Treatment of haematogenous pyogenic vertebral osteomyelitis by single-stage anterior debridement, grafting of the defect and posterior instrumentation

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Anterior debridement, grafting of the defect and posterior instrumentation as a single-stage procedure is a controversial method of managing pyogenic vertebral osteomyelitis. Between 1994 and 2005, 37 patients underwent this procedure at our hospital, of which two died and three had inadequate follow-up. The remaining 32 were reviewed for a mean of 36 months (12 to 66). Their mean age was 48 years (17 to 68). A significant pre-operative neurological deficit was present in 13 patients (41%). The mean duration of surgery was 285 minutes (240 to 360) and the mean blood loss was 900 ml (300 to 1600). Pyogenic organisms were isolated in 21 patients (66%). All patients began to mobilise on the second post-operative day. The mean hospital stay was 13.6 days (10 to 20). Appropriate antibiotics were administered for 10 to 12 weeks. Early wound infection occurred in four patients (12.5%), and late infection in two (6.3%).

At final follow-up, the infection had resolved in all patients, neurological recovery was seen in ten of 13 (76.9%) and interbody fusion had occurred in 30 (94%). The clinical outcome was excellent or good in 30 patients according to Macnab’s criteria. This surgical protocol can be used to good effect in patients with pyogenic vertebral osteomyelitis when combined with appropriate antibiotic therapy.

The diagnosis and management of pyogenic vertebral osteomyelitis remains difficult, not least because of the increasing elderly and immunocompromised population worldwide. Although the spine accounts for only 0.15% to 3.9% of all cases of osteomyelitis, its effects can be devastating, resulting in significant pain, deformity and neurological deficit.

The treatment of choice is conservative, with appropriate antibiotics and external immobilisation, particularly if the diagnosis is made early and the causative organism can be identified from a closed needle biopsy.

Surgical intervention is indicated if conservative management fails, there is a progressive neurological deficit, if there is severe pain, a kyphosis with segmental instability or a recurrence of the infection. Surgery can provide relief from pain, improvement in the patient’s neurological condition, restoration of sagittal balance, and early mobilisation.

When surgery is indicated, anterior debridement is preferred as it is the body of the vertebra which is predominantly involved. There are, however, two main areas of controversy. Should posterior instrumentation be used in the presence of established infection, and should surgery be carried out in one or more stages? We have performed single-stage anterior debridement, grafting of the defect and posterior stabilisation for pyogenic vertebral osteomyelitis since 1993, having previously achieved satisfactory results with this technique in spinal tuberculosis. We present our further experience of this procedure.

Patients and Methods

Between 1994 and 2005, 61 patients presented to our tertiary care hospital with haematogenous pyogenic vertebral osteomyelitis. Of these, 12 were treated conservatively, six by debridement or drainage only, and six by anterior debridement and strut grafting. The remaining 37 patients were treated by single-stage anterior debridement, grafting of the defect and posterior instrumentation.

The pre-operative diagnosis was based on the clinical presentation, the results of radiological investigations including plain radiographs, bone scans and MRI, and the white cell count and erythrocyte sedimentation rate (ESR). We included only adult patients with a microbiological or histopathological diagnosis. The minimum follow-up was for 12 months (mean 35 (12 to 66)).
Our management is depicted as an algorithm in Figure 1.

Back pain was the most common symptom and was present in all cases. Medical comorbidities were seen in 17 patients (46%) (Table I). An identifiable primary focus of infection was seen in eight patients (22%), of whom two had superficial carbuncles, one had typhoid fever, three a urinary tract infection, one sepsicaemia, and one an infected hip implant. Before they presented to us, eight patients had received antibiotics, six incomplete antituberculous treatment and eight had received both.

Any neurological deficit was recorded using Frankel's grade.12 A significant neurological deficit (Frankel A, B or C), severe unrelenting pain which prevented the patient from standing or sitting without using their hands for support, substantial vertebral body destruction leading to local instability, and failure of non-operative management.

Depending on the level of the disease, anterior debridement was carried out through a thoracotomy, retropleural, thoracoabdominal, retroperitoneal or transperitoneal approach. A meticulous debridement of all infected granulation tissue, devitalised disc and sequestra was carried out, followed by a thorough curettage to bleeding cancellous bone. Decompression of the spinal canal was undertaken when necessary. Intra-operative specimens were sent for Gram stain, culture and sensitivity for pyogenic and tuberculous organisms, and histological examination.

Anterior debridement was carried out first. The defect was carefully measured and an autologous bone graft of appropriate length harvested from the iliac crest. The tricortical graft was fashioned into a wedge and punched into the defect. This ensured its stability throughout the remainder of the operation. In instances where a cage was used, one of appropriate diameter and length was cut and filled with morcellised bone graft (from the rib or iliac crest) and tapped into the defect.

Anterior column reconstruction used a tricortical iliac crest bone graft in 29 patients (78%) and a titanium cage in eight (22%). The mean length of graft or cage was 30 mm (12 to 50). During graft placement every effort was made to restore sagittal alignment by manual pressure over the spinous process. The patient was then turned onto a Relton-Hall frame14 to carry out the posterior stabilisation. The type of spinal instrumentation used followed the prevailing trend. Between 1994 and 1998 we used a Hartshill rectangle15 (Surgicraft, Redditch, United Kingdom) and sublaminar wires. Subsequently, we used Steffee plates16.

The indications for surgery included a significant neurological deficit (Frankel A, B or C), severe unrelenting pain which prevented the patient from standing or sitting without using their hands for support, substantial vertebral body destruction leading to local instability, and failure of non-operative management.

Table I. Comorbidities

<table>
<thead>
<tr>
<th>Condition</th>
<th>Number</th>
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<tbody>
<tr>
<td>Diabetes</td>
<td>9</td>
</tr>
<tr>
<td>Smoking</td>
<td>3</td>
</tr>
<tr>
<td>Ankylosing spondylitis</td>
<td>1</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>1</td>
</tr>
<tr>
<td>Hypertension</td>
<td>2</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

Table II. Details of surgery

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior TICCG*</td>
<td>25</td>
</tr>
<tr>
<td>Cage</td>
<td>7</td>
</tr>
<tr>
<td>Posterior Steffee plates and screws</td>
<td>4</td>
</tr>
<tr>
<td>Polyaxial pedicle screws</td>
<td>18</td>
</tr>
<tr>
<td>Hartshill rectangle</td>
<td>10</td>
</tr>
</tbody>
</table>

* TICCG, tricortical iliac crest bone graft
(Acromed, Cleveland, Ohio) and screws before moving to polyaxial screws and rods (Table II). The use of pedicle screws has shortened the required length of the construct. Antibiotics were given for ten to 12 weeks. For the first two weeks they were administered intravenously, then orally for eight to ten weeks. The duration of treatment was influenced by how well the patient felt, their level of pain, the degree of healing and the ESR.

Our antibiotic regimen for typhoid vertebral osteomyelitis was ciprofloxacin intravenously for two weeks and then orally for at least three months. Our antibiotic regimen for methicillin-resistant Staphylococcus aureus (MRSA) vertebral osteomyelitis was chosen on the basis of the sensitivities of the organism. We usually gave vancomycin intravenously for two weeks and then linezolid or a combination of rifampicin and ofloxacin orally for the remaining eight to ten weeks.

If there was no growth on culture, but histopathological evidence of osteomyelitis with necrotic bone spicules, neutrophils and plasma cells, and granulation tissue with no evidence of tuberculous granuloma, we gave broad-spectrum antibiotics using second-generation cephalosporins and quinolones.

All patients were mobilised on the second post-operative day. Patients were followed up at three, six, nine and 12 months, and then yearly. The mean follow-up was 36 months (12 to 66). At follow-up, blood tests, including the ESR, were carried out. Interbody fusion was independently confirmed by our radiologists when bony trabeculae crossed the entire length of the graft bed and graft. It was not easy to diagnose radiologically in those patients in whom we had used a titanium cage. Fusion was deemed to have occurred in those patients in whom there was no pain or tenderness over the site of the operation, the presence of a ‘sentinel sign’,17 no radiological signs of loosening or failure of the implant, and no angular changes on lateral flexion/extension radiographs.

At their last follow-up, patients were assessed for resolution of infection, residual pain, neurological grade, kyphos angle and the state of the fusion and implant. Clinical outcome was assessed using Macnab’s criteria18 (Table III).

**Results**

Three of the 37 patients were excluded because of inadequate follow-up. Two patients died, one within two weeks of surgery from overwhelming sepsis. She was a 58-year-old...
onset. Diabetic with disease at D10-11 and a paraplegia of rapid onset. Escherichia coli was isolated from her spinal lesion, urine and blood cultures. The second patient died six months post-operatively from an unrelated condition. This left 32 patients available for follow-up. There were 26 men and six women, with a mean age of 48 years (17 to 68). The lumbar spine was involved in 17 patients (53%) the thoracic spine in seven (22%), thoracolumbar spine in five (16%) and the lumbosacral spine in three (9%). The mean delay from the time of onset of symptoms to diagnosis was 3.8 months (0.5 to 6).

The mean duration of the combined anterior and posterior surgery was 285 minutes (240 to 360), the mean blood loss 900 ml (300 to 1600) and the mean length of hospital stay 13.6 days (10 to 20).

In 21 of the 32 patients (66%) the causative organism was identified, cultured, and its sensitivities obtained (Table IV).

The 11 patients (34%) for whom no organisms were identified were included as they showed histopathological evidence of bacterial osteomyelitis; no TB bacilli were grown on culture. All 32 cases showed the histopathological features of vertebral osteomyelitis.

No patients showed deterioration in their neurological condition after operation. The 19 patients (59%) who were neurologically intact or who had mild neurological involvement were mobilised on the second post-operative day. The other 13 (41%) who had some neurological compromise pre-operatively were allowed to sit and turn in bed, and underwent progressive rehabilitation. Two of the Frankel A patients showed no neurological improvement while the remaining 11 all showed some recovery (Table V).

In 28 patients (87.5%) the incisions healed uneventfully, but in four (12.5%) there was a delay in wound healing. There were three superficial infections which healed with dressings and antibiotics, and one deep infection that needed surgical lavage and debridement before it healed. One patient developed a post-operative pneumonia which resolved with antibiotics and chest physiotherapy. Late infections were seen in two patients (6.3%) at 12 and 24 months, both of which resolved after the implants were removed. The organism in these cases (coagulase-negative Staphylococcus and Staphylococcus aureus) differed from the initial isolates (Gram-negative bacilli and MRSA, respectively).

Bony fusion with incorporation of the graft was seen in 30 patients (94%) (Fig. 2). One patient developed a pseudarthrosis at the upper end of the graft resulting in a junctional kyphosis. Another patient had subsidence of the titanium cage and a 22° loss of correction after 34 months with a proximal screw backing out and becoming prominent under the skin. He was unwilling to undergo further surgery.

The kyphos angle at final follow-up and the loss of correction are shown in Table VI. Screw failure (breakage) occurred in two patients after bony fusion. In one case the implant was electively removed.

All the infections had resolved by the time of final follow-up. In total, 25 patients (78%) were completely relieved of pain and seven (22%) had mild residual pain which did not interfere with their daily activities or require regular analgesics. On Macnab’s criteria,18 17 (53%) had excellent results, 13 (4%) good, one (3%) fair and one (3%) poor result.

**Discussion**

Despite recent advances in imaging, and further refinement of microbiological and histopathological techniques, the early detection and treatment of vertebral osteomyelitis remains a matter of considerable difficulty and, as in other studies, we found a mean delay of 3.8 months (0.5 to 6) before the patients were correctly diagnosed. A possible cause for this is our function as a tertiary centre for a large geographic area, to which patients usually present after treatment elsewhere has failed.

Timely diagnosis of pyogenic vertebral osteomyelitis depends on its consideration in patients with back pain and fever, especially those who are elderly, diabetic or immuno-compromised. Delay in diagnosis results in greater tissue destruction, spinal instability and worsening neurology.9

Treatment is primarily non-operative. A full course of appropriate antibiotics is imperative. In early disease a needle biopsy may help to identify the infecting organism. In this series, however, CT-guided biopsy was performed in three of 37 patients (8%) and was only positive in one (Salmonella paratyphi A). In the other 34 patients the presentation was delayed and there was already significant vertebral body destruction, resulting in severe pain and/or neurological deficit, which warranted early surgery.

The decision to perform anterior and posterior spinal surgery as a one- or two-stage procedure is complex and controversial.7 We concur with Kuklo et al,7 who felt that

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**Table VI. Mean (range) kyphos angle (as per Konstam17)**

<table>
<thead>
<tr>
<th>Level</th>
<th>Pre-operative</th>
<th>Immediate post-operative</th>
<th>Final follow-up</th>
<th>Loss of correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracic and thoracolumbar(*)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>including two patients with pseudarthrosis</td>
<td>15 (5 to 31)</td>
<td>10 (2 to 20)</td>
<td>17 (7 to 50)</td>
<td>7</td>
</tr>
<tr>
<td>excluding two patients with pseudarthrosis</td>
<td>16 (5 to 31)</td>
<td>13 (5 to 20)</td>
<td>12 (0 to 30)</td>
<td>1</td>
</tr>
<tr>
<td>Lumbar and lumbosacral(*)</td>
<td>2</td>
<td>-10</td>
<td>-3.5</td>
<td>6.5</td>
</tr>
</tbody>
</table>

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unless the patient is medically unstable to a degree that sequential or simultaneous procedure might be life-threatening, the advantages of a single-stage procedure generally outweigh the perceived risks. Performing the procedure in a single stage has the advantage of reduced blood loss, a shorter hospital stay, earlier mobilisation, and less anxiety for the patient and their family. This is important in countries where financial constraints and social circumstances prevent prolonged hospitalisation. Furthermore, sequential anterior and posterior surgery on two different days requires two visits to the operating theatre with two anaesthetics, and risks the possibility of graft displacement during transfers in the waiting period. From our experience of 70 patients with tuberculous spondylitis, the mean hospital stay for those who underwent a single-stage procedure was 12.6 days, compared with 20 days for those operated on in two stages. Consequently, we felt that to use the same strategy for patients with vertebral osteomyelitis who required surgery was justified.

The use of spinal instrumentation in the presence of active infection has been shown to be safe and effective,\textsuperscript{2,7,9,19,20} The presence of a biofilm binding\textsuperscript{21} the organisms to the implant does not seem to present any significant clinical problems. The use of instrumentation confers better sagittal balance, little loss of correction and high fusion rates\textsuperscript{2,3,20,22-24} In this series we had a 94% fusion rate, which is among the best quoted in the literature.\textsuperscript{2,24} Even the two patients who developed late infections at 12 and 24 months healed uneventfully after the implant had been removed without graft infection or erosion. Their clinical outcome was not compromised.

Tricortical iliac crest bone graft was used in 78% of cases, having been shown to be the best option in the presence of infection.\textsuperscript{24} There was no slippage or fracture of the grafts, although some degree of subsidence was noted. This accounted in part for the loss of correction seen in our patients.

A number of studies have shown that it is safe to use titanium cages.\textsuperscript{2,20} We used these in seven of our 32 patients (22%) with satisfactory results.

This study has some inherent limitations because of its retrospective nature. It is, however, a consecutive series of patients who were treated in a uniform manner. All the patients were operated on by a team of surgeons supervised by the senior author (GDS). The treatment philosophy remained constant over the years, with only minor modifications in technique. The length of follow-up, albeit similar to that in other reported series, may not be sufficient to rule out the possibility of late recurrence. The absence of objective pre- and post-operative functional scores prevents us from carrying out a more detailed evaluation of the patients’ functional outcome.

This clinical study shows that patients with thoracic and lumbar pyogenic vertebral osteomyelitis, in whom surgery is performed for specific indications, can safely and successfully undergo single-stage anterior decompression grafting and posterior instrumentation under the same anaesthetic with good pain relief, early ambulation, a high incidence of neurological recovery, and inter-body vertebral fusion in 94% of cases.

Our recommended indications for the use of this approach include severe unrelenting pain, a significant neurological deficit, substantial vertebral body destruction leading to local instability, and failed medical management. Antibiotic cover for ten to 12 weeks is mandatory.

References


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