SYSTEMATIC REVIEW

Surgical Site Infection Management following Spinal Instrumentation Surgery: Implant Removal vs. Implant Retention: an Updated Systematical Review

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ABSTRACT

Background: The number of lumbar spine surgery increased in recent years. Spinal instrumentation surgery was an integral component in the treatment of spinal pathologies, which can cause surgical site infection (SSI). Surgical site infections (SSIs) are the leading cause of mortality and morbidity after spinal instrumentation surgery. The management of SSI was implant retention and removal is still unclear. **Objective:** The objective of this literature is to systematically review the implant removal and retention method for SSI management after spinal instrumentation surgery. **Methods:** We searched in PubMed and ScienceDirect for cohort and randomized control trial studies in English, published between 2002 and 2022, which had data on patients with spinal instrumentation surgery. The underlying disease, comorbidities, common bacteria, type of infection, the onset of infection, implant removal, and retention percentage and recommendation were analyzed. Bias analysis using Newcastle-Ottawa Quality Assessment. **Results:** We included 15 studies with a total sample were 2.584 with an average of age 15 to 66 years old. The most common organism detected were S. Aureus, MRSA, and S. Epidermis. The most common surgical procedure indications were degenerative followed by scoliosis. Implant removal and retention rate were 0-100% and 0-90,32% respectively. Implant removal is more frequently used in patients after spinal instrumentation surgery than the implant retention method. **Conclusion:** Implant retention can be performed in case of SSI is < 3 months after surgery. Implant removal is recommended if the incidence of SSI is > 3 months. Empirical antibiotics therapy is necessary to reduce the possibility of implant removal after debridement. Further studies on the effect of implant removal and retention in patients on infection recurrence, pain, and quality of life of patients are needed.

Keywords: implant, removal, retention, SSI, spinal instrumentation surgery.

1. BACKGROUND

The rate of spine surgery increased by 54%, from 78 to 120 per 100.000, from 1999 to 2013. Among elderly people over 75 years, lumbar surgery increased by a factor of five during the 15-year period. The rates of complications were low, but increased from 0.7% in 1999 to 2.4% in 2013 (1). Instrumentation, now an integral component in the treatment of numerous spinal pathologies, is correlated with a 2-20% infection rate (2)implants must be removed following instrumented PSF. Indications for removal include infection and late operative site pain. Previously, it has been thought that there was little morbidity associated with implant removal in the presence of a solid fusion. However, recent studies have reported loss of coronal correction after implant removal in patients who had a PSF for adolescent idiopathic scoliosis. Few long-term studies have assessed the clinical or radiographic results of complete implant removal after PSF. METHODS: We identified 56 patients who had undergone PSF for idiopathic scoliosis and subsequently had complete removal of all instrumentation. None of these patients had a pseudarthrosis at the time of implant removal. After IRB approval, 43 of 56 (77%. The ability to manage postoperative wound infections has become more critical and challenging,

No	Author	Year	Country	Design	Disease	Sample Size	Mean age
1	Khanna	2018	US	Cohort retrospective	N/A	67	61,9
2	Manet	2018	France	Cohort retrospective	Degenerative	1694	55
3	Wille	2017	France	Cohort retrospective	Degenerative	129	57
4	Tsubouchi	2018	Japan	Cohort retrospective	Degenerative	55	66
5	Kim	2010	Korea	Cohort retrospective	N/A	20	55.8
6	Jentzsch	2016	Switzerland	Cohort retrospective	Fracture	137	39
7	Stavridis	2010	Greece	Cohort retrospective	Degenerative spinal disease or spinal fracture	57	46,5
8	Rathjen	2007	USA	Cohort retrospective	Scoliosis	43	?
9	Muschik	2004	Germany	Cohort retrospective	Scoliosis	45	15
10	Ntilikina	2017	France	cross-sectional	Fracture	27	43,2
11	Farshad	2013	Switzerland	case-control	Scoliosis	50	?
12	Ameri	2021	USA	Cohort retrospective	Scoliosis	31	14,4
13	Alanay	2007	USA	Cohort retrospective	Degenerative	25	45,56
14	Smits	2017	Netherlands	Cohort retrospective	Fracture	102	38
15	Cho	2018	Korea	Cohort retrospective	Degenerative	102	63

Table 1. Journals Identification

No	Author	Year	Design	Selection				Comparability	Outcome		Quality		
				I				II	III	IV			
1	Khanna	2018	Cohort retrospective	*	*	*	*	**	*	*	*	Good	
2	Manet	2018	Cohort retrospective	*	*	*	*	*	*	*	*	Good	
3	Wille	2017	Cohort retrospective	*	*	-	*	**	-	*	*	Good	
4	Tsubouchi	2018	Cohort retrospective	*	-	*	*	**	-	*	*	Good	
5	Kim	2010	Cohort retrospective	*	*	*	-	*	-	-	*	Poor	
6	Jentzsch	2016	Cohort retrospective	*	*	*	-	-	*	*	*	Good	
7	Stavridis	2010	Cohort retrospective	*	*	*	*	-	*	-	-	Poor	
8	Rathjen	2007	Cohort retrospective	*	*	*	*	*	-	-	*	Poor	
9	Muschik	2004	Cohort retrospective	*	*	*	-	*	-	*	*	Good	
10	Ntilikina	2017	cross-sectional	*	*	*	*	*	*	*	*	Good	
11	Farshad	2013	case-control	*	*	*	*	*	-	*	*	Good	
12	Ameri	2021	Cohort retrospective	*	*	*	*	-	-	*	*	Poor	
13	Alanay	2007	Cohort retrospective	*	*	*	*	-	-	*	*	Poor	
14	Smits	2017	Cohort retrospective	*	*	*	*	*	*	*	*	Good	
15	Cho	2018	Cohort retrospective	*	*	*	*	**	-	*	*	Good	

Table 2. Bias Analysis by Newcastle-Ottawa Scale

No	Author	Disease	Comorbidities	Common Bacteria	Removed	Retention		
					N	%	N	%
1	Khanna	N/A	N/A	S. epidermidis	19	28,00	42	62
2	Manet	Degenerative	N/A	S.aureus	28	1,65	9	0,53
3	Wille	Degenerative	N/A	S.aureus	0	0	1006	23,45
4	Tsubouchi	Degenerative	N/A	N/A	12	21,82	33	60
5	Kim	N/A	Diabetes Melitus, Hipertension, Chronic Renal Failure	methicillin-resistant S.aureus	0	0	20	100
6	Jentzsch	Fracture	N/A	N/A	137	100	0	0
7	Stavridis	degenerative spinal disease or spinal fracture	N/A	N/A	36	63,16	0	0
8	Rathjen	Scoliosis	N/A	N/A	22	51,16	0	0
9	Muschik	Scoliosis	N/A	N/A	35	77,78	0	0
10	Ntilikina	Fracture	N/A	N/A	27	100	0	0
11	Farshad	Scoliosis	N/A	P.acnes	50	100	0	0
12	Ameri	Scoliosis	N/A	S.aureus	3	9,68	28	90,32
13	Alanay	Degenerative	N/A	N/A	25	100	0	0
14	Smits	Fracture	N/A	N/A	102	100	0	0
15	Cho	Degenerative	N/A	methicillin-resistant S.aureus	19	18,63	83	81,37

Table 3. Study of Implant Retention and Removal in Spinal Instrumentation Surgery

as they are positively associated with extended hospitalizations, increased morbidity and healthcare costs, poorer long-term outcomes, and greater dissatisfaction with the initial operative procedure (3). Other research showed that the incidence of wound infection after spinal surgery without instrumentation is relatively low (4)and 65 were treated percutaneously. A standardized MRI protocol using axial T1-weighted sequences was performed at a minimum 1-year follow-up after implant removal. Two independent observers measured cross-sectional areas (CSAs, in cm(2. However, using spinal instrumentation clearly increases the risk for postoperative soft tissue infections, and recent estimates from retrospective reviews range from 2.1% to 8.5% (5)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. Infection after spine surgery with instrumentation is becoming a common pathology. The reported infection rates range from 0.7% to 11.9%, depending on the diagnosis and complexity of the procedure. Besides operative factors, patient characteristics could also account for increased infection rates. These infections after instrumented spinal fusion are particularly difficult to manage due to the implanted, and possibly infected, instrumentation. Because the medical, economic and social costs of SSI after spinal instrumentation are enormous, any significant reduction in risks will pay dividends. The goal of this literature review was to analyse risk factors, causative organisms, diagnostic elements (both clinical and biological. Whereas the incidence of surgical site infection (SSI) after adult spine surgery knows a wide variety from 0.7% to 12.0% cause health care costs, patient morbidity and mortality will increase (6)retrospective cohort analysis. OBJECTIVE: To evaluate the presentation, etiology, and treatment of surgical site infections (SSI.

Since implantable devices are highly susceptible to bacterial colonization even low virulent bacteria can cause infection and recurrent infections due to biofilms, making them difficult to detect and eradicate (7). One way to reduce infection is to remove the spinal instruments. But, the incidence of complete removal after surgery for remains unclear (8). In instrumented spine surgery especially implant retention is discussed ambiguously due to potential loss of correction even in infused patients (7).

2. OBJECTIVE

The purpose of this study was to determine the incidence of implant removal and retention following spinal instrumental surgery as well as to characterize patients undergoing these procedures based on diagnosis and reason for removal.

3. MATERIAL AND METHODS

Protocol and registration

A protocol for this review was registered in Saiful Anwar General Hospital. The focus of the review was narrowed to retention or removal of spine instrumentation post-surgery

Eligibility criteria

Inclusion of publications that were observational studies, such as cohort, cross-sectional and case-control research, and randomized control trial. Additionally, we excluded letters, viewpoints, and review studies that provide further advice about spine surgery. The editorials or review studies that just summarize other studies were excluded. Studies didn't consider focused on those that removal and retention spine instrumentation surgery were excluded.

Search strategy

An unrestricted search to 31 April 2022 in PubMed and ScienceDirect was executed. We developed search strategies using keywords and Mesh terms of instrumentation surgery, retention, removal, and infection. In addition, reference lists of eligible articles were screened for further relevant studies and systematic reviews were scanned for appropriate references. (Figure 1)

Search validation and data selection

All articles were discovered by using the search terms and those that were available on the indicated databases during the period of this review were included. All articles not meeting the inclusion criteria as stated above were later discarded. Citations were downloaded into Mendeley. Two authors independently reviewed all titles and abstracts for irrelevant studies. Potentially eligible manuscripts were exported. At this stage, the selected papers were screened again to identify articles relevant to retention or removal and instrumentation surgery and eliminated those duplicated. We obtained the full text of the remaining articles and examined them independently. Results were compared and any controversies surrounding any particular included or excluded paper were resolved by discussion. Data extraction was performed independently using a standard extraction form.

Data extraction and report

Data extraction was performed in this systematic review. The studies were subsequently screened for reporting factors that could influence removal or retention on spine instrumentation surgery. The characteristics of each study and the method are described and presented in the table, in which, patients, the prevalence of implant retention and removal, and also related factors are reported. The descriptions of the extracted data are guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)statement.

4. RESULTS

The identification of the journals in this systematic review is shown in table 1. In this study show that the most of the journals have a retrospective cohort research design. The largest number of samples was 2.584. The average age of the study subjects varied from 15 to 66 years old. In addition, there were 2 studies that did not analyze the mean age of the patients. Table 2 shows that from 15 journals there are 12 journals with good quality and 3 journals with poor quality. Table 3 shows that most of the causes of infection are *S. aureus*. The other bacteria that can cause infection were *S. epidermidis* and *P.acnes*. While most journals use implant removal rather than retention in cases of spinal infection.

NO	Author	Disease	Removal n(%)	Retention n(%)	Type Infection	Onset	Common Bacteria	Recommendation	Other Recommendation
1	Khanna	N/A	19 (28,00)	42 (62)	N/A	N/A	S.epidermidis	Implant retention correlated with the sum of debidement surgery.	IV antibiotic higher in implant removal but oral antibiotic higher in implant retention.
2	Manet	Degenerative	28 (1,65)	9 (0,53)	Deep SSI 46 patients	41 patients (89%) early SSI (< 1 month) 3 patient (7%) delayed SSI (from 1 to 3 months) 2 patient (4%) late SSI (>3 months)	S.aureus	Debridement, antibiotic, implant retention is effective in 3 month after surgery.	N/A
3	Wille	Degenerative	0	129 (100)	Deep SSI 129 patients	N/A	S.aureus	Debridement, antibiotic, implant retention is effective in first 3 month.	Polymicrobial infection increases the risk of implant removal.
4	Tsubouchi	Degenerative	12 (21,82)	33 (60)	N/A	N/A	N/A	Retention rate increase in <3 month and posterior cervical surgery. Delay administration of antibiotic cause increase risk implant removal	N/A
5	Kim	N/A	0	20 (100)	N/A	N/A	methicillin-resistant *S.aureus*	Spinal fusion has higher the index dissability and lower patient satisfaction than non fusion.	N/A
6	Jentzsch	Fracture	137 (100)	0	N/A	N/A	N/A	Implant removal reduce the pain and fingertip floor distance.	Implant removal complication was persistent pain (1%) and dystesia (3%)
7	Stavridis	Degenerative spinal disease or spinal fracture	36 (63,16)	0	N/A	N/A	N/A	Implant removal can decrease the pain	N/A
8	Rathjen	Scoliosis	22 (51,16)	0	N/A	N/A	N/A	Implant removal cause larger main thoracic and lumbar coronal curve	N/A
9	Muschik	Scoliosis	35 (77,78)	0		Late infection	N/A	Implant removal in late infection cause increase the wound healing	N/A
10	Ntilikina	Fracture	27 (100)	0	N/A	N/A	N/A	Implant removal has benefit in thoracolumbar fracture	Percutaneus surgery decrease the fat infiltration after implant removal better than open surgery
11	Farshad	Scoliosis	50 (100)	0	N/A	N/A	P.acnes	Late implant removal can loss Cobbs angle in scoliosis patient	N/A
12	Ameri	Scoliosis	3 (9,68)	28 (90,32)		Late infection (1 year)	S.aureus	Late infection case should use impant removal.	Implant replacement with titanium implant so it can increase the curve correction and reduce the recurrence infection
13	Alanay	Degenerative	25 (100)	0	N/A	N/A	N/A	Impant removal can reduce VAS and increase the free pain	N/A
14	Smits	Fracture	102 (100)		N/A	N/A	N/A	Impant removal is safe and increase the quality of life	N/A
15	Cho	Degenerative	19 (18,63)	83 (81,37)	• Deep SSI	3 patients superficial wound infection (3%) 2 patients deep wound infection (2%)	methicillin-resistant *S.aureus*	Implant retention were independent risk factors for treatment failure	Rifampicin is an potential antibiotic against MSSA and MRSA in surgical site infection

Table 4. The Recommendation of Implant Retention and Removal in Spinal Instrumentation Surgery

5. DISCUSSION

Surgical site infections (SSIs) represent the second most common type of healthcare-associated infections and remain a relatively common postoperative complication and the most common reason for readmission after surgery. SSIs have dire implications for the surgeon, patient, and institution which often require prolonged treatment, impose an economic burden and double the risk of patient mortality. *Staphylococcus aureus* is currently the most common cause of SSIs causing as many as 37% of cases of SSIs in community hospitals with *methicillin-resistant S. aureus* (MRSA) of particular concern (9)patient, and institution which often require prolonged treatment, impose an economic burden and double the risk of patient mortality. Staphylococcus aureus is currently the most common cause of SSIs causing as many as 37% of cases of SSIs in community hospitals with methicillin-resistant S. aureus (MRSA. This research showed that the most of bacteria species were *Staphylococcus aureus*.

The total subject in this systematic review was 2.584. The most common spinal instrumentation surgery with SSIs was degenerative spinal disease followed by scoliosis. Spine surgery has seen a rapid advancement in recent years due to novel technological innovations, safety improvements, and increased understanding of the pathophysiology of spinal conditions (10). With the rising number of annual spinal procedures performed worldwide, the associated growing costs are becoming a major health economic burden (11).

In SSI after spinal instrumentation surgery, implant removal or retention can be performed. In the case of infection, implant retention can be performed if the infection

is < 3 months from the onset of surgery (12,13). However, other studies have shown that implant retention can be used if >3 months with modified debridement-irrigation, antibiotic therapy, and implant retention (14). Treatment based on debridement, implant retention, graft replacement and lengthy courses of antimicrobial therapy seems a very effective strategy in the treatment of patients with deep surgical site infection in spine surgery (15)between January 2010 and December 2014 in the traumatology and orthopaedic surgery department of our institution. All patients with SSIs were treated by debridement, graft replacement, retention of the instrumentation and lengthy courses of antimicrobial therapy. The patients were followed up for a period of 12 months. RESULTS: Of all the patients with arthrodesis, 32 (4%.

Implant retention is also known to correlate with an increase in the number of debridement in SSIs (16)reinstrumentation, retention of instrumentation with continued antibiotic suppression, and retention of instrumentation with no antibiotic suppression. Patient factors, infection factors, debridement, and antibiosis were compared. RESULTS: Of the 67 patients with SSI after spine surgery and instrumentation, 19 (28%. The use of antibiotics is necessary to reduce infection and reduce the types of microbes in SSIs. Polymicrobial correlates with implant removal (13). An antibiotic that is known to be effective in reducing infection is rifampicin (17). Rifampicin is a group of macrocyclic antibiotics mainly used for the treatment of various bacterial infections including tuberculosis (18)"ISSN":"2373-8227 (Electronic.

Implant removal is one of the methods used when implant retention cannot be fully eradicating the SSI. Implant removal is safe and increases the quality-of-life patients (19). Implant removal also reduces the pain and has low complications such as persistent pain (1%) and dystesia (3%) (20). Implant removal can decrease the pain (21), increase wound healing (22). Late implant removal can cause loss of Cobb's angle in scoliosis patients (23)who had pedicle screw instrumentation for posterior correction, for at least 10 years. Seven of these patients needed IR after 3.4 years (range, 1.1-7.9 years. The other research showed that implant replacement with titanium implant so it can increase the curve correction and reduce the recurrence of infection (24)who were surgically treated with PSF was collected. Patients were included for the study if they developed late arising infection (>1 year after index posterior fusion for the deformity, Research by Kim et al, showed that spinal fusion has higher the index disability and lower patient satisfaction than non-fusion (25).

Further research needs to be done to compare implant removal and retention on the infection recurrence, pain, and quality of life of patients. The meta-analysis also needed to conclude the use of implant removal or retention in surgical site infection.

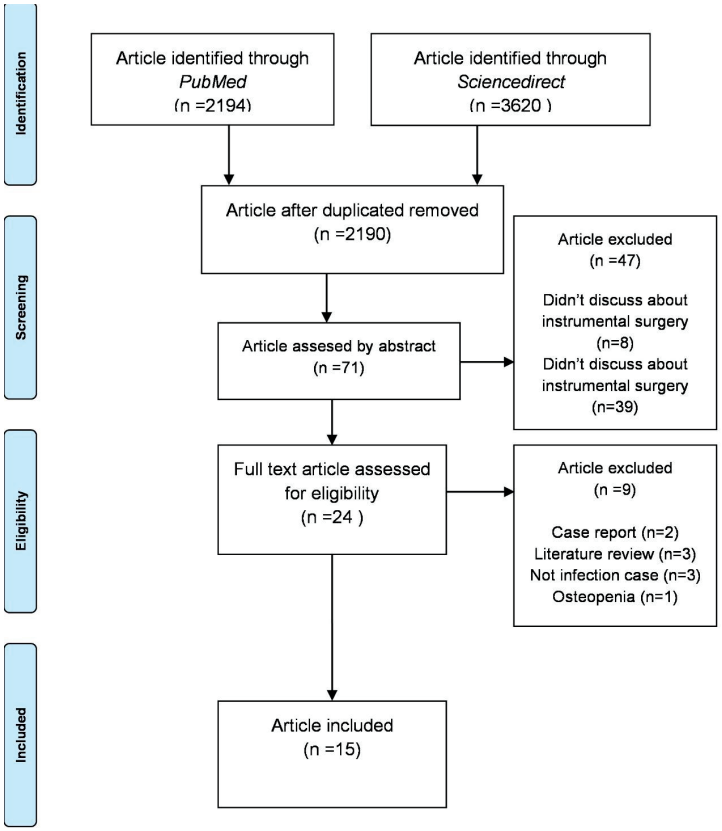

Figure 1. Literature Search Process

6. CONCLUSION

Implant retention can be performed in case of SSI < 3 months after surgery. Implant removal is recommended if the incidence of SSI is more than 3 months. Empirical antibiotics therapy is necessary to reduce possibility of implant removal after debridement.

- **Authors contribution:** Andhika Yudistira: conceptualization, writing original draft preparation, supervision. Syaifullah Asmiragani: supervision, conceptualization. Abdul Waris Imran: writing the paper and editing, data interpretation, data collecting. Muhammad Alwy Sugiarto: writing the paper and editing, data interpretation
- **Conflict of interest statement must be:** There are no conflicts of interest.
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