Outcomes of infection following pediatric spinal fusion

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Background: Removal of instrumentation is often recommended as part of treatment for spinal infections, but studies have reported eradication of infection even with instrumentation retention by using serial débridements and adjuvant antibiotic pharmacotherapy. We sought to determine the effect of instrumentation retention or removal on outcomes in children with spinal infections.

Methods: We retrospectively reviewed the cases of patients who experienced early (< 3 mo) or late (≥ 3 mo) infected spinal fusions. Patients were evaluated at least 2 years after eradication of the infection using the following protocol outcomes: follow-up Cobb angle, curve progression and nonunion rates.

Results: Our sample included 35 patients. The mean age at surgery was 15.1 ± 6.0 years, 65.7% were girls, and mean follow-up was 41.7 ± 26.9 months. The mean Cobb angle was 63.6° ± 14.5° preoperatively, 29.4° ± 16.5° immediately after surgery and 37.2° ± 19.6° at follow-up. Patients in the implant removal group (n = 21) were more likely than those in the implant retention group (n = 14) to have a lower ASA score (71.4% v. 28.6%, p = 0.03), fewer comorbidities (66.7% v. 21.4%, p = 0.03), late infections (81.0% v. 14.3%, p = 0.01) and deep infections (95.2% v. 64.3%, p = 0.03). Implants were retained in 12 of 16 (75.0%) patients with early infections and 2 of 19 (10.5%) with late infections. Patients with implant removal had a higher pseudarthrosis rate (38.1% v. 0%, p = 0.02) and a faster curve progression rate (5.8 ± 9.8° per year v. 0.2 ± 4.7° per year, p = 0.04).

Conclusion: Implant retention should be considered, irrespective of the timing or depth of the infection.

Contexte : Le retrait des implants est souvent recommandé lors du traitement des infections rachidiennes, mais des études ont démontré qu'il est possible d'éliminer les infections tout en maintenant les implants en place, en ayant recours à des débridements répétés et à une antibiothérapie adjuvante. Nous avons voulu mesurer l'effet de la préservation ou du retrait des implants sur les résultats chez les enfants souffrant d'infections rachidiennes.

Méthodes : Nous avons passé en revue de manière rétrospective des cas de fusions rachidiennes infectées à un stade précoce (< 3 mois) ou tardif (≥ 3 mois). Les patients ont été évalués au moins 2 ans après l'éradication de l'infection à l'aide des paramètres suivants : angle de Cobb, progression de la courbure et taux de non fusion au moment du suivi.

Résultats : Notre échantillon comprenait 35 patients. L'âge moyen au moment de la chirurgie était de 15,1 ± 6,0 ans; 65,7 % étaient des filles et le suivi moyen s'est échelonné sur 41,7 ± 26,9 mois. L'angle de Cobb moyen était de 63,6 ° ± 14,5 ° en période préopératoire, de 29,4 ° ± 16,5 ° immédiatement après la chirurgie et de 37,2 ° ± 19,6 ° au moment du suivi. Les patients du groupe soumis au retrait de l'implant (n = 21) étaient plus susceptibles que les patients du groupe chez qui l'implant est demeuré en place (n = 14) de présenter un score ASA plus bas (71,4 % c. 28,6 %, p = 0,03) et un nombre moindre de comorbidités (66,7 % c. 21,4 %, p = 0,03), d'infections tardives (81,0 % c. 14,3 %, p = 0,01) et d'infections profondes (95,2 % c. 64,3 %, p = 0,03). Les implants sont demeurés en place chez 12 patients sur 16 (75,0 %) atteints d'infections précoces et chez 2 patients sur 19 (10,5 %) atteints d'infections tardives. Les patients chez qui l'implant a été retiré ont présenté un taux plus élevé de pseudarthrose (38,1 % c. 0 %, p = 0,02) et un taux de progression plus rapide de la courbure (5,8 ± 9,8 ° par année c. 0,2 ± 4,7 ° par année, p = 0,04).

Conclusion : Il y a lieu d'envisager le maintien des implants, indépendamment du moment d'apparition de l'infection et de sa profondeur.

Surgical site infections (SSIs) are the second most common adverse event in hospitalized patients.[1] The incidence of postoperative infections is approximately 1%–5% in spinal fusions for idiopathic scoliosis and approximately 4%–14% for neuromuscular scoliosis.[2] Neuromuscular scoliosis, the use of allograft bone, the need for postoperative blood transfusions, urinary tract infections (UTIs), increased duration of surgery or of hospital admission and fusions extending distally to the sacrum have all been associated with an increased likelihood of SSIs in pediatric spinal fusions.[3–6] Postoperative infections can lead to the need for revision surgery, ongoing pain, prolonged hospitalization, osteomyelitis and death.[2]

Removal of instrumentation is often recommended as part of treatment for spinal infections.[1,7] However, other studies have reported eradication of infection even with instrumentation retention by using serial débridements and adjuvant antibiotic pharmacotherapy.[8,9] The goal of this study was to determine the effect of instrumentation retention or removal on patient outcomes (e.g., Cobb angle at follow-up, curve progression rate, nonunion) in spinal infections in patients 2 years after infection eradication.

Methods

We retrospectively reviewed the cases of all patients younger than 18 years treated with instrumented spinal arthrodesis for scoliosis (of various etiologies) at The Hospital for Sick Children in Toronto, Ont., between Jan. 1, 2000, and Dec. 31, 2009. Ethics approval was obtained from our institution. All specimens were cultured for 7 days. We used a modified Center for Disease Control–National Health Safety Network (CDC-NHSN) definition of SSIs, which was presence of at least 1 of the following: purulent discharge, positive cultures, evidence of infection on physical examination (tenderness, swelling, redness or heat), wound dehiscence, abscess discovery upon reoperation or evidence of infection on histopathological or radiologic examination.[10,11] Infections were categorized as early (< 3 mo) or late (≥ 3 mo), as described by Hedequist and colleagues.[1] Infections were also categorized as being superficial or deep, as described by the CDC-NHSN and by Horan and colleagues.[11] Deep infections were located in deep soft tissues (e.g., fascial and muscle layers) of the incision and involved the following structures: intervertebral disc, vertebra and paravertebral muscles.[11,12] Superficial infections were located in the skin and subcutaneous tissue and above the fascial layer.[11] Infection eradication was defined as no signs of infection on physical examination and no reported pain with normal blood parameters, as described by Ahmed and colleagues.[13]

All patients were categorized in either the implant removal group or the implant retention group based on their postinfection treatment management. Data on preoperative, perioperative, postoperative and follow-up clinical information as well as diagnostic imaging pertinent to the index surgery, infection, treatment course and outcome were collected for each patient.

Preoperative variables included age, sex, weight, time to follow-up from index surgery, scoliosis etiology, neurologic motor level, Cobb angle, Scoliosis Research Society (SRS) curve type, hematocrit, past medical and surgical history. Perioperative variables included American Society of Anesthesiologists (ASA) score, surgical approach, perioperative antibiotic use, duration of surgery, drain usage, type of instrumentation, bone graft usage, blood loss, perioperative transfusion, volume of packed red blood cells (pRBCs) transfused, distal extent of instrumentation and the number of motion segments instrumented. The postoperative factors included immediate Cobb angle, postoperative transfusion, volume of pRBCs transfused and UTI within 2 weeks of the index surgery.

With respect to the infection, variables included timing, location, duration of the antibiotic therapy, culture results and removal versus retention of instrumentation. The number of irrigation and débridements performed as part of the treatment plan, either before infection eradication (implant retention group) or before implant removal, was also recorded.

Patient outcomes included Cobb angle at follow-up, change in Cobb angle (defined as the percent change of the primary Cobb angle at follow-up with respect to the immediate postoperative state), curve progression rate (defined as the change of the primary Cobb angle per year since the immediate postoperative state), and pseudarthrosis (defined as motion radiographically and/or motion during surgical exploration).[14,15]

Statistical analysis

Statistical analyses were performed using SAS software version 9.1, with the α value predefined at 0.05. Data were evaluated using analysis of covariance for continuous data (assuming unequal variance between groups) and the χ^2 test for categorical data (or Fisher exact test for cells containing fewer than 5 patients). Patients were analyzed based on implant removal or implant retention as part of their treatment course.

Results

Between 2000 and 2009, 827 pediatric patients underwent instrumented spinal fusions for scoliosis. Among them, we identified 35 patients (idiopathic: n = 17, 48.9%; neuromuscular: n = 11, 31.4%; congenital/other: n = 7, 20%) who experienced an early (n = 16, 45.7%) or late infection (n = 19, 54.3%), resulting in a total infection rate of 4.2%. Of these 35 patients, the implants were removed in 21 and retained in 14 patients. The mean age of patients at the time of surgery was 15.1 ±

6.0 years; 65.7% were girls and 34.3% were boys. The types of metal used in patients who experienced infections were stainless steel (n = 15, 42.9%), titanium (n = 2, 5.7%) and unknown (n = 18, 51.4%); the latter group of patients did not have any information written in their charts. Mean follow-up from the time of surgery was 41.7 ± 26.9 (median 38.0, range 12–123) months. Preoperative Cobb angles were 63.6 ± 14.5° and immediate postoperative Cobb angles were 29.4 ± 16.5°, resulting in a 55.2 ± 19.6% curve correction. Follow-up Cobb angles were 37.2 ± 19.6°. Eradication of infection was successful in all 35 patients at the time of follow-up (Table 1).

With respect to baseline preoperative variables, patients who had, compared with those who did not have, implant removal were more likely to have no neurologic deficit (85.7% v. 42.9%, p = 0.019) and were generally healthier, with fewer medical comorbidities (66.7% v. 21.4%, p = 0.031; Table 1).

For peri- and postoperative variables, late infections were more prevalent in the implant removal than the implant retention group (81.0% v. 14.3%, p = 0.001), with the majority of these infections being deep (95.2% v. 64.3%, p = 0.017). In the implant retention group, 7 (50.0%) patients had 1 irrigation and débridement, 2 (14.3%) patients had 4, and 5 (35.7%) patients did not have any (they had superficial infections only) before infection eradication (Tables 2 and 3). In the implant removal group, 1 (4.8%) patient had 2 irrigation and débridements, 3 (14.3%) patients had 3, 1 (4.8%) patient had 5, 1 (4.8%) patient had 8, and 15 (71.4%) patients had concurrent irrigation and débridements with their definitive implant removal. The mean number of irrigation and débridements was 1.14 ± 2.15 in the implant removal group and 1.07 ± 1.33 in the implant retention group (p = 0.90; Table 3).

In terms of outcomes, patients in the implant removal group had a significantly higher rate of associated pseudarthrosis at follow-up than those in the implant retention group (38.1% v. 0% pseudarthrosis, p = 0.012). Of the 8 patients with pseudarthrosis, 7 had late

Table 1. Preoperative variable of patients with infected spinal fusions in the implant retention and removal groups

	Group, no. (%)*			
Variable	All patients n = 35	Implant retention n = 14	Implant removal n = 21	p value
Sex				
Male	12 (34.3)	7 (50)	5 (23.8)	0.11
Female	23 (65.7)	7 (50)	16 (76.2)	
Age, yr	15.1 ± 6.0	16.8 ± 8.4	14.0 ± 3.6	0.20
Follow-up, mean ± SD mo	41.7 ± 26.9	39.0 ± 26.9	43.5 ± 27.4	0.63
Weight, mean ± SD kg	50.7 ± 22.7	51.0 ± 28.3	50.5 ± 18.8	0.96
Diagnosis				0.11
Idiopathic	17 (48.9)	4 (28.6)	13 (61.9)	
Neuromuscular	11 (31.4)	7 (50.0)	4 (19.1)	
Congenital/other	7 (20.0)	3 (21.4)	4 (19.1)	
Neurologic motor level				0.019
Thoracic	9 (25.7)	6 (42.9)	3 (14.3)	
Lumbar/sacral	2 (5.7)	2 (14.3)	0 (0)	
Nil	24 (68.6)	6 (42.9)	18 (85.7)	
Primary Cobb angle, mean ± SD	63.6 ± 14.5	61.7 ± 17.3	64.8 ± 12.5	0.54
SRS curve				0.77
Thoracic	18 (52.9)	8 (57.1)	10 (50.0)	
Thoracolumbar	12 (35.3)	4 (28.6)	8 (40.0)	
Lumbar	4 (11.8)	2 (14.3)	2 (10.0)	
Previous surgery				0.22
Nonspinal surgeries	11 (32.4)	6 (46.2)	5 (23.8)	
Spinal surgeries	5 (14.7)	3 (23.1)	2 (9.5)	
Nil	18 (52.9)	4 (30.8)	14 (66.7)	
Medical history				0.031
Nil	17 (48.6)	3 (21.4)	14 (66.7)	
Respiratory, cardiac, renal, GI	11 (31.4)	7 (50.0)	4 (19.1)	
Multiple	7 (20.0)	4 (28.6)	3 (14.3)	
Hematocrit, mean ± SD	0.34 ± 0.04	0.34 ± 0.04	0.35 ± 0.04	0.63

GI = gastrointestinal; SD = standard deviation; SRS = Scoliosis Research Society.
*Unless otherwise indicated.

infections and 7 had deep infections. Implant removal also resulted in a faster curve progression rate. For the 14 patients in the implant retention group the progression was 0.2° per year for a mean follow-up of 39.0 (range 12–87) months, whereas for patients in the implant removal group the progression was 5.8° per year for a mean follow-up of 43.5 (range 12–123) months (p = 0.036). Of the 16 patients who experienced early infections, 12 (75%) were in the implant retention group and had a change in Cobb angle of 18.8 ± 43.4% and 4 (25%) were in the implant removal group and had a change in Cobb angle of 24.8 ± 30.2% (p = 0.91). For the 19 patients who experienced late infections, 2 (10.5%) were in the implant retention group (1 superficial and 1 deep infection) and had a change in Cobb angle of 29.8 ± 42.1% and 17 (89.5%) patients were in the implant removal group (89.5%) and had a change in Cobb angle of 80.0 ± 122.4% (p = 0.47; Table 3).

Discussion

Data from the SRS Morbidity and Mortality database published in 2011 indicated an overall infection rate of 0.8% for superficial and 1.3% for deep infections for pediatric scoliosis surgery.[16] The reported infection rate for neuromuscular scoliosis was 5.5% (31.4% in our study population) and 1.4% for idiopathic scoliosis (48.9% in our study population).[16] Thus, given the high percentage of neuromuscular scoliosis among patients who received surgery during our study period, our overall infection rate of 4.2% is comparable to those reported in other series.[8,17–19]

Spinal infections may be eradicated using several strategies, but implant removal has often been advocated owing to the potential for biofilm creation on spinal implant.[20] Routine implant removal has also been recommended if *Propoinibacter* is isolated.[21] In our series, 50.0% of cultures grew gram-positive microbes, without any documented cases of *Propoinibacter*. While the timing of infections has also been suggested as a determinant for whether implant retention or removal is chosen, the definitions of early and late infections are inconsistent in the literature, with definitions of late or delayed infections ranging from 30 days to more than 1 year postinstrumentation.[1,7,11,22,23]

Kowalski and colleagues,[22] who defined late infections as those occurring 30 days after instrumentation, reported a failure rate of 22.7% for patients who had early infections

Table 2. Perioperative variables of patients with infected spinal fusions in the implant retention and removal groups

Variable	Group, no. (%)* All patients n = 35	Implant retention n = 14	Implant removal n = 21	p value
ASA score				0.033
I-II	19 (54.3)	4 (28.6)	15 (71.4)	
> III	16 (45.7)	10 (71.4)	6 (28.6)	
Approach				0.19
Anterior	1 (2.9)	1 (7.1)	0 (0)	
Posterior	23 (65.7)	7 (50.0)	16 (76.2)	
Combined	11 (31.4)	6 (42.9)	5 (23.8)	
Perioperative antibiotic use	35 (100)	14 (100)	21 (100)	> 0.99
Duration of surgery, mean ± SD, min	492.6 ± 152.7	504.5 ± 144.7	484.6 ± 160.9	0.71
Instrumentation				0.20
Pedicle screws/rods	20 (57.1)	6 (42.9)	14 (66.7)	
Sublaminar wiring/ rods	14 (40.0)	8 (57.1)	6 (28.6)	
Growing rods	1 (2.9)	0 (0)	1(4.8)	
Bone graft				0.009
Autograft	20 (57.1)	5 (35.7)	15 (71.4)	
Allograft	10 (28.6)	4 (28.6)	6 (28.6)	
Both	5 (14.3)	5 (35.7)	0 (0)	
Blood loss, mean ± SD, mL/kg	26.1 ± 23.5	30.6 ± 27.1	23.1 ± 20.9	0.37
Transfusion	24 (68.6)	10 (71.4)	14 (66.7)	0.77
Volume of transfusion, mean ± SD, mL/kg	9.8 ± 9.9	12.1 ± 12.2	8.4 ± 8.0	0.29
Distal fusion level				0.66
Thoracic	1 (2.9)	0 (0)	1 (4.8)	
Lumbar	31 (88.6)	13 (92.9)	18 (85.7)	
Sacrum/pelvis	3 (8.6)	1 (7.1)	2 (9.5)	
Fusion length, mean ± SD, no. of segments	12.4 ± 3.5	12.9 ± 3.5	12.1 ± 3.5	0.50
Drain usage	15 (42.9)	8 (57.1)	7 (33.3)	0.16

ASA = American Society of Anesthesiologists; SD = standard deviation.
*Unless otherwise indicated.

and whose treatment consisted of débridement, implant retention and suppressive (parenteral followed by oral) antimicrobial therapy (n = 5). However, the failure rate was 21.9% for patients who had late infections treated with débridement and implant removal (n = 7) and 53.8% for those with late infections treated with débridement and implant retention (n = 7).[22] Hedequist and colleagues,[1] who defined late infections as those presenting more than 3 months after the index surgery, reported that no patient was cleared of infection without implant removal (n = 26). They recommended performing immediate implant removal for all patients with late infections and revision surgery at a later date, if needed, for progressive deformity or pseudarthrosis. Ho and colleagues,[7] who defined late infections as those that occurred more than 6 months after the initial operation, reported a nearly 50% reoccurrence rate (20 of 43 patients) if the spinal implant was retained after the initial irrigation and débridement.[7] While many additional irrigation and débridements were performed, 13 of 22 (59%) of patients with late infections ultimately did not have their implants removed. Hahn and colleagues,[23] who defined late infections as those appearing a minimum of 57 weeks after the index instrumentation, reported 100% eradication of late infections with instrumentation removal. In our study, 10.5% of implants were retained in patients who experienced late infections (≥ 3 mo); in patients who experienced late, deep infections, 31.0% of implants were retained.

Implant removal is not without its drawbacks. Implant removal has been associated with a loss of coronal correction of approximately 10° in the main thoracic curve in adolescent patients with idiopathic scoliosis.[7] Ho and colleagues[7] reported on 10 patients treated with implant removal (mean follow-up 10 months); 6 of them experienced a more than 10° increase in deformity in at least 1 plane. Muschik and colleagues[24] reported a progression of 6° for thoracic curves and 5° for lumbar curves at an average follow-up of 3.6 years after implant removal. Our patients had accelerated curve progression, both in absolute and proportional terms, when implants were removed. In our series, the change in Cobb angle at follow-up compared with the immediate postoperative state was higher in the implant removal group than the implant retention group, but the difference was not significant (69.5% ± 112.3% v. 20.3% ± 41.8%, p = 0.08). Furthermore, patients in the implant removal group had a

Table 3. Postoperative and outcome variables of patients with infected spinal fusions in the implant retention and removal groups

Variable	Group, no. (%)*			p value
	All patients n = 35	Implant retention n = 14	Implant removal n = 21	
Initial irrigation and débridements, mean ± SD	1.11 ± 1.84	1.07 ± 1.33	1.14 ± 2.15	0.90
Antibiotic use (48 h postoperative)	34 (97.1)	14 (100)	20 (95.2)	0.41
Immediate postoperative Cobb angle, mean ± SD	29.4 ± 16.5	29.5 ± 15.8	29.2 ± 17.3	0.96
Length of hospital stay, mean ± SD, d	16.0 ± 19.8	20.4 ± 27.8	13.3 ± 12.6	0.32
Transfusion	4 (11.4)	1 (7.1)	3 (14.3)	0.52
Volume of transfusion, mean ± SD, mL/kg	1.1 ± 3.6	0.4 ± 1.6	1.6 ± 4.4	0.36
UTI	7 (21.2)	3 (21.4)	4 (21.1)	0.98
Timing				< 0.001
Early	16 (45.7)	12 (85.7)	4 (19.1)	
Late	19 (54.3)	2 (14.3)	17 (80.9)	
Location				0.017
Superficial	6 (17.1)	5 (35.7)	1 (4.8)	
Deep	29 (82.9)	9 (64.3)	20 (95.2)	
Pseudarthrosis	8 (22.9)	0 (0)	8 (38.1)	0.012
Adjuvant antibiotic therapy	33 (94.3)	13 (92.9)	20 (95.2)	0.77
Duration of antibiotic therapy, mean ± SD, d	117.9 ± 107.1	122.9 ± 111.6	114.6 ± 106.6	0.83
Culture				0.014
Gram-positive	17 (50.0)	6 (46.2)	11 (52.4)	
Gram-negative	5 (14.7)	5 (38.5)	0 (0)	
Atypicals	2 (5.9)	0 (0)	2 (9.5)	
None isolated	5 (14.7)	0 (0)	5 (23.8)	
Polymicrobial	5 (14.7)	2 (15.4)	3 (14.3)	
Follow-up Cobb angle, mean ± SD	37.2 ± 19.6	33.0 ± 17.6	39.7 ± 20.6	0.36
Percent coronal loss, mean ± SD	49.8 ± 93.2	20.3 ± 41.8	69.5 ± 112.3	0.08
Curve progression rate, mean ± SD, °/yr	3.8 ± 8.7	0.2 ± 4.7	5.8 ± 9.8	0.036

SD = standard deviation; UTI = urinary tract infection.
*Unless otherwise indicated.

faster curve progression rate (5.8° ± 9.8° per year v. 0.2° ± 4.7° per year, $p = 0.036$) at an average follow-up of 3.48 ± 2.24 years.

As noted by Viola and colleagues,[17] it is difficult to determine whether spinal infections lead to pseudarthrosis or if pseudarthrosis is a predisposing risk factor for infections. Previously, Katonis and colleagues[12] reported that no association existed between pseudarthrosis and early infections in patients who had spinal fusions. However, an association between late infections and pseudarthrosis has previously been reported to range from 20% to 62%,[17,20] which is consistent with our findings. Of the 17 patients with late infections in our study, 7 (41.1%) patients had pseudarthrosis at a mean follow-up of 50.6 (range 13–78) months. Only 1 case of pseudarthrosis occurred in a patient who experienced an early infection.

Limitations

Our study has several limitations. First, we defined successful outcomes only with respect to clinical and radiographic parameters. However, Mok and colleagues[25] reported that after treatment (in an adult population) of infection in 16 patients with spinal rods (12 treated with implant retention and 4 treated with implant removal), patients with infections reported similar SF-36 scores to matched controls who underwent spinal fusion but did not experience infections. Second, owing to the low incidence of SSIs, our sample size was small, and thus our ability to examine treatment was minimal. However, infection was eradicated successfully in all patients, and the main difference in treatment was the decision to remove or retain the instrumentation.

Conclusion

While implant removal may be needed for the treatment of infected spinal fusions, removal of instrumentation often reveals a pseudoarthrosis and is associated with a high risk of scoliosis progression. When clinically possible, a trial of implant retention should be considered, irrespective of the timing or depth of the infection, and probably no definition of late infections should be used as an absolute indication for immediate rod removal.

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