Surgical site infection rates after minimally invasive spinal surgery

Clinical article

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Object. Postoperative surgical site infections (SSIs) have been reported after 2–6% of spinal surgeries in most large series. The incidence of SSI can be < 1% after decompressive procedures and > 10% after instrumented fusions. Anecdotal evidence has suggested that there is a lower rate of SSI when minimally invasive techniques are used.

Methods. A retrospective review of prospectively collected databases of consecutive patients who underwent minimally invasive spinal surgery was performed. Minimally invasive spinal surgery was defined as any spinal procedure performed through a tubular retractor system. All surgeries were performed under standard sterile conditions with preoperative antibiotic prophylaxis. The databases were reviewed for any infectious complications. Cases of SSI were identified and reviewed for clinically relevant details. The incidence of postoperative SSIs was then calculated for the entire cohort as well as for subgroups based on the type of procedure performed, and then compared with an analogous series selected from an extensive literature review.

Results. The authors performed 1338 minimally invasive spinal surgeries in 1274 patients of average age 55.5 years. The primary diagnosis was degenerative in nature in 93% of cases. A single minimally invasive spinal surgery procedure was undertaken in 1213 patients, 2 procedures in 58, and 3 procedures in 3 patients. The region of surgery was lumbar in 85%, cervical in 12%, and thoracic in 3%. Simple decompressive procedures comprised 78%, instrumented arthrodeses 20%, and minimally invasive intradural procedures 2% of the collected cases. Three postoperative SSIs were detected, 2 were superficial and 1 deep. The procedural rate of SSI for simple decompression was 0.10%, and for minimally invasive fusion/fixation was 0.74%. The total SSI rate for the entire group was only 0.22%.

Conclusions. Minimally invasive spinal surgery techniques may reduce postoperative wound infections as much as 10-fold compared with other large, modern series of open spinal surgery published in the literature.

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Key Words • minimally invasive • postoperative wound infection • spinal surgery • surgical site infection

POSTOPERATIVE SSIs are some of the more common complications after spinal surgery.2,6,34,35 Reported rates of spinal SSIs in the literature have ranged from 0.7 to 16%.2,5,8,10–12,14,18,19,21,25,26,28,30,31,34,35,38,39,41,42,48,49,51 These infections can be challenging to treat and often require prolonged antibiotic therapy, extended hospitalizations, and repeated operations for wound debridement, hardware removal, or delayed complications of infection. All of this serves to increase health care resource utilization dramatically and may worsen overall clinical outcomes.6–8,34,42,50

Abbreviations used in this paper: MED/F = micro- or endoscopic discectomy or foraminotomy; MEDS = micro- or endoscopic decompression of stenosis; MISS = minimally invasive spinal surgery; SSI = surgical site infection.

Minimally invasive surgical techniques have been applied to spinal surgical cases for more than a decade now,16 and anecdotal experience by the authors and others20 has suggested a very low rate of SSI after MISS; precise rates of postoperative wound infections have not been specifically studied in the literature, however. We therefore sought to examine our cumulative experience with SSIs after MISS and compare these findings to the standard infection rates published for traditional open spinal surgery.

Methods

We performed a retrospective review of prospectively collected databases of consecutive patients who underwent MISS over an almost 8-year period (February 2000 to December 2007) performed by 3 surgeons.
Minimally invasive spinal surgery cases were defined as any spinal surgery performed through a tubular retractor–type system. These included the METRx, X-Tube, Quadrant (all Medtronic Sofamor-Danek), MaXcess (Nuvasive), and MARS (Globus Medical) retractor systems. Visualization was microscopic, endoscopic, or loupe-magnified depending on the system used. The procedures performed included simple decompressive procedures such as MED/F or decompression of stenosis, as well as minimally invasive arthrodeses (including posterolateral, posterior/transforaminal interbody, and lateral interbody) with percutaneous instrumentation, and minimally invasive intradural procedures for tumors, filum detethering, or syrinx shunting (Table 1). The various techniques used in these procedures have been described in detail elsewhere.15,23,24,32,33,36,37,40,46 All procedures were performed using a standard surgical scrub, preparation, and draping with the patients in a state of general anesthesia. All patients received a single dose of intravenous antibiotics immediately preoperatively (1–2 gcefazolin or 1-g vancomycin in patients reporting a penicillin or cephalosporin allergy), which was repeated as needed during surgeries lasting longer than 4 hours.

The prospective databases included documentation of all perioperative complications. The incidences of postoperative SSIs were therefore calculated for the entire cohort as well as for subgroups based on the type of procedure performed. Positive cases of SSI were reviewed for clinically relevant details.

A MEDLINE search was performed for English language citations using the key words “surgical site infection,” “wound infection,” and “postoperative infection” with “spine surgery,” “spinal surgery,” “laminectomy,” “discectomy,” and “spinal fusion.” The 1026 results found were screened for review articles and appropriate clinical studies describing SSI rates after spinal surgery. The references from these articles were also screened for relevant publications. The range of cited SSI rates was then used as the comparative benchmark against which our infection rate was measured.

### Results

Over the time period reviewed, we performed 1338 MISSs in 1274 patients. The average patient age was 55.5 years (range 18–97 years), and 56.2% of the collected cohort were men. The primary indication for surgery was degenerative disease in 93% of the patients. Table 1 outlines the spinal regions and types of surgeries performed. A single MISS was performed in 1213 patients, 2 procedures in 58 patients, and 3 procedures were performed in 3 patients. The indications for multiple operations included different region, level, or side surgery (in 38 cases), fusion after a prior minimally invasive decompression (12 cases), or reoperation for recurrent disc herniation (14 cases). The average length of follow-up for the series was 7.8 months (range 3–49 months).

The mean operative times for each of the procedural subgroups was as follows: MED/F, 101 minutes; MEDS, 118 minutes; minimally invasive fusion, 228 minutes; and minimally invasive intradural surgeries, 186 minutes. The mean estimated blood loss for each of the procedural subgroups was as follows: MED/F, 32 ml; MEDS, 49 ml; minimally invasive fusion, 184 ml; and minimally invasive intradural, 121 ml. For the 271 minimally invasive fusion cases, there were 216 single-level, 42 two-level, 11 three-level, and 2 four-level fusions. The mean number of levels fused per minimally invasive fusion case was 1.26.

Three postoperative SSIs were detected (Table 2). Two superficial cases of cellulitis occurred in patients after minimally invasive fusion/fixation procedures, and 1 deep infection (discitis) occurred after a MEDS procedure (described in Illustrative Cases). The procedural infection rate for MEDS was therefore 0.44%, and the rate for minimally invasive fusion/fixation was 0.74%. No infections occurred after MED/F or minimally invasive intradural cases. The SSI rate after simple decompressive procedures (MED/F and MEDS) was 0.10%. The total SSI rate for the entire cohort was 0.22%.

### Illustrative Cases

#### Case 1

This 90-year-old man underwent an uneventful L3–4 MEDS without discectomy for degenerative spinal stenosis. Three months postoperatively, he experienced increasing low back pain without neurological findings. Gadolinium-enhanced MR images revealed discitis at L3–4. The patient had suffered group B *Streptococcus* leg cellulitis and urinary tract infection 2 months after surgery (1 month prior to the onset of new back pain). Cultures of a sample obtained in a CT-guided biopsy of the L3–4 disc grew group B *Streptococci*. The infection was successfully treated with 6 months of antibiotic therapy.

### Table 1: Summary of demographic characteristics of 1274 patients undergoing 1338 operations*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. of Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sex</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>716 (56.2)</td>
</tr>
<tr>
<td>F</td>
<td>558 (43.8)</td>
</tr>
<tr>
<td>region of spinal surgery</td>
<td></td>
</tr>
<tr>
<td>cervical</td>
<td>155 (11.6)</td>
</tr>
<tr>
<td>thoracic</td>
<td>42 (3.1)</td>
</tr>
<tr>
<td>lumbar/sacral</td>
<td>1141 (85.3)</td>
</tr>
<tr>
<td>type of procedure†</td>
<td></td>
</tr>
<tr>
<td>MED/F</td>
<td>813 (60.8)</td>
</tr>
<tr>
<td>MEDS</td>
<td>226 (16.9)</td>
</tr>
<tr>
<td>MI fusion + percutaneous fixation</td>
<td>271 (20.3)</td>
</tr>
<tr>
<td>MI intradural</td>
<td>28 (2.1)</td>
</tr>
</tbody>
</table>

* The patients had a mean age of 55.5 years (range 18–97 years).
† Minimally invasive fusion includes posterolateral fusion and/or posterior/transforaminal or direct lateral interbody fusion; MI intradural includes tumor resections, filum detetherings, and syringosubarachnoid shunt insertions. MI = minimally invasive.
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therapy without repeated operation, and the patient’s back pain resolved.

Case 2
This 71-year-old man underwent minimally invasive L3–4 and L4–5 decompressions and transforaminal interbody arthrodesis and fixation for degenerative stenosis and spondylolisthesis. Immediately postoperatively a skin burn was noted between adjacent incisions for the percutaneous screws unilaterally. Local dressings with silvadene were applied. Eight weeks postoperatively, the patient was running high fevers and had cellulitis at the surgical site; blood cultures grew Staphylococcus aureus. The infection was successfully treated with a long-term antibiotic regimen and no repeated operation.

Case 3
This 53-year-old woman with cirrhosis underwent minimally invasive decompression at L4–5 and transforaminal interbody arthrodesis and fixation for stenosis and spondylolisthesis. An unintended durotomy occurred during surgery, but was primarily repaired with suture at the time. Running nylon suture was used to close both skin incisions. Ten days postoperatively the skin edges of 1 incision became dusky with signs of cellulitis. This was thought to be because the nylon sutures had been pulled too tautly. The sutures were removed, and the infection was successfully treated with 1 week of intravenous and 5 weeks of oral antibiotic therapy with a good clinical outcome.

Discussion
Surgical site infections after spinal surgery remain a serious complication that can lead to major complications and worse outcomes. The generalized adoption of preoperative antibiotic prophylaxis has served to decrease SSI rates by as much as 50%, but has not eliminated them completely. The most common pathogens isolated from wound cultures are Staphylococcus species, predominantly Staphylococcus aureus.

A recent review of 2316 patients who underwent a wide variety of open spinal surgeries over the course of 5 years found an overall infection rate of 2%. Reported risk factors for infection included diabetes, elevated serum glucose, and inappropriate timing or dosing of preoperative antibiotic medications. A prior case-control publication by some of the same authors identified in previously published cases in the present study precludes useful analysis of risk factors for infection as performed in previously published studies.

All of our procedures were posterior approaches (except for a small number of direct lateral cases), and in that regard, our infection rate is appreciably lower than other posterior surgical series. Also problematic is that low rates of infection are often found in series that include anterior procedures (such as anterior cervical discectomy and fusion), which have a much lower rate of SSI than posterior procedures. All of our procedures were posterior approaches (except for a small number of direct lateral cases), and in that regard, our infection rate is appreciably lower than other posterior surgical series.

In the present review of 1338 MISSs performed in 1274 patients, only 3 SSIs were detected. The overall infection rate of 0.22% is ~10-fold lower than that reported in most series that include a variety of spinal surgical cases, especially instrumented cases. The small number of infected cases in the present study precludes useful analysis of risk factors for infection as performed in previously published case-control studies.

Surgical Site Infections After Decompressive Surgery
Valentini and colleagues recently reviewed SSIs in 1727 general neurosurgical procedures performed at a single institution. They reported a 0.15% SSI rate for their 663 spinal operations. However, 89% of these cases were microdiscectomies or laminectomies, and only 1.4% included instrumentation. The authors of other series of such simple decompressive procedures, and in particular microdiscectomy, have reported similarly low rates of SSI, from 0.2 to 2%. We noted only 1 infection after 226 stenosis decompressions and none after 813

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No. of Infections (% of group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MED/F</td>
<td></td>
</tr>
<tr>
<td>MEDS</td>
<td>(0.44)</td>
</tr>
<tr>
<td>all decompressive procedures</td>
<td>(0.10)</td>
</tr>
<tr>
<td>MI fusion + percutaneous fixation</td>
<td>(0.74)</td>
</tr>
<tr>
<td>MI intradural</td>
<td></td>
</tr>
<tr>
<td>all procedures</td>
<td>(0.22)</td>
</tr>
</tbody>
</table>
discectomy/foraminotomy cases. Therefore, the SSI rate for patients in our series who underwent decompressive surgery alone (MED/F or MEDS) was 0.10%, consistent with prior publications, and lower still by 33–95%.

**Surgical Site Infections After Instrumented Fusion**

Twenty percent of our cases were instrumented arthrodeses in which an average of 1.26 levels were fused per case. Superficial wound infections developed in 2 of these 271 cases, and there were no deep infections. Our 0.74% rate of SSIs for this particular procedural subgroup may be the most compelling result in the present series. As mentioned above, other publications have reported infection rates after instrumented fusion of 2–16%, with the majority ~ 2–6%. Perhaps the most direct comparison with open surgical techniques is afforded by the work of Pappou et al. in 2006. These authors published their infection rates and reviewed the literature on SSIs specifically after instrumented posterior lumbar interbody fusion for degenerative disease. They reported a 3% incidence of SSI in this group of patients, and found that the range of similarly published values was 1.4–11%. Our data thus represent a 2–13-fold reduction in SSIs after instrumented interbody fusion compared with open techniques.

The 3 cases of infection in the present study included 2 superficial and 1 deep infection (discitis). All infections arose within the first 3 months postoperatively. It is our supposition that the single deep infection developed because of disc space seeding from postoperative streptococcal bacteremia secondary to sources other than the initial surgery. The 2 superficial infections appear to have originated from problems associated with skin handling or closure, an issue not necessarily specific to minimally invasive techniques. No infection required a repeated operation.

The patients in the present study had an average follow-up of close to 8 months. For patients who underwent instrumented fusion, the mean follow-up was 21 months. With the exception of some scoliosis series, SSIs following spinal surgery are rare after 6 months, and the vast majority present within the first 3 months after surgery. The follow-up period for our cohort, therefore, should be adequate to identify postoperative infections.

This retrospective review obviously suffers from the absence of a dedicated control group. We did not feel that our contemporaneous open surgical procedures represented an equivalent control group to the types of minimally invasive procedures we performed because there were considerably fewer open procedures, they tended to be of far greater complexity, and were often for spinal pathologies such as tumor and trauma that would tend to have higher postoperative infection rates. We therefore used the published literature as a more appropriate surrogate control.

Information on preoperative risk factors for SSI such as diabetes, prior surgery, obesity, prior radiation, and the like can only be studied within the context of a control group. As a result, since we did not have control groups for comparison, we cannot evaluate the potential influence of these risk factors on our results. However, we can say that our procedures were performed on patients with similar indications, and that our very low SSI rate is consistent with prior literature.

<table>
<thead>
<tr>
<th>Authors, Year</th>
<th>Study Design</th>
<th>Procedures (%)</th>
<th>SSI Definition</th>
<th>Total No. of Patients</th>
<th>SSI Rate (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valentini et al., 2008</td>
<td>retro</td>
<td>decompressive (89); instrumented (1.4)</td>
<td>superficial or deep</td>
<td>663</td>
<td>0.15</td>
<td>only 9 fusion cases</td>
</tr>
<tr>
<td>Olsen et al., 2008</td>
<td>CC</td>
<td>decompressive (27.4%); instrumented (72.5%)</td>
<td>superficial or deep</td>
<td>2316</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Collins et al., 2008</td>
<td>retro</td>
<td>instrumented fusions (100%)</td>
<td>deep only</td>
<td>1980</td>
<td>3.7</td>
<td>only included cases requiring hardware removal for infection</td>
</tr>
<tr>
<td>Friedman et al., 2007</td>
<td>CC</td>
<td>laminectomy (100%)</td>
<td>superficial or deep</td>
<td>6365</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Pappou et al., 2006</td>
<td>retro</td>
<td>instrumented posterior (82%); anterior (18%)</td>
<td>deep only</td>
<td>326</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>Kanayama et al., 2007</td>
<td>retro</td>
<td>decompressive (60%); instrumented (40%)</td>
<td>deep only</td>
<td>1133</td>
<td>0.7</td>
<td>only included cases requiring reop</td>
</tr>
<tr>
<td>Mirovsky et al., 2007</td>
<td>retro</td>
<td>instrumented posterior interbody fusion (100%)</td>
<td>deep only</td>
<td>111</td>
<td>7.2</td>
<td></td>
</tr>
<tr>
<td>Fang et al., 2005</td>
<td>CC</td>
<td>mixed decompressive &amp; instrumented</td>
<td>deep only</td>
<td>1095</td>
<td>4.4</td>
<td>only included cases requiring reop</td>
</tr>
<tr>
<td>Olsen et al., 2003</td>
<td>CC</td>
<td>mixed decompressive &amp; instrumented</td>
<td>superficial or deep</td>
<td>1918</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Gaynes et al., 2001†</td>
<td>prosp</td>
<td>laminectomy</td>
<td>nosocomial infection</td>
<td>37,137</td>
<td>0.9–2.6</td>
<td>CDC surveillance, 1992–1998</td>
</tr>
<tr>
<td>Gaynes et al., 2001†</td>
<td>prosp</td>
<td>spinal fusion</td>
<td>nosocomial infection</td>
<td>21,491</td>
<td>1.2–7.2</td>
<td>CDC surveillance, 1992–1998</td>
</tr>
<tr>
<td>Picada et al., 2000</td>
<td>retro</td>
<td>instrumented lumbar fusions (100%)</td>
<td>deep only</td>
<td>817</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Weinstein et al., 2000</td>
<td>retro</td>
<td>mixed decompressive &amp; instrumented</td>
<td>deep only</td>
<td>2391</td>
<td>1.9</td>
<td></td>
</tr>
</tbody>
</table>

* CC = case-control; CDC = Centers for Disease Control; prosp = prospective; retro = retrospective.† These represent the same study, but separated by procedure (laminectomy and spinal fusion).
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and smoking were not consistently recorded in our databases. Therefore, comparison of our group of patients to other published cohorts based on these variables was not possible. Nevertheless, we think it unlikely that our 1274 patients (treated by 3 separate surgeons at 4 academic institutions) would be substantially different from the general spinal surgery patient population with regard to predisposing factors for SSI. In fact, because we have focused only on tertiary/quaternary care centers, the population might theoretically possess a greater number of risk factors for SSI. In addition, one might also postulate that MISS techniques have, in general, allowed us to offer surgery to many more high risk patients than we would have in the past, thus also possibly biasing the studied cohort toward a greater incidence of SSI. More formal case-control or randomized studies on the topic could better answer these important questions.

This study was not designed to investigate the possible reasons for lower infection rates after MISS. However, we postulated at least 4 potential mechanisms that may play a role. First, there is clearly a reduced exposure of deep tissues during minimally invasive surgery. Only the field at the base of the tubular retractor is exposed to the environment, and therefore the surface area for possible contamination is reduced. Second, and in a related way, the tubular retractor itself blocks local contamination of deep tissues by skin flora that might be transported by the movement of the surgeon’s hands or instruments in and out of the field. Thirdly, most MISS incisions are smaller than their open counterparts and so the likelihood of skin dehiscence and postoperative contamination should be less. Finally, and perhaps most importantly, there appears to be a reduction in operative site dead space after closure of the wound compared with open procedures. This reduction may serve to reduce or prevent the formation of postoperative wound seromas or hematomas that can be the nidus for a developing SSI.

In the avoidance of SSIs after spinal surgery, ultimately there is no replacement for sterile technique, meticulous hemostasis and closure, and appropriate preoperative antibiotic prophylaxis. Nevertheless, we believe that our results in the present study demonstrate a possible advantage to MISS techniques, namely a reduction in postoperative wound infections. Clearly, further study is required to validate these findings through more direct comparisons of traditional open versus minimally invasive approaches.

Conclusions

We detected a very low rate of SSIs in this large series of patients who underwent MISS. The postoperative infection rates of 0.74% for instrumented arthrodasis and 0.22% for the entire cohort are some of the lowest ever reported for a series of this size and of this diversity of procedures. Our findings suggest that MISS techniques reduce postoperative wound infections by as much as 10-fold compared with other large, modern series of open spinal surgery in the literature.

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