Review

Evidence-based management of deep wound infection after spinal instrumentation

Rishi R. Lall, Albert P. Wong, Rohan R. Lall, Cort D. Lawton, Zachary A. Smith, Nader S. Dahdaleh

Department of Neurosurgery, Northwestern University Feinberg School of Medicine, 676 N. St. Clair, Suite 2210, Chicago, IL 60611, USA

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A B S T R A C T

In this study, evidence-based medicine is used to assess optimal surgical and medical management of patients with post-operative deep wound infection following spinal instrumentation. A computerized literature search of the PubMed database was performed. Twenty pertinent studies were identified. Studies were separated into publications addressing instrumentation retention versus removal and publications addressing antibiotic therapy regimen. The findings were classified based on level of evidence (I–III) and findings were summarized into evidentiary tables. No level I or II evidence was identified. With regards to surgical management, five studies support instrumentation retention in the setting of early deep infection. In contrast, for delayed infection, the evidence favors removal of instrumentation at the time of initial debridement. Surgeons should be aware that for deformity patients, even if solid fusion is observed, removal of instrumentation may be associated with significant loss of correction. A course of intravenous antibiotics followed by long-term oral suppressive therapy should be pursued if instrumentation is retained. A shorter treatment course may be appropriate if hardware is removed.

1. Introduction

Spinal instrumentation is commonly used in the treatment of various pathologies including fracture, degenerative disease, deformity and tumor. Post-operative infection in the setting of instrumentation is a dreaded complication with reported rates ranging from 1–8% [1–10]. Reported risk factors for post-operative infection include patient factors such as advanced age, malnutrition and being immunocompromised, as well as intra-operative factors such as length of surgery, number of levels operated on, posterior surgical approach, open surgery, and use of intra-operative equipment including microscopes, O-arm or C-arm [1–6,11–13].

Post-operative infection is often subdivided into early and delayed infection due to differences in pathophysiology and management. Early infections typically represent direct inoculation of the surgical site with bacteria and manifest within weeks of the index surgery [13]. The pathogens most commonly associated with early infection include Staphylococcus aureus and beta-hemolytic Streptococcus [2,3,7,14]. In contrast, delayed infection typically presents several months after index surgery and is typically caused by less virulent pathogens, most commonly Propionibacterium acnes [9,15,16].

Infections are also distinguished between deep (subfascial) and superficial (suprafascial) infection. High rates of treatment success have been reported for superficial surgical site infections with local wound care and antibiotic therapy [10]. Management of deep wound infection in the setting of instrumentation may be more challenging. It is widely agreed that deep infection should be managed with surgical washout and debridement and adjuvant antibiotic therapy, but there remains significant variability in terms of management of instrumentation and duration of antibiotic therapy. Metal hardware may harbor bacteria and allow biofilm formation, thus increasing the likelihood of recurrent infection [17–19]. Hardware removal, however, may be associated with progressive deformity, pain, and pseudoarthrosis, particularly if stable bony fusion has not yet occurred [1,7,16,20–22].

Evidence-based management articles for post-operative surgical site infections in the setting of instrumentation are lacking in the literature. Here, we review the current evidence.

2. Methods

A computerized review of the literature prior to March 2014 was performed utilizing PubMed. Keywords used during this search included the following: surgical site infection spine, infected instrumentation fusion, spinal hardware infection, deep wound infection spine, and post-operative spine infection. The
Studies assessing instrumentation retention or removal in the setting of deep post-operative infection

<table>
<thead>
<tr>
<th>Authors (year)</th>
<th>Patients (early/delayed infection)</th>
<th>Surgical management at time of infection</th>
<th>Mean no. of surgeries to eradicate infection</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glassman et al. (1996) [17]</td>
<td>19 (not reported)</td>
<td>Serial debridements until OR cultures negative then delayed primary closure</td>
<td>4.2</td>
<td>Instrumentation retained successfully in 19/19 patients with aggressive serial debridements and IV antibiotics</td>
</tr>
<tr>
<td>Viola et al. (1997) [21]</td>
<td>8 (0/8)</td>
<td>Debridement and instrumentation removal</td>
<td>1</td>
<td>100% eradication of infection with instrumentation removal for delayed infection. 3/8 required delayed reinsertion for progressive deformity</td>
</tr>
<tr>
<td>Szoke et al. (1998) [10]</td>
<td>15 (14/1)</td>
<td>Debridement and primary closure with retention of instrumentation</td>
<td>Not reported</td>
<td>Instrumentation retention successful with early infection after debridement and IV antibiotics (14/14). Delayed infection required instrumentation removal for recurrent infection (1/1)</td>
</tr>
<tr>
<td>Clark et al. (1999) [26]</td>
<td>22 (0/22)</td>
<td>Debridement, removal of instrumentation and primary closure</td>
<td>Not reported</td>
<td>Infected cleared in all patients after instrumentation removal. 4/22 scoliosis patients had pseudoarthrosis/loss of correction after instrumentation removal, three of whom underwent subsequent reinsertion</td>
</tr>
<tr>
<td>Aydinli et al. (1999) [8]</td>
<td>11 (8/3)</td>
<td>Washout and retention of instrumentation</td>
<td>Not reported</td>
<td>Infection recurred in all patients following instrumentation retention, requiring removal within 5 years of index surgery, however all patients went on to develop stable union prior to removal</td>
</tr>
<tr>
<td>Picada et al. (2000) [25]</td>
<td>26 (16/10)</td>
<td>Serial debridements, instrumentation retention and secondary closure</td>
<td>Not reported</td>
<td>24/26 patients successfully cleared infection with serial debridements and antibiotics without instrumentation removal</td>
</tr>
<tr>
<td>Sponseller et al. (2000) [30]</td>
<td>25 (not reported)</td>
<td>Debridement and secondary intention with retention of instrumentation</td>
<td>Not reported</td>
<td>Instrumentation retained successfully in 18/25 (11 with single debridement, seven with multiple). Early versus delayed not reported. 7/25 required instrumentation removal for recurrent infection</td>
</tr>
<tr>
<td>Richards et al. (2001) [27]</td>
<td>23 (0/23)</td>
<td>Debridement and removal of instrumentation at first stage</td>
<td>1.4</td>
<td>Instrumentation removal successful for eradication of delayed infection (23/23). For pseudoarthrosis (3/23), delayed reinsertion was tolerated and did not cause reinfecion</td>
</tr>
<tr>
<td>Hahn et al. (2005) [16]</td>
<td>7 (0/7)</td>
<td>Debridement and instrumentation removal</td>
<td>1</td>
<td>Instrumentation removal successful for eradication of infection, but observed 10–25% loss of correction in 3/8 scoliosis patients</td>
</tr>
<tr>
<td>Collins et al. (2008) [1]</td>
<td>74 (9/63)</td>
<td>Debridement and removal of instrumentation if solid fusion observed</td>
<td>Not reported</td>
<td>Only 46% of scoliosis patients had stable pain-free spines after debridement and instrumentation removal. Only one patient required delayed reinsertion for loss of correction</td>
</tr>
<tr>
<td>Potter et al. (2006) [20]</td>
<td>6 (0/6)</td>
<td>Debridement and instrumentation removal</td>
<td>1</td>
<td>Instrumentation removal in patients with adolescent idiopathic scoliosis associated with mean loss of 10° of coronal correction</td>
</tr>
<tr>
<td>Kowalski et al. (2007) [24]</td>
<td>81 (30/51)</td>
<td>Variable</td>
<td>Not reported</td>
<td>Instrumentation retention successful for early infection (77% 2 year infection-free survival). For delayed infection, instrumentation removal associated with higher 2 year infection-free survival compared to retention</td>
</tr>
<tr>
<td>Mirovsky et al. (2007) [22]</td>
<td>8 (not reported)</td>
<td>Debridement and instrumentation retention</td>
<td>Not reported</td>
<td>Instrumentation retained successfully in all eight patients with 100% infection eradication</td>
</tr>
<tr>
<td>Ho et al. (2007) [28]</td>
<td>53 (31/22)</td>
<td>Variable</td>
<td>1.6</td>
<td>50% rate of recurrent infection when instrumentation retained, compared to 20% with removal. Following instrumentation removal in deformity patients, 6/10 patients developed &gt;10° loss of correction. Instrumentation retention was unsuccessful for delayed infection. All 26 patients had recurrent infection requiring removal. Hospital costs were lower with early instrumentation removal</td>
</tr>
<tr>
<td>Hedquist et al. (2008) [29]</td>
<td>26 (0/26)</td>
<td>Debridement and instrumentation retention</td>
<td>4</td>
<td>Instrumentation removal associated with higher 2 year infection-free survival compared to retention</td>
</tr>
<tr>
<td>Rihn et al. (2008) [9]</td>
<td>7 (1/6)</td>
<td>Hardware removed for delayed infection. Retained for early infection</td>
<td>2</td>
<td>All delayed infections resolved with a single debridement and hardware removal. Instrumentation retention failed for acute infection, requiring five debridements, removal, and reimplantation</td>
</tr>
<tr>
<td>Cahill et al. (2010) [7]</td>
<td>61 (32/29)</td>
<td>Variable</td>
<td>2</td>
<td>Higher rate of reoperation in patients who underwent instrumentation removal compared to retention. Average 23° of deformity progression after instrumentation removal compared to only 2° with retention</td>
</tr>
<tr>
<td>Pulter Guine et al. (2010) [12]</td>
<td>84 (not reported)</td>
<td>Debridement, instrumentation removal and primary closure</td>
<td>1.3</td>
<td>76% of patients with deep surgical site infection were able to clear infection with single debridement and instrumentation retention</td>
</tr>
<tr>
<td>Ahmed et al. (2012) [18]</td>
<td>16 (not reported)</td>
<td>Debridement and instrumentation retention</td>
<td>Not reported</td>
<td>Instrumentation retention successful in all 16 patients, with 100% eradication of infection at 2 year follow-up</td>
</tr>
<tr>
<td>Maruo et al. (2014) [15]</td>
<td>166 (not reported)</td>
<td>Instrumentation retention for 76%, removal for 24%</td>
<td>1.4</td>
<td>79% rate of early resolution of infection with implant retention, this is equal to the rate of early resolution with instrumentation removal. Authors favor retention for early infection</td>
</tr>
</tbody>
</table>

IV = intravenous, no. = number, OR = operating room.

*All studies were retrospective and the quality of the evidence is level III.

*b Number of patients with deep post-operative infection in the setting of instrumentation. Early infection <90 days after index surgery.

Search yielded 3522 citations. A total of 278 citations pertained to post-operative surgical site infections in patients following spinal instrumentation. This total was narrowed down to 20 citations after selecting only English-language articles specifically addressing medical or surgical management of patients with these infections and excluding citations for the following reasons: redundant citations, case reports or case series with fewer than five patients, or articles focusing on epidemiology, risk factors, and pathophysiology of post-operative surgical site infections following spinal instrumentation. Articles were classified according to the level of evidence (I–III) [23]. Only deep wound infections were included in this study. Outcomes were divided based on the timing of infection (early or delayed), where reported. We created evidentiary tables summarizing the studies and level of evidence. We created two tables, one summarizing studies that focus on instrumentation retention or removal in the setting of an infection.
Table 2
Studies addressing duration of antibiotic therapy

<table>
<thead>
<tr>
<th>Authors (year)</th>
<th>No. of patients (early/delayed infection)</th>
<th>Duration of postoperative antibiotics (mean)</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clark et al. (1999) [26]</td>
<td>22/20</td>
<td>48–72 hours IV + 7 days oral</td>
<td>For delayed infection, short course of IV therapy followed by 1 week oral therapy is adequate after instrumentation removal (100% infection eradication)</td>
</tr>
<tr>
<td>Kowalski et al. (2007) [24]</td>
<td>81</td>
<td>Varied</td>
<td>If instrumentation retained, 6 weeks of IV therapy followed by 6 months of oral suppressive therapy associated with higher rate of infection control (27% treatment failure) than IV therapy alone (83% treatment failure)</td>
</tr>
<tr>
<td>Rihn et al. (2008) [9]</td>
<td>7</td>
<td>6 weeks IV only</td>
<td>6 weeks of IV therapy adequate for treatment of delayed infection (6/6 without recurrence). Acute infection required longer course (8 weeks IV followed by 8 weeks oral) for successful eradication</td>
</tr>
<tr>
<td>Collins et al. (2008) [11]</td>
<td>74</td>
<td>4 weeks IV followed by 5 weeks oral</td>
<td>Prolonged IV therapy followed by suppressive oral regimen was inadequate if instrumentation retained (40% recurrence), but adequate if instrumentation removed (0% recurrence)</td>
</tr>
</tbody>
</table>

IV = intravenous. No. = number.

a All studies were retrospective and the quality of the evidence is level III.

b Number of patients with post-operative infection in the setting of instrumentation. Early infection <90 days after index surgery.

(Table 1) and one summarizing studies that focus on length of antibiotic therapy (Table 2).

3. Results

3.1. Instrumentation retention versus removal

Twenty articles were identified addressing the retention or removal of instrumentation. All studies were retrospective with level III evidence (Table 1). For early infection, five studies supported instrumentation preservation in the setting of infection [7,10,15,24,25]. Skothe et al. reported on 14 consecutive patients treated for early post-operative infection after scoliosis surgery [10]. They found that with early debridement and healing by secondary intention, instrumentation retention was successful in all 14 patients, with only one repeat debridement required for recurrent abscess. Likewise, in a series of 61 pediatric deformity patients with early and delayed infections, Cahill et al. reported a lower rate of re-operation in patients whose instrumentation was retained, compared to those whose instrumentation was removed, with a low rate of recurrent infection [7].

In contrast, Aydini et al. reported on instrumentation retention in 11 patients, of whom eight had early infections [8]. All eight developed recurrent infection after initial debridement, eventually requiring instrumentation removal; however, by temporarily retaining instrumentation, all eight were able to achieve stable fusion prior to hardware removal. The duration between initial debridement and eventual hardware removal was not reported.

For delayed infection, on the other hand, seven studies support instrumentation removal [9,16,21,26–29]. Hahn et al., Richards et al. and Viola et al. all report 100% rates of infection eradication after a single debridement and instrumentation removal in the setting of delayed implant infection [16,21,27]. Hedequist et al. reported failure of instrumentation retention in the setting of delayed infection [29]. They present a single institution series of 26 deformity patients who developed delayed post-operative infection. In this series, all 26 developed recurrent infection and eventually required instrumentation removal for successful eradication. Additionally, they reported lower hospital costs for patients who underwent early removal of instrumentation and proportionally increasing costs with increasing number of debridements prior to removal. Of note, in this series six patients required eventual hardware reimplantation due to curve progression.

Kowalski et al. reviewed 51 patients with delayed spinal implant infection [24]. Thirty-two underwent early hardware removal whereas 19 attempted hardware retention [24]. The authors report a higher 2 year treatment-failure free survival in patients who underwent early removal compared to those who had attempted retention (hazard ratio 0.3, 95% confidence interval 0.1–0.7). As such, the authors recommend hardware removal for delayed implant infection.

Instrumentation removal is not without risk, however, as it may be associated with progressive deformity. Hahn et al. reported on eight consecutive scoliosis patients who underwent hardware removal for delayed infection [16]. At the time of washout and debridement, all patients were noted to have stable bony fusion without evidence of pseudarthrosis. Nonetheless, 3/8 patients developed significant loss of correction, ranging from 10–26° at final follow-up. Likewise, Cahill et al. reported a mean deformity progression of 23° in patients who underwent instrumentation removal compared to only 2° with instrumentation retention [7]. Viola et al. reported on eight patients with delayed implant infection after either posterior only or combined anterior and posterior fusion. In their series, all eight patients had successful infection resolution after hardware removal, but 3/8 required subsequent hardware reimplantation due to progressive deformity [21].

3.2. Antibiotic regimen

Four articles, all of which were retrospective with level III evidence, assessed post-operative antibiotic protocols following surgical debridement (Table 2). Clarke and Shufflerbger reviewed 22 scoliosis patients treated at a single center for delayed post-operative infection [26]. All patients underwent surgical debridement and hardware removal followed by 48–72 hours of intravenous antibiotics, most commonly either oxacillin or cefazolin. They subsequently received 7 days of oral antibiotics, most commonly cephalixin or ciprofloxacin. All 22 patients had complete resolution of infection without evidence of recurrence. The authors recommend this abbreviated antibiotic regimen in patients with delayed infection after debridement and hardware removal.

Kowalski et al. reviewed 81 patients with post-operative infection after instrumentation, including 30 with early acute infection [24]. Of the patients with acute infection, 28/30 underwent instrumentation removal. A total of 22 patients received a 4–6 week course of intravenous therapy followed by long-term oral suppressive therapy for >6 months; the remaining six received only 4–6 weeks of intravenous therapy. The authors report lower treatment failure rates (22%) in the group receiving long-term oral suppressive therapy compared to those receiving intravenous therapy only (83%).

Rihn et al. reviewed seven scoliosis patients with infected instrumentation [9]. For delayed infection, they attempted 6 weeks of intravenous therapy only after debridement and instrumentation removal. This treatment protocol was associated with 100% infection clearance. In contrast, for the single patient with early...
infection, this treatment protocol was inadequate and the patient required six surgical debridements and 8 weeks of intravenous therapy followed by 8 weeks of oral therapy prior to infection clearance.

Collins et al. reviewed 74 consecutive patients treated for infected instrumentation [1]. All patients underwent surgical debridement, and instrumentation removal if solid fusion was observed, followed by a mean of 4 weeks of intravenous antibiotic therapy and 5 weeks of oral suppressive therapy. The authors reported a high rate of treatment success if instrumentation was removed (0% recurrence). In contrast however, this protocol was not adequate if instrumentation was retained (40% recurrence).

4. Discussion

Surgical site infection following spinal instrumentation remains a challenging and controversial subject. There remains no consensus on indications for implant retention versus removal. Additionally, the ideal duration of antibiotic therapy remains unclear; currently published protocols range from short courses of mostly oral therapy to several months of intravenous therapy followed by long-term oral suppression.

The goal of this study was to review the current literature on medical and surgical management of surgical site infection after spinal instrumentation. We created evidentiary tables to summarize the current evidence. All studies identified were retrospective and no studies were classified as having level I or II evidence.

With regards to surgical management, 20 studies were identified (Table 1). We found that all studies advocated for early surgical debridement and washout. Management of instrumentation varied however, and five studies advocated for instrumentation retention in patients with early postoperative infection. Though retention may be associated with a higher rate of recurrent infection, it may provide enough time for a stable fusion to occur, after which instrumentation may be more safely removed [8,10,15].

In contrast, for patients with delayed infection, particularly if stable fusion was observed, seven studies supported instrumentation removal at the time of surgical debridement. One study (Hedequist et al.) showed a 100% rate of recurrent infection if instrumentation was retained in the setting of delayed implant infection [29]. In contrast, six studies showed near 100% rates of infection resolution after a single debridement and instrumentation removal [9,16,21,26–28]. Six authors, however, did report significant loss of correction in deformity patients after instrumentation removal, even if stable fusion was observed. Surgeons should be aware of this potential complication.

Four studies, all retrospective, were identified regarding appropriate antibiotic therapy (Table 2). For patients with early infection in whom instrumentation was retained, one study (Kowalski et al.) reported higher rates of treatment-failure free survival if patients received 4–6 weeks of intravenous therapy followed by at least 6 months of long term oral suppression, when compared to patients who received intravenous therapy only [24]. In contrast, a shorter treatment course may be appropriate for patients with delayed infection, particularly if instrumentation is removed. A single study (Clark et al.) reported a 100% rate of infection eradication with just 2–3 days of intravenous therapy followed by 1 week of culture-guided oral therapy [26].

5. Conclusions

No level I or II evidence was identified in the literature regarding surgical or medical management of post-operative deep infection after spinal instrumentation. Twenty pertinent studies were identified and outcomes were compiled into evidentiary tables.

With regards to surgical management, five studies support instrumentation retention in the setting of early deep infection. In contrast, for delayed infection, the evidence favors removal of instrumentation at the time of initial debridement. Surgeons should be aware, however, that for deformity patients, even if solid fusion is observed, removal of instrumentation may be associated with significant loss of correction. A course of intravenous antibiotics followed by long term oral suppressive therapy should be pursued if instrumentation is retained. A shorter treatment course may be appropriate if hardware is removed. Further prospective and randomized studies are required to further clarify the optimal management of post-operative infection after spinal instrumentation.

Conflicts of Interest/Disclosures

The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.

References


