Clinical Outcome of Deep Wound Infection After Instrumented Posterior Spinal Fusion

A Matched Cohort Analysis

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Study Design. Retrospective case control study.

Objective. Determine the impact of infection on clinical outcome in patients undergoing posterior spinal fusion surgery.

Summary of Background Data. The outcome of patients treated for infection after spinal surgery is not well established because of variability in cohort identification, definition of infection, outcomes instrument, use of a control group, and/or sample size.

Methods. Thirty-two patients were included. Sixteen patients (“infection group”) met inclusion criteria of deep wound infection after spinal fusion with posterior segmental instrumentation (including combined approach). A 1:1 matched cohort (“control group”) was created based on primary or revision status, length of fusion, diagnosis, and age. Postoperative patient outcomes were evaluated using the physical components of SF-36 v2.0 with minimum 2-year follow-up.

Results. No significant difference in the Physical Function, Role Physical, Bodily Pain, and General Health domains was detected between the infection group and control group. Mean follow-up was 62 months. Mean Physical Component Summary was 41.4 in the infection group and 44.3 in the control group (P = 0.6). Infection occurred early in 12 patients and late in 4 patients. Most common organisms isolated were Staphylococcus epidermidis, Enterococcus sp., and Staphylococcus aureus. Multiple debridements were significantly associated with polymicrobial infections and late pseudarthrosis requiring reoperation.

Conclusion. An aggressive approach to deep wound infection emphasizing early irrigation and debridement allowed preservation of instrumentation and successful fusion in most cases. At the conclusion of treatment, patients can expect a medium-term clinical outcome similar to patients in whom this complication did not occur.

Key words: complications, postoperative infection, deep wound infection, clinical outcome, spinal fusion, instrumentation. Spine 2009;34:578–583

Complex reconstructive procedures in spine surgery may entail long operative times, extensile approaches, significant fluid shifts, and implantation of instrumentation. In an aging population, many patients undergoing spinal surgery are older, and many have had previous surgery and significant comorbidities. Complications of spine surgery are important in the patient and physician’s choice of a care pathway. Postoperative spine infection is a complication that may have a significant impact on clinical outcome and is an important consideration in choosing surgery.

Sequelae of deep wound infection are potentially serious, including failure of fixation, osteomyelitis, pseudarthrosis, and significant medical morbidity. One or more operative debridement procedures combined with prolonged intravenous antibiotics are usually necessary to eradicate or at least control the infection. Deep wound infection may have important long-term consequences that affect final outcome, including need for revision surgery, persistent pain or deformity, additional hospitalization, prolonged recovery time, and considerable cost.

Increasingly, the benefit of surgical intervention is being evaluated based on patient-reported outcomes and standardized health-related quality of life measures that allow comparison with alternative techniques, unrelated disease states, and population norms. Validated quality of life scales have become a critical element of postoperative assessment. The Medical Outcomes Study Short Form (SF)-36 general health survey is a quality of life instrument useful for patients with spinal disorders and has been suggested to achieve an optimal balance among length, reliability, validity, responsiveness, and experience in patients.

The clinical outcome of patients treated for infection after spinal surgery is not well established. The purpose of this study is to investigate clinical outcome in patients who underwent posterior spinal fusion complicated by deep wound infection in comparison to a matched cohort. Instrumented posterior spinal fusion was studied because of the relatively higher infection rate compared with noninstrumented surgery. Clinical outcome was measured by the physical domains of the SF-36, which have been shown to be responsive to treatments that change physical morbidity. Secondary outcomes included radiographic fusion, need for reoperation, and characteristics of the infections.

Methods

Institutional review board approval was obtained for this study. We performed a retrospective study of 824 patients who
underwent instrumented thoracolumbar spinal fusion using a posterior only or posterior and anterior (combined) approach at our institution from 1997 through 2002. Sixteen patients (“infection group”) met inclusion criteria, consisting of spinal fusion with posterior segmental instrumentation (including combined approach), deep wound infection requiring treatment by operative irrigation and debridement, positive intraoperative cultures from subfascial intraoperative specimens, minimum 2-year clinical follow-up, and radiographic follow-up at greater than 1 year after surgery. A 1:1 matched cohort (“control group”) consisting of patients who underwent fusion with posterior instrumentation within the same approximate period and did not develop deep wound infection was created, based on matching criteria including primary or revision status, length of fusion, diagnosis, and age.

Clinical data regarding each patient were collected using patient charts, computerized records, operative logs, and clinic notes. Patient characteristics recorded included age, gender, comorbidities, and diagnosis. Surgical data collected included levels fused, primary or revision status, time of infection, number of irrigation and debridement procedures, organisms identified in intraoperative specimens, and reoperation. Time of infection was defined as time from the index procedure to the first irrigation and debridement. Revision status for the index procedure was defined as fusion involving levels that had undergone previous surgery. Reoperation was defined as any further surgery during the follow-up period that included the levels of the index surgery. The indication and procedure performed for the first reoperation after surgical debridement(s) was recorded. Infections were categorized as early or late, depending on whether they occurred earlier or later than 90 days after the index procedure.

Radiographic outcome was based on evaluation of films for evidence of pseudarthrosis, including loss of fixation, implant breakage, radiolucency around pedicle screws, and/or progression of deformity. Radiographic fusion was defined as continuous bridging bone visible on the anteroposterior radiograph.

All patients received intravenous antibiotic prophylaxis before at the index operation. Protocol consisted of cefazolin unless the patient had a history of a significant allergy, in which case vancomycin or clindamycin was substituted, and redosing every 4 hours or after blood loss requiring transfusion. Antibiotics were continued for 48 hours after the procedure. Suction drains were routinely used and removed 1 to 3 days after the procedure. Indications for irrigation and debridement included persistent wound drainage, erythema, fever, and increased pain. Surgery was recommended for all suspected cases of deep wound infection; management with antibiotic therapy only was not attempted. Antibiotics were not administered until after intraoperative cultures were obtained in order to maximize the yield. Irrigation and debridement consisted of pustule irrigation with at least 9 L of irrigation containing bacitracin (50,000 IU/3 L), removal of necrotic tissue, and scrubbing of retained instrumentation with dilute Dakin solution to decrease the biofilm on these surfaces. The wound was then closed primarily over suction drains. The drains were discontinued when the volume collected decreased to less than 30 mL over 24 hours. Further irrigation and debridement procedures were performed if tissue necrosis was extensive or signs of infection persisted. Removal of instrumentation was performed because of the inability to eradicate infection or in the presence of solid fusion (in the setting of late infection). Postoperative antibiotic treatment was tailored to the subsequent microbiologic analysis in consultation with an infectious disease specialist. Standard medical therapy after debridement included 6 weeks of intravenous antibiotics and, in most cases, long-term suppressive oral antibiotics.

Patient outcomes were evaluated using the physical component of the Medical Outcomes Study SF-36 general health survey version 2.0 at the most recent follow-up visit or by mail. The scales measured included Physical Function (PF), Role Physical (RP), Bodily Pain (BP), General Health (GH), summarized by the Physical Component Score (PCS). Version 2.0 scores are calculated using norm-based scoring method based on the US population norms in 1998 (mean score 50, standard deviation 10 for each domain and PCS).5

Data were analyzed using SPSS software (SPSS, Inc., Chicago, IL). Dichotomous variables were compared using the Pearson x² test. If the expected count for any cell was less than 5, Fisher exact test was used. Age, length of fusion, number of comorbidities, clinical outcomes scores, and length of follow-up were analyzed using Wilcoxon signed rank test for paired data. Statistical significance was set at P < 0.05.

### Results

Patient and surgical characteristics of the infection and control groups are shown in Table 1. By matching, there were no significant differences detected in age, gender, primary or revision status of the index case, and fusion length between the infection and control groups. The mean absolute difference in age between pairs was 6.6 years (range, 1–16). Primary or revision status were precisely matched for all pairs. The mean difference in fusion length was 0.7 levels (range, 0–3). Fusion included the sacrum in 14 patients in the infection group and 11 patients in the control group (P = 0.4). Of the patients with neuromuscular scoliosis, 1 in the infection group had a diagnosis of cerebral palsy and 1 in the control group had a diagnosis of myopathy. The mean number of comorbidities was 2.6 (range, 0–6) in the infection group and 1.7 (range, 0–5) in the control group (P = 0.16). Univariate analysis revealed no significant differences in proportion of patients with collagen vascular disease (n = 1 in
Infection group vs. none in control group, diabetes mellitus (0 vs. 1), hepatitis (1 vs. 0), hypertension (8 vs. 7), hypothyroidism (5 vs. 1), heart disease (1 vs. 2), respiratory disease (2 vs. 2), or psychiatric disorder (3 vs. 2) ($P > 0.2$).

All infections were posterior. The majority of infections (12 of 16) occurred within 90 days of the initial surgery. Mean time to irrigation and debridement was 23.5 days (range, 9–39) in the early infection group and 28.1 months (range, 14.6–37.9) in the late infection group (4 of 16). The 4 patients with late infection presented with either drainage ($n = 2$) or pain at the previous operative site ($n = 2$). Mean number of irrigation and debridement procedures was 1.75 (range, 1–5); 6 patients required multiple irrigation and debridement for a mean of 3 times (range, 2–5). All 4 patients in the late infection group had removal of implants at a mean of 44.5 months (range, 33–65) after the index surgery. Patients who eventually required removal of implants underwent a mean of 2.5 debride-ments (range, 1–4) compared to 1.5 (range, 1–5) in patients who did not, although this difference was not statistically significant ($P = 0.1$). At the time of implant removal, solid fusion in 3 patients and pseudarthrosis in 1 patient were found. Comparing early and late infections, no significant differences were detected for age, fusion length, and number of comorbidities.

Table 2 shows the organisms identified from intraoperative culture specimens. The most common organisms isolated were Staphylococcus epidermidis, Enterococcus sp., and Staphylococcus aureus. Antibiotic-resistant organisms included 3 cases of methicillin-resistant S. epidermidis (MRSE), 1 case of vancomycin-resistant Enterococcus (VRE), and 2 cases of methicillin-resistant S. aureus (MRSA).

Infection was monomicrobial in 7 patients and polymicrobial in 9 patients. All 7 patients with a monomicrobial infection underwent a single irrigation and debridement, whereas 6 of 9 patients with polymicrobial infection underwent more than one irrigation and debridement; this difference was statistically significant ($P < 0.01$). S. aureus was the most common organism in monomicrobial infections (4 of 7). Of the 6 patients who underwent multiple debridements, 4 (67%) required a change in antibiotic regimen, indicating that the first regimen based on the initial culture results was inadequate. The most common organisms in patients undergoing multiple debride-ments were S. epidermidis (6 of 6) and Enterococcus sp. (4 of 6). In the 4 patients who presented with late infection and underwent removal of implants, the most common organisms were S. epidermidis (4 of 4) and Propionibacterium acnes (3 of 4). All wounds healed without need for further soft tissue coverage procedures.

Three patients in the infection group underwent reoperation: 2 from the early infection group and 1 from the late infection group ($P \leq 1.0$). Patients underwent reoperation at 9, 49, and 87 months after the index surgery. Patients who underwent reoperation had significantly more debride-ments than patients who did not (mean, 3.3 vs. 1.4; $P < 0.05$). All had pseudarthrosis noted at time of reoperation. One patient in the control group underwent reoperation for pseudarthrosis 14 months after the index surgery. This difference was not significant for pseudarthrosis ($P = 0.6$). The sacrum was included in the index procedure for all patients undergoing reoperation for pseudarthrosis in both the infection group and control group. An additional patient in the control group underwent reoperation for adjacent segment stenosis at 59 months for a total of 2 patients in the control group who required reoperation. Most recent radiographs obtained at a mean of 70.7 months (range, 12–103) showed solid arthrodesis in all 16 infection patients.

SF-36 scores for PF, RP, BP, GH, and PCS are shown in Table 3. No significant differences were found for any domain or the PCS by the Wilcoxon signed rank test for paired nonparametric data. Mean follow-up was 56.7 months (34–97) for the infection group and 65.1 months (24–168) for the control group ($P > 0.2$). For the early infection group, no significant differences in SF-36 scores with matched controls were detected. For the late infection group, the infection group had higher GH scores, though not statistically significant (mean, 59.1 vs. 42.9; $P \approx 0.07$); no significant differences with matched controls were detected for the other domains. Comparing SF-36 scores of the early and late infection patients, the late infection group had higher GH scores (mean, 59.1 vs. 48.3; $P \approx 0.06$), and no other significant differences were detected.

### Table 2. Organisms Identified*

<table>
<thead>
<tr>
<th>Organism</th>
<th>Infection Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus epidermidis</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Enterococcus sp.</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Propionibacterium acnes</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Enterobacter sp.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Peptostreptococcus sp.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Serratia sp.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Bacteroides sp.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Haemophilus influenzae</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Klebsiella sp.</td>
<td>1</td>
<td></td>
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</tbody>
</table>

*Shown as number of patients in whom organisms were cultured from intraoperative specimens.

### Table 3. SF-36 V2.0 Physical Domain Scores*

<table>
<thead>
<tr>
<th>Domain</th>
<th>Infection Group</th>
<th>Control Group</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF</td>
<td>38.5 (39.2, 21.3–57.1)</td>
<td>40.0 (46.5, 21.3–57.1)</td>
<td>0.5</td>
</tr>
<tr>
<td>RP</td>
<td>43.3 (42.3, 28.0–56.2)</td>
<td>44.4 (47.1, 22.6–56.9)</td>
<td>0.8</td>
</tr>
<tr>
<td>BP</td>
<td>46.5 (46.3, 25.1–62.7)</td>
<td>46.8 (44.0, 33.0–62.7)</td>
<td>0.9</td>
</tr>
<tr>
<td>GH</td>
<td>51.2 (48.5, 33.7–64.1)</td>
<td>48.9 (50.6, 26.5–64.0)</td>
<td>0.8</td>
</tr>
<tr>
<td>PCS</td>
<td>41.4 (44.3, 23.5–58.4)</td>
<td>44.3 (47.3, 24.1–61.8)</td>
<td>0.6</td>
</tr>
</tbody>
</table>

*Shown as mean (median, range). Number of significant differences were detected.


Discussion

The impact of spinal disorders and the efficacy of treatments are being increasingly measured by their effects on self-reported patient outcomes.6–8 This paper demonstrates that, after treatment for postoperative deep wound infection, patients reported a health status that is similar to matched controls who underwent instrumented posterior spinal fusion without this complication. All physical domains of the SF-36 (PF, RP, BP, and GH) and the PCS showed no significant differences from matched controls. Mean PCS was 41.4 in the infection group and 44.3 in the control group (P > 0.6). Similarly, when analyzed separately as early and late infections, no significant differences were found with their matched controls. The GH scores in the late infection group were not significantly different compared to the matched controls. The finding of higher GH scores may be a function of the small sample size (n = 4).

Interpretation of previous studies on outcomes of deep wound infection after spine surgery is difficult because of variability in definition for infection, outcomes instrument used, use of a control group, and/or sample size, leading to varying conclusions. Although some authors have stated that outcomes can be good to excellent with no long-term loss of function,9,10 Collins et al reported that only 46% of patients had stable pain-free spines when managed with routine removal of implants in established fusions.4 Calderone et al, examining a challenging worker’s compensation population, reported poor quality of life and return to work in 15 patients with deep wound infection after lumbar fusion and similar results in 15 matched controls, as measured by the Dallas Pain Questionnaire and Prolo scale.11 Glassman et al reported 80% of 19 patients treated for postoperative infection rated symptoms as improved at final follow-up, although this occurred in the setting of 3 deaths and a 58% rate of medical complications.12

The impact of complications, including postoperative infection, has recently been measured using validated outcomes instruments.13,14 Glassman et al studied 1 year outcomes, using SF-12 and SRS-22 scores in matched cohorts of patients with complications after adult deformity surgery. Deep wound infection represented 9 of 47 major complications, the remainder including more serious sequelae (e.g., cord injury). Postoperative SRS scores improved significantly in all 3 groups, and 1-year SF-12 PCS was 36.68 in the major complication group, 36.47 in the minor complication group, and 35.61 in the no complication group.15 The current study found similar PCS in the infection group (41.4) and control group (44.3).

The purpose of this study was to compare the final health status after deep wound infection and not to assess the effect of surgery, which would have required comparison with preoperative data. The outcomes scores at final follow-up are consistent with other reports.16–18 despite a large proportion of revision procedures on multiply operated spines. With the exception of GH, which has been shown to be least affected by spinal disorders,2,19 all scores remained below the population mean. However, these results must be evaluated in the context of the heavy burden of disease caused by spinal conditions.2,6 Fanuèle reported mean scores from 17,774 patients from the National Spine Network as RP 31.3, BP 30.6, PF 31.3, and PCS 30.4 (all scores in the Discussion are converted to version 2.0 norm-based scoring). Previous studies have demonstrated the magnitude of disability caused by spinal disorders that may hinder improvement to normal levels despite successful treatment.16

The matched cohorts included in this analysis showed no differences in known risk factors such as age, diabetes, and combined surgery.20,21 Patients in the infection group had a higher number of comorbidities on average, though this did not reach significance. Although a higher number of comorbidities has been associated with smaller improvements in SF-36 and ODI scores, final SF-36 scores were similar in this series.22 No consensus exists on the impact of revision status on outcomes measures.23–26 Patients in this study were matched by primary or revision status at the index procedure.

More patients underwent reoperation for pseudarthrosis in the infection group, but the study numbers were not sufficient to demonstrate a significant difference from the control group. Patients who do not have mechanical stability because of either removal of instrumentation or in situ fusion may be at higher risk for pseudarthrosis. Therefore, preservation of stable implants has been recommended.27 In addition to pseudarthrosis, removal of instrumentation is associated with loss of correction.28–30 In order to maximize the possibility of preserving instrumentation, early irrigation and debridement is performed at this institution on recognition of infection and repeated if needed until clinical improvement is noted. Conservative management with antibiotic therapy alone is not attempted at our institution, considering the high risk of failure, presence of instrumentation, and possible consequences of delay, including increasing severity of infection, clinically significant sepsis, and osteomyelitis. With this aggressive approach to infection, instrumentation was retained in all early infections. Other authors have reported successful retention of implants using a variety of techniques, including delayed primary closure or secondary intention,31 closed irrigation-suction system,3 or antibiotic cement beads.12 Ho et al, presenting a series of 53 patients with deep wound infection, reported preservation of implants in 97% of early (<6 months) infection, but only 59% in late infection group.32 In this series, 4 of 16 cases were late infections, presenting an average 28.1 months after the index procedure, consistent with the literature.33 All were treated with removal of instrumentation, irrigation and debridement, and antibiotics, as recommended by most authors.33,34
Several interesting characteristics about the infections in this series are significant. Overall, coagulate-negative S. epidermidis was the most common bacteria, which was also described by Ho et al. 12 Deep wound infection has been described as predominantly monomicrobial and caused by S. aureus, whereas in this series, only 7 of 16 were monomicrobial, most of which were S. aureus. A proportion of polymicrobial cases similar to the current study has been described in infected lumbar fusion.12 All single organism infections were successfully treated with a single debridement, whereas multiple debriding was required for 6 of the 9 polymicrobial infections. Patients who required reoperation for pseudarthrosis underwent a significantly higher number of debridements, possibly because of more aggressive debridements with removal of bone graft. In addition, most of the cases undergoing multiple debridements had a change in antibiotics regimen. One possibility is that the failure of the initial debridement was because of inadequate antibiotic coverage. We therefore recommend that specimens be cultured at every debridement. Enterococcus sp. was the second most frequently isolated organism. Sponseller et al identified S. epidermidis and Enterococcus sp. as the most frequent Gram-positive organisms causing infections after neuromuscular scoliosis surgery. In that series, nearly half of the infections were polymicrobial, which they attributed to contamination because of incontinence, drains, or at time of surgery. The proximity of the wound to the perineum, caudally exiting drains, intravenous and arterial lines, and Foley catheterization have also been identified as possible routes of contamination for Gram-negative and polymicrobial infections. The organisms identified in the late infections in this series were most commonly S. epidermidis and P. acne, consistent with the literature.

The organisms identified in this and other series indicate both the effectiveness and limitations of current antibiotic prophylaxis. S. aureus infections, which are usually targeted by perioperative antibiotic regimens, have been replaced by bacteria which may be introduced by hematogenous spread or the other mechanisms as described above. Some authors have advocated broadening antibiotic coverage. However, broad-spectrum antibiotics such as third-generation cephalosporins or vancomycin may disrupt the patient’s endogenous intestinal flora, allowing growth of opportunistic pathogens such as Enterococcus. Development of antibiotic resistance with widespread use of broad-spectrum agents also remains a concern, as 6 instances of resistant organisms (MRSE, VRE, MRSA) were observed in this series.

Weaknesses of this study include the lack of preoperative health status data. As discussed above, the purpose of the study was to compare the final health status of patients with infection to a matched cohort. The 2 groups were carefully matched by age, diagnosis, surgery, revision status, and comorbidities, factors shown to affect SF-36 scores. The scores obtained were also similar to published results. Although comparable to previous series, the sample sizes in the groups were small and the possibility of a type II error cannot be excluded. However, the values in all measured domains and the PCS were highly similar between the infection and control groups. Only the physical component of the SF-36 was used. Pahl et al identified PF, RP, and BP as the SF-36 domains showing the largest negative impacts because of spinal disorders. Restricting measurement to these domains also decreases likelihood of a type I error. A disease-specific instrument such as the ODI may have provided additional useful information. However, this would have entailed increased respondent burden, redundancy, data collection, and analysis burden. Fusion status was determined in most cases by plain radiographs, which may not be as accurate as CT reconstruction or surgical exploration. Finally, other radiographic parameters that may correlate with outcome, such as sagittal balance, were not measured.

**Conclusion**

Deep wound infection after instrumented fusion of the spine remains a difficult clinical problem and entails substantial morbidity, cost, and recovery time for the patient. An aggressive approach to deep wound infection emphasizing early irrigation and debridement allowed preservation of instrumentation and successful fusion in most cases. Late infections required treatment with implant removal and antibiotics. At the conclusion of treatment, patients can expect a medium-term clinical outcome similar to patients in whom this complication did not occur. Accurate information about clinical outcome after infection is useful for patients and surgeons in making informed choices regarding surgical care.

**Key Points**

- Patients with deep wound infection complicating instrumented posterior spinal fusion had similar clinical outcomes to matched controls.
- Emphasis on early irrigation and debridement allowed retention of implants in early postoperative infections.
- Multiple debridements were associated with polymicrobial infections and later pseudarthrosis.

**Acknowledgment**

The authors thank Alan Bostrom for assistance with statistical analysis.

**References**

