity of the infection.

MRI is highly sensitive, specific and accurate (96, 94 and 92%, respectively) and is currently the investigation of choice for the management of spinal infection [40]. In this study, MRI was also highly sensitive (100% sensitivity) for the diagnosis of spinal infection. This higher sensitivity rate may be due to the late presentation of all cases and the small number of cases in this study. CT scan better detects the actual extent of bone destruction that is overestimated by MRI and proven to be oedema of the bone marrow.

Studies have shown that the advantages of combined single-stage, same-day two-approach surgery generally outweigh the risks, including lower blood loss, shorter hospital stay and cost, earlier mobilization and lower rate of complications [5,41,42]. In this study using single-stage single-approach achieved the same good final results without increase in the risk of persistence or relapse of infection with lower blood loss, operative time, hospital stay, cost, cosmoses and complications. Thus, the use of one approach is better compared with two approaches.

Conclusion

Surgical treatment of PSI is associated with good results. Sick patients with complicated PSI can be safely and successfully treated with single-stage surgery using

the posterior approach in the thoracolumbar spine and the anterior approach in the cervical spine.

Titanium implants can be safely used immediately at the site of spinal infection after good debridement of all necrotic tissues together with maintenance of high serum levels of prolonged antibiotics through the parenteral route. It is important for control of infection and is not associated with relapse, persistence or chronicity of infection. It leads to good functional and radiological results.

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Conflicts of interest
There are no conflicts of interest.

References

1 Kulowski J. Pyogenic osteomyelitis of the spine an analysis and discussion of 102 cases. J Bone Joint Surg 1936; 18:343–364.

2 Wilensky AO. Osteomyelitis of the vertebrae. Ann surg 1929; 89:561–570.

3 Acosta FL Jr, Galvez LF, Aryan HE, Ames CP. Recent advances: infections of the spine. Curr Infect Dis Rep 2006; 8:390–393.

4 Calderone RR, Larsen JM. Overview and classification of spinal infections. Orthop Clin North Am 1996; 27:1–8.

5 Carragee EJ. Pyogenic vertebral osteomyelitis. J Bone Joint Surg Am 1997; 79:874–880.

6 Sapico FL, Montgomerie JZ. Pyogenic vertebral osteomyelitis: report of nine cases and review of the literature. Rev Infect Dis 1979; 1:754–776.

7 Garcia A Jr, Grantham SA. Hematogenous pyogenic vertebral osteomyelitis. J Bone Joint Surg Am 1960; 42-A:429–436.

8 Selby RC, Pillay KV. Osteomyelitis and disc infection secondary to *Pseudomonas aeruginosa* in heroin addiction. Case report. J Neurosurg 1972; 37:463–466.

9 Bonfiglio M, Lange TA, Kim YM. Pyogenic vertebral osteomyelitis. Disk space infections. Clin Orthop Relat Res 1973; 96:234–247.

10 Hadjipavlou AG, Mader JT, Necessary JT, Muffoletto AJ. Hematogenous pyogenic spinal infections and their surgical management. Spine (Phila Pa 1976) 2000; 25:1668–1679.

11 American Spinal injury Association. *Standards for Neurologic and Functional Classification of Spinal Cord Injury*. Chicago, IL: American Spinal Injury Association; 1992.

12 Fairbank JC, Pynsent PB. The Oswestry disability index. Spine (Phila Pa 1976) 2000; 25:2940–2952.

13 Ware JE Jr, Sherbourne CD. The MOS 36-Item Short-Form Health Survey (SF-36): I. Conceptual framework and item selection. Med Care 1992; 30:473–483.

14 Farcy J, Weidenbaum M, Glassman S. Sagittal index in management of thoracolumber burst fractures. spine 1990; 15:958–965.

15 Eismont FJ, Bohlman HH, Soni PL, Goldberg VM, Freehafer AA. Pyogenic and fungal vertebral osteomyelitis with paralysis. J Bone Joint Surg Am 1983; 65:19–29.

16 Rothman RH, Simeone FA. *The Spine*. 5th ed. Philadelphia, PA: WB Saunders Company; 2006.

17 Woertgen C, Rothoerl RD, Englert C, Neumann C. Pyogenic spinal infections and outcome according to the 36-item short form health survey. J Neurosurg Spine 2006; 4:441–446.

18 Versca J, Leung KY, Wagner TA, *et al*. *Primary Infections of the Spine Treated Surgically: Instrumented Versus Non Instrumented Presented Before the 10th Annual Meeting of the North American Spine Society*. Washington, DC: 1995.

19 Korovessis P, Sidiropoulos P, Piperos G, Karagiannis A. Spinal epidural abscess complicated closed vertebral fracture. A case report and review of literature. Spine (Phila Pa 1976) 1993; 18:671–674.

20 Nakase H, Tamaki R, Matsuda R, Tei R, Park YS, Sakaki T. Delayed reconstruction by titanium mesh-bone graft composite in pyogenic spinal infection: a long-term follow-up study. J Spinal Disord Tech 2006; 19: 48–54.

21 Korovessis P, Petsinis G, Koureas G, Iliopoulos P, Zacharatos S. Anterior surgery with insertion of titanium mesh cage and posterior instrumented fusion performed sequentially on the same day under one anesthesia for septic spondylitis of thoracolumbar spine: is the use of titanium mesh cages safe?. Spine (Phila Pa 1976) 2006; 31:1014–1019.

22 Liljenqvist U, Lerner T, Bullmann V, Hackenberg L, Halm H, Winkelmann W. Titanium cages in the surgical treatment of severe vertebral osteomyelitis. Eur Spine J 2003; 12:606–612.

23 Ha KY, Chung YG, Ryoo SJ. Adherence and biofilm formation of *Staphylococcus epidermidis* and *Mycobacterium tuberculosis* on various spinal implants. Spine (Phila Pa 1976) 2005; 30:38–43.

24 Carragee EJ. Instrumentation of the infected and unstable spine: a review of 17 cases from the thoracic and lumbar spine with pyogenic infections. J Spinal Disord 1997; 10:317–324.

25 Arens S, Schlegel U, Printzen G, Ziegler WJ, Perren SM, Hansis M. Influence of materials for fixation implants on local infection. An experimental study of steel versus titanium DCP in rabbits. J Bone Joint Surg Br 1996; 78:647–651.

26 Cordero J, Munuera L, Folgueira MD. Influence of metal implants on infection. An experimental study in rabbits. J Bone Joint Surg Br 1994; 76:717–720.

27 Gristina AG, Hobgood CD, Webb LX, Myrvik QN. Adhesive colonization of biomaterials and antibiotic resistance. Biomaterials 1987; 8:423–426.

28 Gracia E, Fernández A, Conchello P, Laclériga A, Paniagua L, Seral F, Amorena B. Adherence of *Staphylococcus aureus* slime-producing strain variants to biomaterials used in orthopaedic surgery. Int Orthop 1997; 21:46–51.

29 Chang CC, Merritt K. Infection at the site of implanted materials with and without preadhered bacteria. J Orthop Res 1994; 12:526–531.

30 Chang CC, Merritt K. Effect of *Staphylococcus epidermidis* on adherence of *Pseudomonas aeruginosa* and *Proteus mirabilis* to polymethyl methacrylate (PMMA) and gentamicin-containing PMMA. J Orthop Res 1991; 9:284–288.

31 Kuklo TR, Potter BK, Bell RS, Moquin RR, Rosner MK. Single-stage treatment of pyogenic spinal infection with titanium mesh cages. J Spinal Disord Tech 2006; 19:376–382.

32 Fraser RD, Osti OL, Vernon-Roberts B. Discitis after discography. J Bone Joint Surg Br 1987; 69:26–35.

33 Sapico FL. Microbiology and antimicrobial therapy of spinal infections. Orthop Clin North Am 1996; 27:9–13.

34 O'Daly BJ, Morris SF, O'Rourke SK. Long-term functional outcome in pyogenic spinal infection. Spine (Phila Pa 1976) 2008; 33:E246–E253.

35 Hadjipavlou AG, Crow WN, Borowski A, Mader JT, Adesokan A, Jensen RE. Percutaneous transpedicular discectomy and drainage in pyogenic spondylodiscitis. Am J Orthop (Belle Mead NJ) 1998; 27:188–197.

36 Emery SE, Chan DP, Woodward HR. Treatment of hematogenous pyogenic vertebral osteomyelitis with anterior debridement and primary bone grafting. Spine (Phila Pa 1976) 1989; 14:284–291.

37 Torda AJ, Gottlieb T, Bradbury R. Pyogenic vertebral osteomyelitis: analysis of 20 cases and review. Clin Infect Dis 1995; 20:320–328.

38 Rath SA, Neff U, Schneider O, Richter HP. Neurosurgical management of thoracic and lumber vertebral osteomyelitis and discitis in adults: a review of 43 cosecutive surgically treated patients Neurosurgery 1996; 38: 926–933.

39 Sapico FL, Montgomerie JZ. Vertebral osteomyelitis. Infect Dis Clin North Am 1990; 4:539–550.

40 Dagirmanjian A, Schils J, McHenry M. MR imaging of spinal infections. Magn Reson Imaging Clin N Am 1999; 7:525–538.

41 Safran O, Rand N, Kaplan L, Sagiv S, Floman Y. Sequential or simultaneous, same-day anterior decompression and posterior stabilization in the management of vertebral osteomyelitis of the lumbar spine. Spine (Phila Pa 1976) 1998; 23:1885–1890.

42 Fountain SS. A single-stage combined surgical approach for vertebral resections. J Bone Joint Surg Am 1979; 61:1011–1017.