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Review

Evidence-based management of deep wound infection after spinal instrumentation

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ABSTRACT

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 instrumented fusion, spinal hardware infection, deep wound infection spine, and post-operative spine infection. The

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Table 1
Studies assessing instrumentation retention *versus* removal in the setting of deep post-operative infection

Authors (year)[a]	Patients[b] (early/delayed infection)	Surgical management at time of infection	Mean no. of surgeries to eradicate infection	Findings
Glassman et al. (1996) [17]	19 (not reported)	Serial debridements until OR cultures negative then delayed primary closure	4.2	Instrumentation retained successfully in 19/19 patients with aggressive serial debridements and IV antibiotics
Viola et al. (1997) [21]	8 (0/8)	Debridement and instrumentation removal	1	100% eradication of infection with instrumentation removal for delayed infection. 3/8 required delayed reinstrumentation for progressive deformity
Szoke et al. (1998) [10]	15 (14/1)	Debridement and primary closure with retention of instrumentation	Not reported	Instrumentation retention successful with early infection after debridement and IV antibiotics (14/14). Delayed infection required instrumentation removal for recurrent infection (1/1)
Clark et al. (1999) [26]	22 (0/22)	Debridement, removal of instrumentation and primary closure	Not reported	Infection cleared in all patients after instrumentation removal. 4/22 scoliosis patients had pseudoarthrosis/loss of correction after instrumentation removal, three of whom underwent subsequent re-instrumentation
Aydinli et al. (1999) [8]	11 (8/3)	Washout and retention of instrumentation	Not reported	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
Picada et al. (2000) [25]	26 (16/10)	Serial debridements, instrumentation retention and secondary closure	Not reported	24/26 patients successfully cleared infection with serial debridements and antibiotics without instrumentation removal
Sponseller et al. (2000) [30]	25 (not reported)	Debridement and secondary intention with retention of instrumentation	Not reported	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
Richards et al. (2001) [27]	23 (0/23)	Debridement and removal of instrumentation at first stage	1.4	Instrumentation removal successful for eradication of delayed infection (23/23). For pseudoarthrosis (3/23), delayed re-instrumentation was tolerated and did not cause reinfection
Hahn et al. (2005) [16]	7 (0/7)	Debridement and instrumentation removal	1	Instrumentation removal successful for eradication of infection, but observed 10–26° loss of correction in 3/8 scoliosis patients
Collins et al. (2008) [1]	74 (9/65)	Debridement and removal of instrumentation if solid fusion observed	Not reported	Only 46% of scoliosis patients had stable pain-free spines after debridement and instrumentation removal. Only one patient required delayed reinstrumentation for loss of correction
Potter et al. (2006) [20]	6 (0/6)	Debridement and instrumentation removal	1	Instrumentation removal in patients with adolescent idiopathic scoliosis associated with mean loss of 10° of coronal correction
Kowalski et al. (2007) [24]	81 (30/51)	Variable	Not reported	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
Mirovsky et al. (2007) [22]	8 (not reported)	Debridement and instrumentation retention	Not reported	Instrumentation successfully retained in all eight patients with 100% infection eradication
Ho et al. (2007) [28]	53 (31/22)	Variable	1.6	50% rate of recurrent infection when instrumentation retained, compared to 20% with removal. Following instrumentation removal in deformity patients, 6/10 patients developed >10° loss of correction
Hedequist et al. (2008) [29]	26 (0/26)	Debridement and instrumentation retention	4	Instrumentation retention was unsuccessful for delayed infection. All 26 patients had recurrent infection requiring removal. Hospital costs were lower with early instrumentation removal. Six patients required subsequent reinstrumentation for deformity progression
Rihn et al. (2008) [9]	7 (1/6)	Hardware removed for delayed infection. Retained for early infection	2	All delayed infections resolved with a single debridement and hardware removal. Instrumentation retention failed for acute infection, requiring five debridements, removal, and reimplantation
Cahill et al. (2010) [7]	61 (32/29)	Variable	2	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
Pull ter Gunne et al. (2010) [12]	84 (not reported)	Debridement, instrumentation removal and primary closure	1.3	76% of patients with deep surgical site infection were able to clear infection with single debridement and instrumentation retention
Ahmed et al. (2012) [18]	16 (not reported)	Debridement and instrumentation retention	Not reported	Instrumentation retention successful in all 16 patients, with 100% eradication of infection at 2 year follow-up
Maruo et al. (2014) [15]	166 (not reported)	Instrumentation retention for 76%, removal for 24%	1.4	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

IV = intravenous, no. = number, OR = operating room.
[a] 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