

Management of Infection After Instrumented Posterior Spine Fusion in Pediatric Scoliosis

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Study Design. Case series retrospective review.

Objective. To identify what factors predict successful eradication of infection after I&D of an infected posterior spinal fusion with instrumentation.

Summary of Background Data. The treatment of infection of instrumented spine fusions in children has few clear guidelines in the literature.

Methods. The medical records of patients who required a surgical irrigation and debridement (I&D) for infection after posterior spinal fusion and instrumentation for scoliosis from 1995 to 2002 were retrospectively reviewed.

Results. Fifty-three patients were identified with the following underlying diagnoses: 21 patients (40%) idiopathic scoliosis, 10 patients (23%) cerebral palsy, 3 patients (6%) spina bifida, 1 patient (2%) congenital scoliosis, and 17 patients (32%) other. There were 31 patients (58%) with surgery <6 months from initial fusion, and 22 (42%) patients >6 months. Of the 43 patients with implant retained at the time of the first I&D, 20 patients required a second I&D (47%). Of the 10 patients with complete implant removal, 2 patients required a second I&D (20%). Coagulase-negative *Staphylococcus* was the most prevalent organism, growing in 25 (47%) of the cultures. Of patients with idiopathic scoliosis, 8 of 21 (38%) required a second I&D; of the patients with other diagnoses, 14 of 32 (44%) required a second I&D, which was not a significant difference ($P > 0.05$).

Conclusion. To the best of our knowledge, this is the largest reported series of spinal implant infections. When children with an infection after posterior spinal fusion with instrumentation undergo irrigation and debridement, there is a nearly 50% chance that the infection will remain if all spinal implants are not removed. As nearly 50% of the infections were caused by coagulase-negative *Staphylococcus*, we recommend that prophylactic antibiotic coverage for this organism is used at the time of the initial spinal fusion.

Key words: infection, scoliosis, posterior spinal fusion, implant removal, irrigation and debridement. **Spine 2007; 32:2739–2744**

Infection after spinal fusion for scoliosis is a commonly reported complication. Studies dating from the 1970s through 1990s report infection rates ranging from 9.3%

to 20%.^{1,2} Although techniques in pediatric spinal fusion have improved with regard to infection prophylaxis, postoperative infections and wound complications remain, with current reported scoliosis infection rates range from 0.4% to 8.7%.^{3,4}

Currently, there is a general agreement that a draining spinal wound or hematoma necessitates operative irrigation and debridement. Intravenous or oral antibiotics are tailored to the results of intraoperative cultures.^{2,5–7} Richards and Emara identified a series of 23 idiopathic patients who presented with late infections after posterior TSRH instrumentation. He reported good results after implant removal, primary closure, and a short-term course of antibiotics.^{8,9} Clark and Shufflebarger reported on the treatment of 22 idiopathic scoliosis patients treated with posterior instrumentation, who developed delayed infections. They concluded that these infections could be treated with implant removal, primary skin closure, and short-term oral antibiotics.¹⁰ Soultanis *et al* reported eradication of infection in 5 patients using implant removal, continuous antibiotic irrigation for 5 days after surgery, and intravenous antibiotics followed by oral antibiotics.¹¹ There are also authors who recommend different management of infection in this setting. Szoke *et al* advocated leaving the wound open with retention of instrumentation and bone graft after irrigation and debridement in cerebral palsy patients.¹²

We were also interested in bacteriology of infections in the postscoliosis fusion patient. Although multiple studies have documented a high prevalence of *Staphylococcus aureus*, gram-negative, and polymicrobial organisms in scoliosis spinal wound infections,^{12,13} we were suspicious that there was a low prevalence of these organisms in our patient population. Instead, our anecdotal experience suggested that low-virulence organisms were often primarily responsible for these infections at our institution.

Our experience with persistent infections has often led to removal of spinal implants. Very little literature is available regarding sequelae after implant removal.^{14,15} Although fusion may appear to be solid both radiographically and intraoperatively, there still may be the possibility of loss of correction with further follow-up.

Although there are numerous reports of infection, there is very little literature available to help guide management of these patients. Controversies still exist regarding the retention of spinal implant, wound management, and the need for repeat irrigation and debridement surgeries.

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The purpose of this study is to identify what factors predict successful eradication of infection after I&D of an infected posterior spinal fusion with instrumentation. Our null hypotheses are that the efficacy of irrigation and debridement of an infected spinal fusion are not affected by the following factors: (1) removal *versus* retention of spinal implants, (2) type of bone graft, (3) underlying diagnosis, (4) time from initial fusion to presentation of infection, and (5) type of infecting organism. The intent of this study is not to examine rates of infection, risk factors for infection, or how to diagnose spine infection after spine fusion.

Materials and Methods

Inclusion criteria for this study was all patients undergoing posterior spinal instrumentation and fusion for scoliosis and a subsequent irrigation and debridement of the posterior spinal wound from 1995 to 2002. Patients were excluded if spinal surgery was done for reasons other than scoliosis (*i.e.*, spondylolisthesis, tumor, or fracture). IRB approval was obtained from the institution. Of the 622 children having a posterior instrumented spine fusion for scoliosis during this period, 8.5% (53 of 622) of patients met inclusion criteria for infection.

Age of patient at the index surgery (posterior spinal instrumentation and fusion), time from the index surgery to initial irrigation and debridement, use of allograft *versus* autograft, patient diagnosis, white blood cell count, sedimentation rate, c-reactive protein level, retention and removal rate of implants, culture results, type of wound closure, and drain management were examined. For the purposes of this study, we define early wound infections as those that occurred <6 months after the index operation, and late infections as those that occurred >6 months after the index surgery. Fisher exact tests and χ^2 tests were used and were considered significant for a *P* value of <0.05.

Patients who had spinal implants removed were identified, and radiographs immediately before implant removal and at final follow-up were examined. For these patients, scoliosis was measured using the Cobb angle and sagittal angulation was measured from T1–T12, and from L1–L5.

The operative approach to suspected infection after a spinal fusion for scoliosis at our institution during the time of this study was that operative irrigation and debridement was performed with a primary wound closure over drains. If an infection occurs <6 months postfusion, the spinal implants were usually retained when possible on the assumption that a solid fusion may not yet be present. Drains were removed once the output is less than approximately 30 cc in a 24-hour period. Infectious disease consultation was obtained to manage the antibiotic regimen. In cases where infection is greater than 6 months, implants were most often removed if the spinal fusion appeared solid in an effort to help clear infection.

Results

Fifty-three patients met the inclusion criteria. Average age of the patients was 14.3 years (range, 5.8–20.4 years) at time of index spinal fusion. The average number of irrigation and debridements required was 1.6 (range 1–8). Twenty-two patients required a second irrigation and debridement, and 5 patients required a third irrigation and debridement. Average time from initial instru-

Table 1. Patient Diagnoses

	All Patients	Early Infections	Late Infections
Idiopathic	21 (42%)	11 (35%)	10 (45%)
CP	12 (23%)	6 (19%)	6 (27%)
Spina Bifida	3 (6%)	1	2
Congenital	1	1	0
Other	16 (30%)	12 (39%)	4 (18%)
Total	53	31 (59%)	22 (41%)

mentation and fusion to initial irrigation and debridement was 294 days (range, 10–1723).

At the time of the first irrigation and debridement, average WBC was 13.3 (range, 5.4–37.4), average ESR was 61 (range, 11.98–110), and average CRP was 5.69 (range, 1–24.2). However, not all patients had routine infection labs drawn before surgery. Data on initial WBC was available on 34 patients, data for ESR on 20 patients, and data for CRP on 17 patients.

Thirty-one (59%) of 53 patients were in the early wound infection group (<6 months from time of initial fusion), and of these, 12 (39%) patients had idiopathic scoliosis (Table 1). Average age of the patients in this group was 15 years. An average of 1.8 irrigation and debridements (range, 1–8) were performed. Average time from initial instrumentation and fusion to initial irrigation and debridement was 32 days (range, 10–123). The average WBC was 15.1 (range, 6.2–37.4), average ESR was 58.1 (range, 30–110), and average CRP was 6.78 (range, 1.0–24.2).

Twenty-two (42%) of 53 patients were in the late group, and of these, 10 patients (46%) had idiopathic scoliosis (Table 1). Average age of the patients in this group was 13 years. Allograft in the initial spinal fusion was used in 10 (46%) of 22 patients. An average of 1.4 irrigation and debridements (range, 1–2) were performed in this late group. Average time from initial instrumentation and fusion to initial irrigation and debridement was 663 days (range, 814–1723). The average WBC was 10.9 (range, 5.4–20.0), average ESR was 66.4 (range, 30–90), and average CRP was 4.13 (range, 2.0–8.1) in this group at time of presentation before I&D.

Infecting Pathogen

Cultures often grew out multiple organisms. Each organism was counted once. For the sake of simplicity, the culture was deemed polymicrobial if at least 3 different bacterial species grew out and if the species were of 2 different types (*i.e.*, gram-negative *vs.* gram-positive, aerobic *vs.* anaerobic). Because of this, our number of culture results is greater than the number of our patients (Table 2).

At the time of the first irrigation and debridement, coagulase-negative *Staphylococcus* was the most prevalent organism, growing in 25 of 53 (47%) cultures. Polymicrobial bacteria cultures occurred in 6 of 53 cultures, and oxacillin sensitive *S. aureus* was isolated in 5 of 53 cultures.

For patients requiring a second irrigation and debridement, coagulase-negative *Staphylococcus* was the most

Table 2. Infecting Pathogen

Pathogen	Patients (n = 53)
Coagulase negative <i>Staphylococcus</i>	47% (25)
<i>S. aureus</i>	17% (9)
Polymicrobial	15% (8)
<i>Enterococcus</i>	6% (3)
<i>Pseudomonas</i>	6% (3)
No growth	6% (3)
<i>E. coli</i>	4% (2)
Enterobacter	4% (2)
Peptostreptococcus	4% (2)

prevalent organism isolated from the first irrigation and debridement, growing in 10 of 22 (45%) of cultures. Cultures from the second irrigation and debridement had no growth in 7 of 22 (32%) of patients, and 3 cultures (14%) grew coagulase-negative *Staphylococcus*.

Five patients required a third irrigation and debridement. The most prevalent bacteria in these patients from prior irrigation and debridements, were coagulase-negative *Staphylococcus* (2), polymicrobial flora (2), and *Pseudomonas* (2). Cultures during the third irrigation and debridement grew out oxacillin sensitive *S. aureus* in 1 patient, polymicrobial flora in 1 patient, and coagulase-negative *Staphylococcus* with group D *Enterococcus* in 1 patient. One patient had no growth in either culture medium or broth, and 1 patient had their irrigation and debridement performed by the plastic surgery service, and no cultures were taken.

Although coagulase negative *Staphylococcus* was overwhelmingly the most common pathogen isolated from patients, the infecting pathogen was not found to be a significant predictor for the need for further irrigation and debridement ($P > 0.05$).

Type of Bone Graft

Allograft was used at the time of the initial spinal fusion in 26 (49%) of 53 patients.

For patients who required a second irrigation and debridement, allograft was used in the initial fusion surgery in 10 (46%) of 22 patients. The use of allograft was not found to be a significant predictor of the need for a second irrigation and debridement ($P > 0.05$).

Patient Diagnosis

Twenty-one (40%) of 53 patients were diagnosed with idiopathic scoliosis, 12 patients (23%, 12 of 53) with cerebral palsy, 3 patients (6%, 3 of 53) with spinal bifida, 1 with congenital scoliosis (2%, 1 of 53), and 17 patients (32%, 17 of 53) with other diagnoses (*i.e.*, anoxic encephalopathy, polio, muscular dystrophy, dwarfism, *etc.*)

During the second irrigation and debridement, patients with idiopathic scoliosis accounted for 36% (8 of 22) of these patients, cerebral palsy for 27% (6 of 22) of these patients, spina bifida for 1 of these patients, and "other" for 7 of these patients.

At the time of third irrigation and debridement, 2 of the 5 patients had a diagnosis of cerebral palsy, 1 patient had a diagnosis of idiopathic scoliosis, 1 patient had

Meckel–Gruber syndrome, and 1 patient had translocation of chromosome 17.

Patients with idiopathic scoliosis made up 40% (21 of 53) of the patients in our series and 36% (8 of 22) of the patients requiring a second irrigation and debridement. The diagnosis of the patient was not found to be a significant predictor of the need for further surgery ($P > 0.05$).

Implant Removal

During the first irrigation and debridement, 43 (81%) of 53 patients had their implants retained, and 10 patients had all implants removed. Of the patients in the early infection group, only 1 of 31 patients (3%) had complete implant removal. Nine of 22 patients (41%) in the late infection group had complete implant removal. Of the 43 patients with implants retained, 20 patients required a second irrigation and debridement (47%), and 5 required a third irrigation and debridement (12%). Of the 10 patients with complete implant removal, only 2 patients required a second irrigation and debridement (20%) and none required a third irrigation and debridement. Retention of implant was found to be a significant predictor of the need for a second irrigation and debridement ($P < 0.05$).

Twenty-two (42%) of 53 patients required a second irrigation and debridement. Twenty (91%) of these patients had their spinal implants retained from the initial irrigation and debridement, and 2 (9%) had all of their implants completely removed from the initial irrigation and debridement.

Five (9%) of 53 patients required a third irrigation and debridement. All of these patients were in the early infection group, and all but 1 patient had their spinal implants retained from the initial fusion.

One patient, with translocation of chromosome 17, required 5 irrigation and debridements and did not clear her infection until all of the spinal instrumentation was removed. Prior cultures had yielded coagulase-negative *Staphylococcus*, *Morganella morganii*, oxacillin sensitive *Staphylococcus aureus*, and *Candida*.

One patient, diagnosed with Meckel–Gruber syndrome, required 8 irrigation and debridements. Her initial irrigation and debridement occurred a mere 21 days after her posterior spinal instrumentation and fusion. This patient's wound was left open and treated with a wound vac during the initial 2 irrigation and debridements. The patient eventually required treatment by the Plastic Surgery service for multiple local muscle flaps and irrigation and debridement. Cultures from her various surgeries grew methacillin resistant *Staphylococcus aureus* multiple times and *Pseudomonas*, *Candida*, and *Bacterioides fragilis*. Her infection eventually resolved after her spinal instrumentation was removed at 19 months after her initial posterior spinal fusion.

Several variables were found to be significant for prediction of the need for a second irrigation and debridement. Factors such as the use of allograft, culture results, or patient diagnosis were not found to be significant ($P >$

0.05). However, the retention of implants was found to be a significant predictor of further surgery ($P < 0.05$). Forty-three patients had implants retained from the initial irrigation and debridement, and 47% (20 of 43) of these patients required a second irrigation and debridement. Twelve percentage (5 of 43) of these patients required a third irrigation and debridement. Of the 10 patients who had implants removed at the initial irrigation and debridement, only 20% required a second irrigation and debridement, and no patient required a third irrigation and debridement.

Radiographic Outcome After Removal of Implants

Twenty-three of 53 patients (42%) had complete removal of spinal implants. Average length of time from initial fusion to implant removal was 735 days (range, 43–1719). There were follow-up radiographs at least 4 months after implant removal in 10 patients. Radiographs for these 10 patients were analyzed and compared with radiographs taken immediately before implant removal. Average age of these 10 patients was 16.2 years old. Average time from implant removal to final radiographs was 10 months (range, 4–30). In the coronal plane, average loss of correction of the thoracic curve was 9° (range, $2\text{--}25^\circ$), and average loss of correction of the lumbar curve was 3° (range, $0\text{--}13^\circ$). One patient actually had an increase of correction of her thoracic curve, and 1 patient had improved correction of her lumbar curve. Three patients had loss of correction of their thoracic curve greater than 10° , and 1 patient had greater than 10° loss of correction of her lumbar curve. In the sagittal plane, average change in kyphosis was 15° (range, $2\text{--}29^\circ$) and average change in lordosis was 8° (range, $0\text{--}15^\circ$). There were 2 patients who had improvement of their kyphosis and 4 patients who had improvement of their lordosis. Six patients had greater than 10° loss of kyphosis and 3 patients had greater than 20° loss of kyphosis. Two patients had greater than 10° loss of lordosis. Of the 10 patients with at least 4-month follow-up after removal of spinal implants, 6 of them (60%) had at least a 10° progression of deformity in at least 1 plane.

In our small group of patients, there did not appear to be a correlation between age and loss of correction. Only 3 of our 10 patients were younger than 15 years of age at the time of implant removal, and the 3 patients who had the greatest loss of correction were 9, 15, and 18 years of age. A greater number of patients and longer length of follow-up would be needed to assess the long-term implications of implant removal.

Discussion

There is a limited amount of literature regarding the management of wound complications and infection in scoliosis patients. The goal for this study was to report our experience and algorithm in treating these patients. This is the largest case series of spinal implant infection after deformity surgery to date in the current literature

with 53 patients identified, with the previous largest study including 45 patients.¹⁵ In addition, this is one of the few studies to analyze all infected scoliosis patients, both early and late appearing infections, without regard to underlying diagnosis. This is the only study to our knowledge to compare and correlate the reoperation rate with spinal implant removal and retention in this patient population.

There are authors who recommend leaving the wound open at the time of irrigation and debridement. For early, deep wound infections, Szoke *et al* recommended leaving the wound open after the initial irrigation and debridement while leaving spinal instrumentation and bone graft intact.¹² Banta reported successfully treating 4 deep wound infections by allowing healing to occur by secondary intention.¹⁶ Wenger *et al* felt that if the diagnosis was delayed and the wound grossly purulent, the wound should be left open and left to heal by secondary intention via dressing changes.¹⁷ Sponseller *et al* also advocated this approach allowing granulation over instrumentation if there was failure of prior treatment, extensive purulence, or poor soft tissue coverage. However, 7 of 14 patients managed in this fashion had recurrent infection.¹³ Use of suction-irrigation catheter systems using antibiotic solutions has also been described with good results in earlier literature.^{18,19}

Mitra *et al* found good results using a modified, extended latissimus dorsi myocutaneous flap combined with a gluteus maximus muscle flap as needed and reported no flap losses, pseudarthrosis, or loss of spinal instrumentation on follow-up.²⁰

Although some have not found use of allograft to carry an increased infection rate in spinal fusion,²¹ Sponseller *et al* have suggested that the use of allograft in neuromuscular patients may cause an increased risk of infection.¹³ The purpose of this study was not to look at risks for infection after a primary fusion, but risks for persistent infection after an irrigation and debridement of an infected posterior spine fusion. Almost 50% (26 of 53) of the patients in this series had allograft used in their initial fusion. Of those requiring a second irrigation and debridement for persistent infection, 46% (10 of 22) had of allograft. There was not a significant association ($P > 0.05$) between use of allograft and eradication of infection.

Our findings support those of many other investigators in demonstrating that low-virulence organisms are often primarily responsible for postoperative spinal infections.^{4,8–10,22,23} In our study, coagulase-negative *Staphylococcus* (*Staphylococcus epidermis*) accounted for 47% (25 of 53) of the culture results during the first irrigation and debridement. We also found that the seemingly low virulence coagulase negative *Staphylococcus* was responsible for 45% (10 of 22) of persistent infections. There was no significant correlation between this organism and risk of persistent infection ($P > 0.05$).

In a prospective, randomized study, Cheng *et al* found that irrigation of the spinal wound with dilute betadine solution completely prevented infection in a group of

208 patients, compared with a 2.9% rate of infection in 206 patients who did not have betadine irrigation.²⁴ At the recommendation of our hospitals infectious disease service, we have changed our antibiotic prophylaxis protocol from cefazolin to vancomycin and ceftazadine to cover *S. epidermis*, and other organisms. The routine use of Vancomycin for perioperative antibiotics raises the concern of creating Vancomycin-resistant MRSA. How to best balance the risk of emerging antibiotic resistance versus the risk of continued spinal infections with coagulase-negative *Staphylococcus* is not clear. After the completion of this study, we have adopted a new protocol of using vancomycin and ceftazadine as prophylactic antibiotics on posterior spinal fusions. In addition, jet lavage irrigation with detergent solution,²⁵ is used before closure, with early results suggesting a greatly smaller rate of infection.

Hahn *et al* had 5 patients with idiopathic scoliosis out of their series of 7 infections, and found his infection rate to be 7.5% for idiopathic patients and 6.3% for neuromuscular patients.²² Others have associated cerebral palsy and paraplegia with higher infection risks,^{3,18,21} and Hull *et al* reported a 43% infection rate in myelomeningocele patients treated with spinal fusion.²⁶ Sponseller *et al* has implicated cognitive impairment as a risk factor for infection,¹³ and multiple authors have associated neuromuscular scoliosis with a higher risk of infection.^{2,3,26-28} An unexpected finding in this study is that children with idiopathic scoliosis, who made up 40% (21 of 53) of our study, did not appear to clear infection any better than patients with other diagnoses. Of the patients with idiopathic scoliosis, 38% (8 of 22) required a second irrigation and debridement.

Retention of spinal instrumentation at the time of irrigation and debridement has been recommended.^{3,17-19} We found that the retention of implants strongly correlated to recurrent infection in our patient population ($P < 0.05$). We found an almost 50% (20 of 43) rate of recurrence in patients in whom the implants were left in place. Of the patients requiring a second irrigation and debridement, 91% (20 of 22) of them had implants retained from the initial fusion. All but 1 of the 5 patients who underwent a third irrigation and debridement had implants present. Both patients who underwent more than 3 irrigations and debridements did not finally resolve their infections until all implants were removed. Other authors have described a similar experience in being unable to eliminate infection until after the spinal instrumentation is removed.^{21,29} Hahn *et al* reported 100% success of infection eradication with implant removal (24–106 month follow-up).²² However, in our series, 9% (2 of 22) of our patients still required a repeat irrigation and debridement after complete implant removal.

The data in this study supports the removal of spinal implants to remove infection, however, this must be weighed against the significant chance of progressive spinal deformity after implant removal. One approach to this difficult situation is long-term suppres-

sion of the infection with antibiotics, followed by removal of spinal implants once the fusion is solid if the infection remains persistent. A short-coming of this approach is that it is impossible to tell when a fusion is solid, and removal of the implants even years after surgery may uncover a pseudarthrosis, resulting in progressive spinal deformity.

Literature regarding loss of correction after removal of spinal instrumentation is sparse. Deckey *et al* reported that 4 of 14 adult patients who underwent removal of spinal implantation for deformity had increased pain or loss of correction requiring revision surgery on the average of 4.8 months after implant removal.¹⁴ They recommended that implant removal be avoided to prevent failure of what intraoperatively seemed to be a solid fusion. Muschik *et al* retrospectively reviewed 45 scoliosis patients who had implant removal for infection and reported average loss of correction of 6° for the thoracic curve, 5° for the lumbar curve, and 11° for thoracic kyphosis with an average length of follow-up of 3.6 years.¹⁵ In our series, of the 10 patients with at least 4-month follow-up after removal of spinal implants, 6 of them (60%) had at least a 10° progression of deformity in at least 1 plane. This is very worrisome as the mean follow-up for this group was only 10 months.

Neither this study nor others clearly define the likelihood of a child's spinal deformity progressing after implant removal, though we suspect it will be very high. A future long-term follow-up study of the patients in whom implants were removed is planned to clarify the risk of progressive spinal deformity. In infected total joint replacements in adults, a common treatment strategy is removal of all implants at time of irrigation and debridement, followed by replacement of implants at a later date.^{30,31} Perhaps this approach may be applicable to children with infected spine implants at risk for progressive deformity after implant removal.

To the best of our knowledge, this is the largest reported series of spinal implant infection after spinal deformity surgery to date. In this series, an irrigation and debridement performed without complete implant removal predicted an almost 50% chance that a second irrigation and debridement would be required. However, the treating surgeon should be prudent in balancing the need for eradication of infection with the stability of the spine. Patients who have spinal implants removed may be at risk for loss of correction and should be monitored with serial radiographs. Low virulent skin flora is primarily responsible for both early and late wound complications seen in this series, and can often be as difficult to eradicate as other pathogens. Patients with idiopathic scoliosis do not seem to clear infections any better than patient with neuromuscular scoliosis. As nearly 50% of the infections were caused by coagulase-negative *Staphylococcus*, and we recommend that prophylactic antibiotic

coverage for this organism be used at the time of the initial spinal fusion.

■ Key Points

- When children with an infection after posterior spinal fusion with instrumentation undergo irrigation and debridement, there is a nearly 50% chance that the infection will remain if all spinal implants are not removed.
- Caution is needed in removing implants as this may lead to progressive deformity.
- Patients with idiopathic scoliosis do not appear to clear infection after an irrigation and debridement better than neuromuscular patients.
- As nearly 50% of the infections were caused by coagulase-negative *Staphylococcus*, we recommend that prophylactic antibiotic coverage for this organism be used at the time of the initial spinal fusion.

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