Instrumentation in patients with spinal infection

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Object. Placement of instrumentation in the setting of a spinal infection has always been controversial. Although the use of allograft and autograft bone has been accepted as safe, demonstrations of the effectiveness of titanium have been speculative, based on several retrospective reviews. The authors’ goal in this study was to demonstrate the effectiveness of instrumentation in the setting of a spinal infection by retrospectively reviewing their cases over the last 4 years and searching the literature regarding instrumentation in patients with pyogenic spinal infections.

Methods. The authors conducted a retrospective review of their cumulative data on spinal infections. Diagnosis was based on subjective and objective clinical findings, along with radiographic and laboratory evaluation of infection and mechanical stability. Patients with medically managed disease and those who did not receive instrumentation were eliminated from this review.

Of 105 patients with spinal infections who were admitted to the neurosurgical service between January 2000 and June 2004, 30 underwent surgical debridement necessitating spinal instrumentation. There were 17 women and 13 men in this group ranging from 28 to 86 years of age. Follow-up duration ranged from 3 to 54 months. There was one death, which occurred 3 months postsurgery. In three patients a deep wound infection developed, necessitating intervention, and two patients experienced a graft expulsion. Twenty-nine patients went on to demonstrate adequate fusion based on follow-up neuroimaging studies.

Conclusions. The goal of neurosurgical intervention in the setting of spinal infection is to obtain an organism culture and the debridement of infection while maintaining neurological and mechanical stability. The authors demonstrate the effectiveness of radical debridement of infected bone and placement of instrumentation in patients with spinal infections.

KEY WORDS • osteomyelitis • infection • spine • instrumentation

The recent resurgence of spinal infections, which is attributed to an increase in immunocompromised patients and antibiotic-resistant strains of bacteria, has become a significant problem for most spine surgeons. Indications for surgical intervention are not always clear. In addition, questions frequently arise about the timing of surgery and which procedure to use. The use of spinal instrumentation in the setting of infection has also been controversial. To advance discussion of these issues, we describe our experience with instrumentation in patients with spinal infection and review the current literature.

CLINICAL MATERIAL AND METHODS

We conducted a nonrandomized retrospective review of spinal infections treated with instrumentation between January 2000 and June 2004 at the Departments of Neurosurgery at Stanford University Medical Center, the University of Southern California, and the University of Chicago. Of 105 patients who were admitted to the neurosurgical services with spinal infections, the number of infections managed with spinal instrumentation was 31 in 30 patients. Iatrogenically acquired infections were excluded.

Indications for spinal instrumentation included mechanical instability which was determined based on the results of preoperative imaging and examination. In addition, iatrogenic disruption through surgical decompression was taken into consideration. Dynamic x-ray films were not obtained in all patients.

This patient population presented with disease at all levels of the spinal axis. Hence, the spectrum of surgical procedures was diverse; both anterior and posterior procedures were performed (Fig. 1).
RESULTS

During the study period, 30 patients with spinal infections were admitted and underwent debridement and instrumentation. Of these, 17 were women and 13 were men ranging in age from 28 to 86 years (mean age 56.7 years). Clinical findings varied; 20 patients presented with various degrees of weakness, and the other 10 presented with axial pain. Follow-up duration ranged from 3 to 54 months (mean duration 21.1 months). Organisms grown in cultures included tuberculous, pyogenic, and fungal entities. Disease was distributed throughout the spine: levels included seven cervical, one C7–T1, 11 with thoracic disease (one of whom had two lesions), two at T12–L1, and 10 lumbar.

Radiographic findings were similar to the description previously published: evidence of endplate erosion, kyphosis, spondylolisthesis, and prevertebral swelling to various degrees. Admission MR imaging demonstrated similar findings. In addition, MR imaging revealed prevertebral and epidural abscess.

Routine plain x-ray films of the fusion site were obtained in each patient at the follow-up visit. All films demonstrated adequate fusion based on the presence of bone trabeculae in the graft site, posterior fusion, and/or absence of movement on flexion/extension radiographs. In addition, all patients attained improvement (or normal results) in their sagittal alignment compared with findings on their preoperative imaging.

As shown in Table 1, complications were varied. One patient (Case 9) died 3 months postsurgery; she suffered a brainstem stroke from hypotension during hemodialysis. There were two graft dislodgements. In one patient a graft extrusion was noted on postoperative Day 1 (Case 5); another patient with renal osteodystrophy had a graft extrusion on postoperative Day 3 (Case 9). The patient in Case 5 underwent a revision on postoperative Day 1 and her postoperative stay was uneventful.

In one patient (Case 12), the fungal source of infection persisted at the site of debridement. This remained unresolved with maximal medical management, and the patient underwent further debridement at that level. In another patient an infection developed at an adjacent level to the interbody fusion (Case 8). This was managed with appropriate antibiotics. Deep wound infections developed in three patients, two of whom (Cases 14 and 22) underwent percutaneous drainage of their abscesses. The third patient (Case 21) required another thoracotomy for further debridement of the abscess. One patient with persistent low-grade fevers (Case 24) underwent elective removal of her instrumentation. Cultures from the explants, however, yielded no microorganisms.

DISCUSSION

Spinal infections may be divided into two groups: pyogenic and nonpyogenic. The culprit in pyogenic infections may be bacteria or mycobacteria, and in nonpyogenic infections it may be fungi, yeast, or parasites. Spinal pyogenic osteomyelitis represents 2% of all cases of osteomyelitis and 7% of cases of this disease in adults. The spine is the most common site for hematogenously acquired osteomyelitis. The mean age in patients with spinal osteomyelitis is 58 years, and there is a 1.5:1 male/female ratio, although some studies have demonstrated no male preponderance. Risk factors were identified in 77% of cases, with multiple risk factors found in 53% of patients (mean of three risk factors per patient). Primary risk factors included diabetes mellitus (44%); extraspinal infection, especially urinary tract infections (33%); long-term steroid drug use (24%); malignancy (17%); and alcoholism (11%). Additional risk factors were acquired immunodeficiency syndrome infection and chemotherapy treatment.

The presentation of spinal osteomyelitis may be insidious. The mean time to diagnosis is more than 3 months, except in intravenous drug abusers, who present with a more fulminant course (3 weeks to 3 months). Localization is predominantly in the thoracic (52%) and lumbar (43%) spine, and presenting symptoms are varied. In patients with spinal osteomyelitis, 15% present with neurologic deficits, and of patients with tuberculous spondylitis, 50 to 75% present with deficits. Axial spine pain was present in 95% of cases, and radicular pain ranged from 20 to 65% of cases. Of the neurologic deficits that were identified in 74% of cases, significant weakness was
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TABLE 1
Demographic data and description of surgical procedure with instrumentation in 30 patients with spinal infections*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Presenting Symptoms</th>
<th>Involved Levels</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28, F</td>
<td>paraplegia</td>
<td>T-8</td>
<td>T-8 corp w/ rib autograft &amp; ATLP; T-5–11 fusion w/ ICBG &amp; Synthes Universal hooks</td>
</tr>
<tr>
<td>2</td>
<td>53, M</td>
<td>back pain</td>
<td>L-1–2</td>
<td>T10-L4 fusion w/ ICBG &amp; Advanced Spine laminar clamps; L-1–2 corp w/ humerus, rib autograft, &amp; ATLP</td>
</tr>
<tr>
<td>3</td>
<td>38, F</td>
<td>myelopathy</td>
<td>C-5-6</td>
<td>C-5-6 corp w/ fibula allograft &amp; Atlantis plate; T6–10 pst fusion w/ ICBG &amp; Synthes Universal Screw System</td>
</tr>
<tr>
<td>4</td>
<td>66, M</td>
<td>paraplegia</td>
<td>L-1–2</td>
<td>L-1–2 corp w/ rib autograft, DePuy stackable cages, &amp; Kaneda plate; T11–L3 pst fusion w/ ICBG &amp; Monarch pedicle screws</td>
</tr>
<tr>
<td>5</td>
<td>42, M</td>
<td>paraplegia</td>
<td>L-3–4</td>
<td>L-3–4 corp w/ rib autograft &amp; DePuy stackable cages</td>
</tr>
<tr>
<td>6</td>
<td>49, M</td>
<td>paraplegia</td>
<td>T-6–7</td>
<td>T-5–8 laminectomy; T-3–11 pst fusion w/ ICBG &amp; Moss–Miami hooks</td>
</tr>
<tr>
<td>7</td>
<td>58, M</td>
<td>paraparesis</td>
<td>L-1–2</td>
<td>L-1–2 corp w/ rib autograft, DePuy stackable cages, &amp; Kaneda plate; T11–L4 pst fusion w/ Monarch pedicle screws</td>
</tr>
<tr>
<td>8</td>
<td>48, F</td>
<td>myelopathy</td>
<td>T12–L1</td>
<td>T12–L1 corp w/ humerus allograft, rib autograft, &amp; MACS-TL</td>
</tr>
<tr>
<td>9</td>
<td>79, F</td>
<td>quadriplegia</td>
<td>C-3–5</td>
<td>C-3–5 corp w/ fibula allograft, BMP sponge, &amp; Atlantis plate</td>
</tr>
<tr>
<td>10</td>
<td>70, F</td>
<td>paraplegia</td>
<td>T-8–9</td>
<td>T-8–9 corp w/ femur allograft, rib autograft, BMP sponge, &amp; Kaneda plate</td>
</tr>
<tr>
<td>11</td>
<td>51, M</td>
<td>paraplegia</td>
<td>L-1–2</td>
<td>L-1–2 corp w/ femur allograft, rib autograft, &amp; Kaneda plate; T11–L4 pst fusion w/ Monarch pedicle screws</td>
</tr>
<tr>
<td>12</td>
<td>41, F</td>
<td>back pain</td>
<td>L-4–5</td>
<td>L-4–5 &amp; S-1 PLIF w/ Monarch pedicle screws</td>
</tr>
<tr>
<td>13</td>
<td>72, F</td>
<td>back pain</td>
<td>L-4–5</td>
<td>L-4–5 &amp; S-1 PLIF w/ Monarch pedicle screws</td>
</tr>
<tr>
<td>14</td>
<td>66, F</td>
<td>pain</td>
<td>T12–L1</td>
<td>T12–L1 corp w/ VBR; T-8–L2 PLF w/ Monarch pedicle screws</td>
</tr>
<tr>
<td>15</td>
<td>46, M</td>
<td>pain</td>
<td>T-7–8</td>
<td>T-7–8 corp w/ VBR; T3–12 PLF w/ Isola hooks</td>
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<tr>
<td>16</td>
<td>71, M</td>
<td>pain</td>
<td>L-2–3</td>
<td>L-2–3 corp w/ VBR &amp; ant Moss–Miami screws; T12–S1 PLF w/ Monarch pedicle screws</td>
</tr>
<tr>
<td>17</td>
<td>42, F</td>
<td>pain</td>
<td>L-3–4</td>
<td>L-1–5 PLF w/ Monarch pedicle screws</td>
</tr>
<tr>
<td>18</td>
<td>60, M</td>
<td>paraplegia</td>
<td>T-1–2</td>
<td>T-1–2 corp w/ VBR; C-3–T4 fusion w/ Summit &amp; Isola</td>
</tr>
<tr>
<td>19</td>
<td>54, F</td>
<td>paraplegia</td>
<td>T-1–2</td>
<td>T-1–2 corp w/ VBR; C-3–T4 fusion w/ Summit &amp; Isola</td>
</tr>
<tr>
<td>20</td>
<td>68, F</td>
<td>paraplegia</td>
<td>T-2</td>
<td>T-2 transpedicular corp w/ VBR; C–T5 fusion w/ Summit &amp; Isola</td>
</tr>
<tr>
<td>21</td>
<td>86, F</td>
<td>pain</td>
<td>T11–12</td>
<td>T11–12 corp w/ VBR &amp; MACS-TL; T11–L1 fusion w/ Monarch</td>
</tr>
<tr>
<td>22</td>
<td>73, M</td>
<td>paraplegia</td>
<td>T-3</td>
<td>T-3 corp w/ VBR; C-3 fusion w/ Summit &amp; Isola</td>
</tr>
<tr>
<td>23</td>
<td>73, M</td>
<td>pain</td>
<td>L-4–5</td>
<td>L-4–5 fusion w/ Monarch</td>
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<tr>
<td>24</td>
<td>45, F</td>
<td>paraplegia</td>
<td>T-7</td>
<td>T-7 corp w/ ICBG, VBR, &amp; MACS-TL; T5–9 fusion w/ Monarch</td>
</tr>
<tr>
<td>25</td>
<td>54, F</td>
<td>pain</td>
<td>C-2</td>
<td>transoral C-2 corp &amp; O–C7 fusion w/ Summit</td>
</tr>
<tr>
<td>26</td>
<td>78, M</td>
<td>paraplegia</td>
<td>C–T1</td>
<td>C-7–T1 corp w/ VBR &amp; C-3 instr, pst fusion w/ Summit</td>
</tr>
<tr>
<td>27</td>
<td>56, F</td>
<td>pain</td>
<td>L-4–5</td>
<td>L-3–S1 fusion w/ Monarch</td>
</tr>
<tr>
<td>28</td>
<td>55, M</td>
<td>paraplegia</td>
<td>C–T6</td>
<td>C-6–7 corp w/ VBR &amp; C-3 instr; C-5–T4 fusion w/ Summit &amp; Isola</td>
</tr>
<tr>
<td>29</td>
<td>55, F</td>
<td>pain</td>
<td>C-5–6</td>
<td>C-5–6 corp w/ VBR &amp; C-3 instr</td>
</tr>
<tr>
<td>30</td>
<td>55, F</td>
<td>pain</td>
<td>C-5–6</td>
<td>C-5–6 corp w/ VBR &amp; C-3 instr</td>
</tr>
</tbody>
</table>

* ATLP = anterior thoracolumbar locking plate; BMP = bone morphogenetic protein; corp(s) = corpectomy(ies); costos(s) = costa-transversectomy(ies); ICBG = iliac crest bone graft; instr = instrumentation; MACS-TL = brand of anterior plating; PLIF = posterior lumbar interbody fusion; PLF = posterior lateral fusion; pst = posterior; VBR = vertebral body replacement.

**TABLE 2**

Neurosurgical management of potential neurological threats and mechanical instability.

- Mechanical instabilities may occur with deformities more prevalent in the thoracic spine. These were associated with a greater neurological deficit (Frankel Grades A–C). Mortality rates for this serious infection are reported to be between 1 and 20%.

- A spine surgeon is only consulted 15 to 20% of the time in patients with spinal infections, and the majority of these consultations are for an open biopsy procedure or because of neurological deficit. The main goal of treatment is the maximal preservation of neurological function. This goal may be attained through aggressive decompresion of neural tissue, parenteral delivery of antibiotic drugs, and spinal stabilization. Other goals of surgical intervention include the prevention of sepsis by aggressive debridement and absceses, which may lead to the permanent eradication of infection.

- The range of options for surgical management of spinal infections is broad, and can be divided into the management of potential neurological threats and of mechanical instability. Determinations of the state of neurological threat or mechanical instability aids decision making about the surgical approach and technique. The potential for neurological injury requires at least a neural decompression with or without spinal arthrodesis, whereas mechanical instability requires arthrodesis. The decision whether to augment spinal arthrodesis with spinal fixation is determined by the degree of instability present. In general, the correction of a spinal deformity or severe instability requires fixation in the form of spinal instrumentation. Bed rest or rigid external bracing may improve lesser degrees of instability. In pyogenic discitis, interbody fusion usually occurs spontaneously. This fusion, however, may be accompanied by narrowing of the foramina and kyphosis or listhesis. Because spinal osteomyelitis generally involves the vertebral body and adjacent disk spaces, an anterior surgical approach is used to allow direct access to the focus of infection for aggressive debridement. Aggressive anterior debidement is mandatory for successful reconstruction. Posterior decompression and posterior access to anterior decompressions have led to further instability. Spontaneous fusion is not as common in tuberculous spondylitis, and progressive kyphotic deformity is fre-
sequent. This may lead to progressive neurological deterioration. Although medical therapy continues to be the cornerstone of treatment, surgical intervention is commonly performed to optimize functional outcomes.24

Unfortunately, the question whether to perform arthrodesis in the setting of spinal infections is controversial. On the other hand, numerous examples of successful arthrodesis with and without instrumentation have been published.

In general, the use of interbody grafts in patients with spinal osteomyelitis is accepted.5,7,38 Autologous interbody bone grafting in the setting of an active infection was first reported for chronic vertebral osteomyelitis by Wiltberger43 in 1952, and has been used safely ever since.11,12,23 Although iliac crest bone grafts are preferred, vascularized rib grafts have been used with good success.3,28

Fibula allografts have also been shown to be effective in the cervical spine.9,42 Ozdemir, et al.,32 and Govender17 attempted to address concerns regarding implantation of devitalized bone in an actively infected spine by assessing the efficacy of allograft fibular fusion and anterior spinal stabilization as an alternative treatment for tuberculosis spondylitis. Bone fusion was achieved in 96% of the patients, with one experiencing instrumentation failure that necessitated revision.

Titanium cages have gained wide acceptance in reconstructive surgery performed in the setting of concomitant infection. Retrospective studies demonstrate greater improvement in sagittal alignment for patients with titanium cages and for those with posterior instrumentation than for patients who did not receive either of these interventions.21,27 In addition, expandable titanium cages have been demonstrated to be efficacious. Again, few major complications or recurrent infections have been reported in retrospective reviews of these devices. In addition, expandable titanium cages restored stability and neurological function in patients who received them.

Other methods for interbody fusion have been attempted in the setting of spinal infection. Included in this array are bone cement and methyl methacrylate.6,35 Similar results occur with these methods; few late infections have been presented.36

Jeanneret and Magerl32 managed spinal osteomyelitis with a percutaneous external spinal fixation. The treatment consisted of a percutaneous vertebral biopsy procedure, irrigation system, and external posterior stabilization. A report on internal instrumentation was first published by Redfern and colleagues.36 Since then, several publications have presented various authors’ experiences with spinal instrumentation for acute spinal pyogenic infections.5,8–10,13,16,17,19,20,30,34,35

Przybylski and Sharan33 evaluated the efficacy of combining debridement, autograft, and instrumentation in the setting of failed medical management. With a mean follow-up duration of 30 months, all 17 patients demonstrated significant improvements in their neurological deficits. This was a reiteration of a study published in 1997,1 in which 17 patients showed improvement after treatment with anterior debridement, graft placement, and posterior instrumentation. Neurological improvements were also seen with the use of expandable titanium cages,27 titanium mesh with and without posterior instrumentation,21 and posterior instrumentation alone.13

Dietze and colleagues25 reviewed results in 20 patients who underwent surgical debridement and reconstruction, with placement of instrumentation in 15 of them. In a follow-up period of 37 months, these patients demonstrated adequate arthrodesis. Since then, other investigators have demonstrated good fusion rates after anterior debridement and interbody grafting supplemented with posterior instrumentation, with adequate posterior fusion found in more than 90% of cases.2,20,45 In addition, improvement in sagittal angulation was demonstrated in patients who underwent instrumentation.14,21,25,27

The complication rate in patients with spinal infections is high, as demonstrated in a review of 12 retrospective studies (Table 2). Among these 12 studies, instrumentation was placed in 195 patients with spinal infections. In those patients, nine deaths were reported and 10 wound infections were mentioned. In addition, five graft expul-

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Type of Instrumentation</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redfern, et al., 1988</td>
<td>5 stabilizing rods</td>
<td>1 wound infection</td>
</tr>
<tr>
<td>Graziano &amp; Sidhu, 1993</td>
<td>7 ant grafts w/ pst instrumentation</td>
<td>none reported</td>
</tr>
<tr>
<td>Arnold, et al., 1997</td>
<td>17 ant grafts w/ pst instrumentation</td>
<td>none reported</td>
</tr>
<tr>
<td>Dietze, et al., 1997</td>
<td>4 Caspar plates, 5 hook/rod constructs, &amp; 6 screw/rod constructs</td>
<td>1 death, 1 wound infection, 1 cervical graft telescope/ pseudarthrosis, 1 graft extrusion, &amp; instrumentation failure</td>
</tr>
<tr>
<td>Safran, et al., 1998</td>
<td>10 ant grafts w/ pst screw/rod constructs</td>
<td>1 graft extrusion &amp; 1 instrumentation failure</td>
</tr>
<tr>
<td>Faraj &amp; Webb, 2000</td>
<td>30 pst instrumentation &amp; 1 ant instrumentation</td>
<td>1 death, 1 graft extrusion, 1 instrumentation failure, &amp; 3 deep wound infections</td>
</tr>
<tr>
<td>Przybylski &amp; Sharan, 2001</td>
<td>17 ant grafts w/ internal instrumentation</td>
<td>2 deaths &amp; 1 wound infection</td>
</tr>
<tr>
<td>Hee, et al., 2002</td>
<td>11 ant titanium mesh &amp; 9 ant mesh w/ pst instrumentation</td>
<td>3 deaths, 2 recurrences of osteomyelitis, 1 wound infection, 1 pseudarthrosis, &amp; 1 instrumentation failure</td>
</tr>
<tr>
<td>Klockner &amp; Valencia, 2003</td>
<td>22 ant grafts w/ pst screw/rod construct</td>
<td>none reported</td>
</tr>
<tr>
<td>Liljenqvist, et al., 2003</td>
<td>20 expandable titanium cages</td>
<td>1 death, 1 pseudarthrosis, &amp; 1 instrumentation failure</td>
</tr>
<tr>
<td>Fayazi, et al., 2004</td>
<td>11 interbody titanium mesh &amp; pst screw/rod constructs</td>
<td>1 death, 2 graft extrusions, &amp; 3 wound infections</td>
</tr>
<tr>
<td>present study</td>
<td>30 patients, various</td>
<td></td>
</tr>
</tbody>
</table>
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In addition to the complications associated with instrumentation failure, three patients with pseudarthrosis, and five cases of instrumentation failure were reported.

We present our cases to demonstrate the efficacy of instrumentation in the setting of spinal infection. In addition, this provided an opportunity to review the literature on arthrodesis within the setting of infection. Although the indications for spinal instrumentation should be specific and reserved for clear spinal instability, reconstruction and instrumentation of the spine are acceptable during active spinal osteomyelitis, provided that debridement of diseased tissue is complete and an appropriate course of antibiotic therapy is followed. Acceptable materials for reconstruction include autologous graft, allograft, titanium cages, and alloy screw/rod/plate systems. With that said, the surgical decision-making process must take into account the overall condition of the patient and the balance of the host defenses against the virulence of the pathogen. Selected patients may be at an increased risk for operative and postoperative complications.

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