

Spinal instrumentation infection

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The incidence of late infection published in the literature varies from 1% to 12% with varying definition of late infection (range, 3 mo to 1 y) ¹⁾.

Etiology and Risk Factors

Factors such as posterior surgical approach, [arthrodesis](#), use of [spinal instrumentation](#), [age](#), [obesity](#), [diabetes](#), [tobacco](#) use, operating-room environment and estimated blood loss are well established in the literature to affect the risk of infection ²⁾.

SII can be caused by a variety of pathogens, including:

[Staphylococcus aureus](#) (including [MRSA](#))

Coagulase-negative Staphylococci (e.g., [Staphylococcus epidermidis](#))

Gram-negative bacilli (e.g., [Pseudomonas aeruginosa](#), [Enterobacter](#), [Klebsiella](#))

Polymicrobial infections (especially in complex or revision surgeries).

Either [Escherichia coli](#) or [Enterococcus faecalis](#) suggest genitourinary or fecal wound contamination caused most other cases of deep SSI ³⁾.

Risk factors include:

Prolonged surgical [duration](#)

High [blood loss](#) and multiple [transfusions](#)

[Diabetes mellitus](#)

[Obesity](#)

[Malnutrition](#)

[Immunosuppression](#)

[Reoperation](#) or prior [surgical site infection](#) (SSI)

Diagnosis

There are multiple risk factors for postoperative spinal infections. Infections in the setting of instrumentation are more difficult to diagnose and treat due to biofilm. Infections may be early or delayed. [C Reactive Protein](#) (CRP) and [Magnetic Resonance Imaging](#) (MRI) are important diagnostic tools. ⁴⁾

Blood specimens were obtained from patients who underwent posterior decompression, instrumentation with pedicular screws, and posterolateral fusion from June 2009 to January 2011. CRP and ESR levels were measured on the day before surgery and on postoperative days 1, 3, 7, 11, 14, 28, and 42.

Mean CRP levels peaked on the third day postoperatively in all groups. By day 7 postoperatively, it had dropped rapidly. At the 14th and 28th postoperative days, decreases to normal CRP levels were found in 16% and 80% of all patients, respectively. The pattern of decline in CRP was similar among groups. Values of ESR increased and peaked between the third and seventh postoperative days. ESR values gradually decreased. At the 42 day postoperatively, ESR level still remain above normal values in all groups ⁵⁾.

MRI is a useful tool for the early diagnosis of a deep SSI. However, the diagnosis is frequently difficult with feverish patients with clear wounds after posterior spinal instrumentation (PSI) because of artifacts from the metallic implants. There are no reports on MRI findings that are specific to a deep SSI after PSI.

Kimura et al. found that fluid collection outside the head of the PS on an axial MRI scan (PS fluid sign) strongly suggested the possibility of an abscess.

The SSI group comprised 17 patients with a deep SSI after posterior lumbar spinal instrumentation who had undergone an MRI examination at the onset of the SSI. The non-SSI group comprised 64 patients who had undergone posterior lumbar spinal instrumentation who did not develop an SSI and had an MRI examination within 4 weeks after surgery. The frequency of a positive PS fluid sign was compared between both groups.

The PS fluid sign had a sensitivity of 88.2%, specificity of 89.1%, positive predictive value of 68.1%, and negative predictive value of 96.6%. The 2 patients with a false-negative PS fluid sign in the SSI group had an infection at the disk into which the interbody cage had been inserted. Three of the 7 patients with a false-positive PS fluid sign in the non-SSI group had a dural tear during surgery.

The PS fluid sign is a valuable tool for the early diagnosis of a deep SSI. The PS fluid sign is especially useful for diagnosing a deep SSI in difficult cases, such as feverish patients without wound discharge

⁶⁾.

Treatment

[Spinal instrumentation infection treatment](#).

Outcome

[Surgical site infection](#) (SSI) in the spine is a serious [postoperative complication](#).

Evidence based medicine

In a study, from the Department of Neurosurgery, Northwestern University Feinberg School of Medicine, [Chicago](#), USA [evidence based medicine](#) was 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 of evidence 1](#) or [level of evidence 2](#) 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 ⁷⁾.

The objective of a study was to investigate the morbidity and mortality associated with instrumented fusion in the setting of primary spinal infection.

A search was performed in the PubMed and Medline databases for clinical case series describing instrumented fusion in the setting of primary spinal infection between 2003 and 2013. The search was limited to the English language and case series including at least 20 patients. The primary outcome measure was postoperative infection (recurrent local infection) + surgical site infection (SSI); secondary outcome measures included reoperation rates, development of other complications, and perioperative mortality.

There were 26 publications that met the inclusion criteria, representing 931 patients with spondylodiscitis who underwent decompression, debridement, and instrumented fusion. Spinal infections occurred most commonly in the lumbosacral spine (39.1%) followed by the thoracic spine (27.1%). The most common microorganisms were *Staphylococcus* spp. After decompression, debridement, and instrumented fusion, the overall rate of postoperative infection was 6.3% (1.6% recurrent infection rate + 4.7% SSI rate). The perioperative complication rate was 15.4%, and the mortality rate was estimated at 2.3%. Reoperation for wound debridement, instrumentation removal, pseudoarthrosis, and/or progressive neurological deficit was performed in 4.5% of patients.

The findings in this literature review suggest that the addition of instrumentation in the setting of a primary spinal infection has a low local recurrent infection rate (1.6%). However, the combined risk of postoperative infection is 6.3% (recurrent infection + SSI), more than three-fold the current infection rate following instrumentation procedures for degenerative spine disease. Moreover, the addition of hardware does usher in complications such as instrumentation failure and pseudoarthrosis requiring reoperation ⁸⁾.

Case series

[Spine surgery infection treatment](#) continues to be a challenge. [Negative pressure wound therapy](#) (NPWT) has been an effective method in the context of [infection](#) therapy, and its use has gained popularity in recent decades.

A study of Rickert et al. aimed to analyze the impact of known [risk factors](#) for postoperative [wound infection](#) on the efficiency and length of NPWT therapy until healing.

They analyzed 50 cases of NPWT treatment for deep wound infection after posterior and posteroanterior spinal fusion from March 2010 to July 2014 retrospectively. We included 32 women and 18 men with a mean age of 69 years (range, 36-87 years). Individual risk factors for postoperative infection, such as age, gender, obesity, diabetes, immunosuppression, duration of surgery, intraoperative blood loss, and previous surgeries, as well as type and onset (early vs. late) of the infection were analyzed. We assessed the associations between these risk factors and the number of revisions until wound healing.

In 42 patients (84%), bacterial pathogens were successfully detected by means of intraoperative swabs and tissue samples during first revision. A total of 19 different pathogens could be identified with a preponderance of *Staphylococcus epidermidis* (21.4%) and *S. aureus* (19.0%). Methicillin-resistant *S. aureus* (MRSA) was recorded in two patients (2.6%). An average of four NPWT revisions was required until the infection was cured. Patients with infections caused by mixed pathogens required a significantly higher number of revisions (5.3 vs. 3.3; $p < 0.01$) until definitive wound healing. For the risk factors, no significant differences in the number of revisions could be demonstrated when compared with the patients without the respective risk factor.

[Negative pressure wound therapy](#) (NPWT) was an effective therapy for the treatment of [wound infections](#) after spinal [fusion](#). All patients in the study of Rickert et al. had their [infections](#) successfully cured, and all spinal [implants](#) could be retained. The number of revisions was similar to those reported in the published [literature](#). The study provides insights regarding the effectiveness of NPWT for the treatment of [deep wound infection](#) after spinal fusion. Further investigations on the impact of potential risk factors for postoperative wound healing disorders are required. Better knowledge on the impact of specific risk factors will contribute to higher effectiveness of prophylaxis for postoperative

wound infections considering the patient-specific situation ⁹⁾.

2017

A retrospective, cohort study of 84 patients with deep spine infection managed at a major tertiary hospital over 14 years with a minimum follow up of 2 years.

It is often believed that implants should not be inserted in patients with deep spine infection because of the risk of persistent or recurrent infection. However, there are often concerns about spinal stability and a paucity of evidence to guide clinical practice in this field.

Dennis et al. compared the mortality, reoperation, and reinfection rates in patients with spine infection treated with antibiotics alone, antibiotics with debridement, and antibiotics with debridement and instrumentation. Significant outcome predictors were determined using multivariable logistic regression model.

Forty-nine males and 35 females with a mean age was 62.0 years had spine infection affecting the lumbar spine predominantly. The most common form of infection was osteomyelitis and spondylodiscitis (69.4%). *Staphylococcus aureus* was the most common causative organism (61.2%). There was no difference in terms of reoperation or relapse for patients treated with antibiotics alone, antibiotics with debridement, or antibiotics with debridement and instrumentation. However, compared with antibiotics alone, the crude in-hospital mortality was lower for patients treated with instrumentation (odds ratio, OR, 0.82; P=0.01), and antibiotics with debridement (OR 0.80; P=0.02).

Spinal instrumentation in an infected spine is safe and not associated with higher reoperation or relapse rates. Mortality is lower for patients treated with instrumentation ¹⁰⁾.

A retrospective review of patients with MRSE-related SSIs from 665 consecutive cases of SI surgery performed between 2007 and 2014

During the study period, SSIs occurred in 21 patients. MRSE was isolated from cultures obtained from surgical wounds in nine of the 21 patients (43%). There were four males and five females with a mean age of 63.9 ± 15.1 years. Six patients presented with inflammatory signs, such as wound drainage, pyrexia, erythema, and elevated C-reactive protein. Three patients did not have signs of infection, but had early implant failure, and were diagnosed by positive cultures collected at the time of revision surgery. The mean time from index surgery to the diagnosis of infection was 23.6 days (range, 7-88 days). In one patient, the implant was removed before antibiotic treatment was administered because of implant failure. Eight patients were managed with antibiotics and implant retention. During the follow-up period, MRSE-related SSIs in seven of the eight patients were resolved with implant retention and antibiotics without the need for further surgical intervention. One patient did not complete the antibiotic course because of side effects, and implant removal was required to control the infection.

Early detection, surgical debridement, and administration of appropriate antibiotics for a suitable duration enabled infection control without the need for implant removal in the treatment of MRSE-related SSI after SI surgery ¹¹⁾.

Eleven patients with SSI after undergoing spinal surgery involving instrumentation were studied. All had been refractory to conventional treatments, including intravenous antibiotic administration and conventional debridement and irrigation. Antibiotic-loaded bone cement was placed on and around the instrumentation to cover them and to occupy the surrounding dead space. Two general types of antibiotics were loaded into the polymethylmethacrylate bone cement. The recipes for the mixture were changed depending on the bacterial cultures. Sensitive antibiotics were administered generally for 2-6 weeks until the C-reactive protein level was normalized.

All patients were treated successfully using antibiotic-loaded bone cement. Only 1 patient needed a repeat of this procedure to treat an infection. Antibiotic-loaded bone cement was placed in situ in all patients during the follow-up period and there were no significant adverse events.

Antibiotic-loaded bone cement treatment reduces the dead space and achieves the targeted drug delivery simultaneously. Treatment using antibiotic-loaded bone cement is an effective treatment option for complex spinal SSI ¹²⁾.

Between 2010 and 2015, 12 out of 514 patients who developed a deep infection after spinal surgery, were selected and reviewed retrospectively at multiple centers (MGM Hospital, Kamothe and Center for Orthopaedic & Spine Surgery, New Panvel, Navi Mumbai, India). Out of 12 patients, one of the patients needed a partial implant exchange although none of the cases needed complete implant removal. All patients had achieved clean closed wounds along with a retention of the instrumentation. There was no need for flap surgery to cover wound defect in any case. However, antibiotic treatment was necessary in all cases. None of the patients showed a new infection after the treatment.

The study demonstrates the usefulness of VAC therapy as an alternative management for wound conditioning of a back wound with the high complexity in nature after instrumented spine surgeries as it eliminates complex secondary surgeries, prolong use of antibiotics and removal of the implants ¹³⁾.

2016

Tominaga et al. retrospectively reviewed 511 patients who underwent spine surgery with instrumentation at [Kagoshima University Hospital](#) from January 2006 to December 2014. Risk factors associated with SSI were analyzed via multiple logistic regression analysis. Parameters of the group that needed instrumentation removal were compared with the group that did not require instrumentation removal using the Mann-Whitney U and Fisher's exact tests. The posterior approach was used in most cases (453 of 511 cases, 88.6%). SSI occurred in 16 of 511 cases (3.14%) of spine surgery with instrumentation. Multivariate logistic regression analysis identified 2 significant risk factors for SSI: operation time, and American Society of Anesthesiologists physical status classification ≥ 3 . Twelve of the 16 patients with SSI (75%) were able to keep the instrumentation after SSI. Pseudarthrosis occurred in 2 of 4 cases (50%) after instrumentation removal. Risk factors identified for instrumentation removal after spine SSI were a greater number of past surgeries, low preoperative hemoglobin, high preoperative creatinine, high postoperative infection treatment score for the spine, and the presence of [methicillin resistant Staphylococcus aureus](#). In these high risk cases, attempts should be made to decrease the risk factors preoperatively, and careful postoperative monitoring should be conducted ¹⁴⁾

2015

A retrospective database review of consecutive patients with traditional open lumbar spinal surgery was performed. SSIs patients were identified and reviewed for clinically relevant details, and postoperative SSIs' incidence was calculated for the entire cohort as well as for subgroups with or without spinal implants. In 15 years, 1,176 patients underwent open lumbar spinal surgery with spinal implants and 699 without. Thirty-eight developed postoperative SSIs. Total SSI rate for the entire group was 2.03%. The incidence of postoperative SSIs in the nonimplant group was relatively low. Patients received antibiotics, hyperbaric oxygen therapy, and wet dressing.

Liu et al. provided the precise rates of postoperative SSIs in traditional open spinal surgery obtained from a single-centre data. Patients with spinal implants had higher SSIs' incidence than those without ¹⁵⁾.

2014

Thirty-six patients underwent only decompression, and 82 underwent decompression and instrumented fusion. In the decompression-only group, 8.33% of patients had continued osteomyelitis/discitis compared with 9.76% of patients in the instrumented group ($P = 0.807$). Importantly, the reoperation rate was also similar between the decompression-only group (19.44%) and the instrumented group (17.07%; $P = 0.756$). Similarly, subanalyses based on infection location revealed no significant increase in rates of recurrent infection or reoperation in patients who underwent instrumentation ¹⁶⁾.

Patients who received just [decompression](#) for spinal infection had similar [reoperation](#) and continued [infection](#) rates as patients who additionally underwent [instrumentation](#), irrespective of infection location within the [spine](#). These findings suggest that instrumentation of the infected spine may be a safe treatment modality and should be considered when the spinal integrity is compromised ¹⁷⁾.

2008

A 10-year retrospective audit. (1) The incidence of infection; (2) causative organisms; (3) whether eradication of infection is achievable with spinal implant retention; (4) patient outcome. The reported incidence of infection following posterior spinal instrumentation is between 2.6 and 3.8%. Management of infection is controversial, with some advocating serial wound debridement while others report that infection cannot be eradicated with retention of implants. There are no published data demonstrating that propionibacteria are associated with early postoperative infection. The management of infected cases at our institution includes eventual removal of their implants. Our population was identified by studying the case notes of all patients who had undergone removal of spinal implants and cross-referencing this population with positive microbiology or histology reports. The incidence of infection was 3.7%. Propionibacteria were isolated in 45% of cases. The diagnosis of infection was unexpected in 25% of patients, following removal of implants for prominence of implants or back pain. Sixty per cent of patients with acute postoperative deep wound infection had continuing active infection on subsequent removal of implants, despite long-term antibiotics and wound debridement. Forty-six per cent of patients had a stable, pain-free spine at the end of their treatment. This is the largest reported series of infections following posterior spinal instrumented

fusions of which we are aware. Propionibacteria are a common cause of infection and successful eradication of infection cannot be reliably achieved with antibiotics and wound debridement alone ¹⁸⁾.

1997

Twenty-three of 238 patients (9.7%) developed wound infections following segmental spinal instrumentation. When the infected group and a matched control group were compared, the infected group had a significantly higher number of patients with cerebral palsy and myelodysplasia (nonambulatory), patients with wound hematomas, patients with fusions that extended into the sacral region, and patients who were incontinent of urine. A high incidence of infections with gram-negative aerobic bacilli correlated with the extension of the surgery into the sacral region and bowel and/or bladder incontinence. Prophylactic antibiotics with broader coverage for gram-negative bacilli may be warranted for these procedures. Postoperative wound infections were managed by surgical drainage and debridement as well as antibiotics. Removal of the hardware was not necessary to control the infection in these patients who underwent segmental spinal instrumentation ¹⁹⁾.

1)

Garg S, LaGreca J, Hotchkiss M, Erickson M. Management of late (>1 y) deep infection after spinal fusion: a retrospective cohort study. *J Pediatr Orthop*. 2015 Apr-May;35(3):266-70. doi: 10.1097/BPO.0000000000000252. PubMed PMID: 25025743.

2) 3)

Gerometta A, Rodriguez Olaverri JC, Bitan F. Infections in spinal instrumentation. *Int Orthop*. 2012 Feb;36(2):457-64. doi: 10.1007/s00264-011-1426-0. Epub 2012 Jan 5. Review. PubMed PMID: 22218913; PubMed Central PMCID: PMC3282865.

4)

Kasliwal MK, Tan LA, Traynelis VC. Infection with spinal instrumentation: Review of pathogenesis, diagnosis, prevention, and management. *Surg Neurol Int*. 2013 Oct 29;4(Suppl 5):S392-403. doi: 10.4103/2152-7806.120783. eCollection 2013. PubMed PMID: 24340238; PubMed Central PMCID: PMC3841941.

5)

Kunakornsawat S, Tungsiripat R, Putthiwara D, Piyakulkaew C, Pluemvitayaporn T, Pruttikul P, Kittithamvongs P. Postoperative Kinetics of C-Reactive Protein and Erythrocyte Sediment Rate in One-, Two-, and Multilevel Posterior Spinal Decompressions and Instrumentations. *Global Spine J*. 2017 Aug;7(5):448-451. doi: 10.1177/2192568217699389. Epub 2017 Apr 11. PubMed PMID: 28811989; PubMed Central PMCID: PMC5544159.

6)

Kimura H, Shikata J, Odate S, Soeda T. Pedicle Screw Fluid Sign: An Indication on Magnetic Resonance Imaging of a Deep Infection After Posterior Spinal Instrumentation. *Clin Spine Surg*. 2017 May;30(4):169-175. doi: 10.1097/BSD.000000000000040. PubMed PMID: 28437330.

7)

Lall RR, Wong AP, Lall RR, Lawton CD, Smith ZA, Dahdaleh NS. Evidence-based management of deep wound infection after spinal instrumentation. *J Clin Neurosci*. 2015 Feb;22(2):238-42. doi: 10.1016/j.jocn.2014.07.010. Epub 2014 Oct 11. Review. PubMed PMID: 25308619.

8)

DE LA Garza-Ramos R, Bydon M, Macki M, Abt NB, Rhee J, Gokaslan ZL, Bydon A. Instrumented fusion in the setting of primary spinal infection. *J Neurosurg Sci*. 2017 Feb;61(1):64-76. Epub 2015 Apr 15. Review. PubMed PMID: 25875732.

9)

Rickert M, Rauschmann M, Latif-Richter N, Arabmotlagh M, Rahim T, Schmidt S, Fleege C. Management of Deep Spinal Wound Infections Following Instrumentation Surgery with Subfascial Negative Pressure Wound Therapy. *J Neurol Surg A Cent Eur Neurosurg*. 2021 Jan 27. doi:

10.1055/s-0040-1720999. Epub ahead of print. PMID: 33506474.

¹⁰⁾

Dennis Hey HW, Nathaniel Ng LW, Tan CS, Fisher D, Vasudevan A, Liu KG, Thambiah JS, Kumar N, Lau LL, Wong HK, Tambyah PA. Spinal Implants Can Be Inserted in Patients With Deep Spine Infection: Results From a Large Cohort Study. *Spine (Phila Pa 1976)*. 2017 Apr 15;42(8):E490-E495. doi: 10.1097/BRS.0000000000001747. PubMed PMID: 27333342.

¹¹⁾

Takizawa T, Tsutsumimoto T, Yui M, Misawa H. Surgical Site Infections Caused by Methicillin-resistant *Staphylococcus epidermidis* After Spinal Instrumentation Surgery. *Spine (Phila Pa 1976)*. 2017 Apr 1;42(7):525-530. doi: 10.1097/BRS.0000000000001792. PubMed PMID: 27428392.

¹²⁾

Masuda S, Fujibayashi S, Otsuki B, Kimura H, Matsuda S. Efficacy of Target Drug Delivery and Dead Space Reduction Using Antibiotic-loaded Bone Cement for the Treatment of Complex Spinal Infection. *Clin Spine Surg*. 2017 Jul 7. doi: 10.1097/BSD.0000000000000567. [Epub ahead of print] PubMed PMID: 28692571.

¹³⁾

Kale M, Padalkar P, Mehta V. Vacuum-Assisted Closure in Patients with Post-operative Infections after Instrumented Spine Surgery: A Series of 12 Cases. *J Orthop Case Rep*. 2017 Jan-Feb;7(1):95-100. doi: 10.13107/jocr.2250-0685.706. PubMed PMID: 28630851; PubMed Central PMCID: PMC5458710.

¹⁴⁾

Tominaga H, Setoguchi T, Kawamura H, Kawamura I, Nagano S, Abematsu M, Tanabe F, Ishidou Y, Yamamoto T, Komiya S. Risk factors for unavoidable removal of instrumentation after surgical site infection of spine surgery: A retrospective case-control study. *Medicine (Baltimore)*. 2016 Oct;95(43):e1118. PubMed PMID: 27787365; PubMed Central PMCID: PMC5089094.

¹⁵⁾

Liu JT, Liao WJ, Chang CS, Chen YH. Management of Deep Infection after Instrumentation on Lumbar Spinal Surgery in a Single Institution. *Biomed Res Int*. 2015;2015:842010. doi: 10.1155/2015/842010. Epub 2015 Jul 26. PubMed PMID: 26273650; PubMed Central PMCID: PMC4529929.

¹⁶⁾ ¹⁷⁾

Bydon M, De la Garza-Ramos R, Macki M, Naumann M, Sciubba DM, Wolinsky JP, Bydon A, Gokaslan ZL, Witham TF. Spinal Instrumentation in Patients with Primary Spinal Infections Does Not Lead to Greater Recurrent Infection Rates: An Analysis of 118 Cases. *World Neurosurg*. 2014 Jun 14. pii: S1878-8750(14)00560-9. doi: 10.1016/j.wneu.2014.06.014. [Epub ahead of print] Review. PubMed PMID: 24937598.

¹⁸⁾

Collins I, Wilson-MacDonald J, Chami G, Burgoyne W, Vineyakam P, Berendt T, Fairbank J. The diagnosis and management of infection following instrumented spinal fusion. *Eur Spine J*. 2008 Mar;17(3):445-450. doi: 10.1007/s00586-007-0559-8. Epub 2007 Dec 13. Erratum in: *Eur Spine J*. 2017 Jul 20;:. PubMed PMID: 18075763; PubMed Central PMCID: PMC2270376.

¹⁹⁾

Perry JW, Montgomerie JZ, Swank S, Gilmore DS, Maeder K. Wound infections following spinal fusion with posterior segmental spinal instrumentation. *Clin Infect Dis*. 1997 Apr;24(4):558-61. PubMed PMID: 9145726.

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