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ORIGINAL ARTICLE

Surgical site infection in spinal surgery: a comparative study between 2-octyl-cyanoacrylate and staples for wound closure

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Abstract
Background Surgical site infection (SSI) after spinal surgery is a devastating complication. Various methods of skin closure are used in spinal surgery, but the optimal skin-closure method remains unclear. A recent report recommended against the use of metal staples for skin closure in orthopedic surgery. 2-Octyl-cyanoacrylate (Dermabond; Ethicon, NJ, USA) has been widely applied for wound closure in various surgeries. In this cohort study, we assessed the rate of SSI in spinal surgery using metal staples and 2-octyl-cyanoacrylate for wound closure.
Methods This study enrolled 609 consecutive patients undergoing spinal surgery in our hospital. From April 2007 to March 2010 surgical wounds were closed with metal staples (group 1, $n = 294$). From April 2010 to February 2012 skin closure was performed using 2-octyl-cyanoacrylate (group 2, $n = 315$). We assessed the rate of SSI using these two different methods of wound closure. Prospective study of the time and cost evaluation of wound closure was performed between two groups.
Results Patients in the 2-octyl-cyanoacrylate group had more risk factors for SSI than those in the metal-staple group. Nonetheless, eight patients in the metal-staple group compared with none in the 2-octyl-cyanoacrylate group acquired SSIs ($p < 0.01$). The closure of the wound in length of 10 cm with 2-octyl-cyanoacrylate could save 28 s and $13.5.
Conclusions This study reveals that in spinal surgery, wound closure using 2-octyl-cyanoacrylate was associated with a lower rate of SSI than wound closure with staples. Moreover, the use of 2-octyl-cyanoacrylate has a more time saving effect and cost-effectiveness than the use of staples in wound closure of 10 cm in length.

Keywords Surgical site infection · Spinal surgery · Wound closure · 2-Octyl-cyanoacrylate · Staples

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Introduction

Surgical site infection (SSI) after spinal surgery is a devastating complication. SSI results in long-term intravenous antibiotics uses, re-operation and prolonged hospitalization and increases morbidity and mortality [1]. The total cost of care for a patient with SSI is more than four times that of an uncomplicated case [2]. The rate of SSI in spinal surgery has been reported from 0 to 32 % [3–10]. There are various methods of skin closure in spinal surgery, but the optimal skin-closure method remains unclear [11, 12]. A recent report recommended against the use of metal staples for skin closure in orthopedic surgery [13].

In 1949, a group of adhesives called 'cyanoacrylates' were synthesized via the reaction of cyanoacetate with formaldehyde, with variations in the alkyl group [14]. Octyl-cyanoacrylates, which are the longest-chain derivatives, represent the least toxic of the cyanoacrylates [15]. 2-Octyl-cyanoacrylate (Dermabond® topical skin adhesive; Ethicon, NJ, USA) has been widely used for wound closure in traumatic laceration [16, 17], facial surgery [18], craniotomy and craniectomy [19], pediatric neurosurgery [20, 21], corneal surgery [22], orthopedic surgery [23] and mammoplasty [24]. The use of 2-octyl-cyanoacrylate for wound closure in spinal surgery has been reported to provide sufficient wound closure with a low risk of SSI [25, 26]. In the current cohort study, 2-octyl-cyanoacrylate or metal staples were applied for wound closure in spinal surgery. The aim of this cohort study was to assess the rate of SSI in spinal surgery using these two different methods of wound closure.

Patients and methods

A total of 609 consecutive patients undergoing spinal surgery in Wakayama Rosai Hospital from April 2007 to February 2012 were enrolled in the study. All patients were followed up for more than 1 year after operation. Patients undergoing microendoscopic decompression surgery for the lumbar spine and debridement combined with interbody fusion for pyogenic or tuberculous spondylitis were excluded. All spinal surgeries were performed by two doctors (M.A. and K.M.) who were specialists in spinal surgery. The patients were divided into two groups. From April 2007 to March 2010 surgical wounds were closed with metal staples (group 1, $n = 294$). After Smith's report against metal staples [13], skin closure was performed using 2-octyl-cyanoacrylate (group 2, $n = 315$) from April 2010 to February 2012. Group 1 included 151 men and 143 women with a mean age at operation of 65.3 years (range 15–91 years). Group 2 included 173 men and 142 women with a mean age at operation of 66.4 years (range 13–94 years). The following additional data were collected: body mass index, serum albumin, red blood cell count, smoking history, steroid use, the presence of hypertension, diabetes mellitus, malignant tumor, rheumatoid arthritis, obstructive lung disease or coronary artery disease, transfusion, diagnosis, region, surgical approach, instrumentation, revision, number of decompression levels, number of fusion levels, estimated blood loss and duration of operation (Table 1).

Wound closure and postoperative wound care

In group 1, subcutaneous layers were closed with 2–0 absorbable sutures for wound adaptation and skin-edge approximation followed by skin closure with skin staples (Precise™ Vista disposable skin stapler; 3 M, Maplewood, MN, USA). Wounds were covered with a post-surgical dressing (Opposite Post-Op Visible; Smith and Nephew Medical, Hull, UK). Staples were removed 10–14 days post-operation. In group 2, subcutaneous layers were closed in the same manner as that in group 1, followed by applying 2-octyl-cyanoacrylate (Dermabond® topical skin adhesive, Ethicon, Inc., NJ, USA) to skin incision. After crushing the inner vial, 2-octyl-cyanoacrylate was brushed on-to the skin incision. After the layers had dried, the wound was covered with the same post- surgical dressing as in group 1. Patients were allowed to shower on post-operative day 3. The post-surgical dressing was removed ~7–10 days after surgery.

Identification of SSIs was determined according to the criteria of Centers for Disease Control and Prevention [27]. A wound infection occurring within 30 days of the operation in non-instrumented surgery and within 1 year in instrumented surgery was considered an SSI. A superficial SSI was defined as an infection involving only the skin and subcutaneous tissue, while an infection involving the deep soft-tissue muscle and fascia was designated a deep SSI. All SSIs were confirmed by specialists for orthopedic surgery (M.A., K.M. and S.S.)

C-reactive protein (CRP) and leukocyte count were monitored as infection markers preoperatively and on postoperative days 3, 7 and 10 in all patients.

For intraoperative antimicrobial prophylaxis, cefazolin sodium (CEZ) or sulbactam sodium/ampicillin sodium (SBT/ABPC) was administrated by intravenous drip infusion at the induction of general anesthesia. CEZ was used for non-instrumented surgery while SBT/ABPC was used for instrumented surgery. Additional intraoperative injections of CEZ or SBT/ABPC were given every 3 h during surgery. Antibiotics were administrated every 6 h during the first 24 h after wound closure followed by the administration of every 12 h during second 24 h after operation, while closed-suction drainage was removed 48 h after surgery. The dose of CEZ administrated per one intraoperative injection was 1 g and the total dose after surgery was 6–8 g. A single dose of SBT/ABPC was 1.5 g and the total dose administered after surgery was 9–12 g.

Skin preparation was performed with 0.2 % benzalkonium chloride (WELPAS; Maruishi pharmacy, Osaka, Japan) and 10 % povidone iodine, followed by covering of the surgical field with an iodine-impregnated incision drape. Surgical staff used double gloves and changed the outer gloves every 3 h and just before wound closure. During surgery, pulse lavage using saline was performed every 3 h and just before wound closure to decrease intraoperative bacterial contamination. In addition, just before and after setting of instrument, pulse lavage irrigation was performed in instrumentation surgeries. The amount of saline used in one lavage was 1,000–2,000 ml depending on the size of operative field.

To analyze the time the surgeons needed for and the costs of these two different skin closures, wound closures of each ten patients with 7–20 cm wound length were

Table 1 Patient characteristics

	Group 1 ($n = 294$)	Group 2 ($n = 315$)	p value
Gender (*n*, %)			
Male	151 (51)	173 (55)	0.379
Female	143 (49)	142 (45)	
Age at surgery (years) (range)	65.3 (15–91)	66.4 (13–94)	0.304
Body mass index (kg/m^2) (range)	23.5 (11.3–34.7)	23.8 (15.4–35.3)	0.425
Serum albumin (g/dl) (range)	4.2 (2–5.2)	4.2 (2.6–5.2)	0.582
Red blood cells ($\times 10^4$ μl) (range)	428 (271–652)	419 (267–564)	0.040
Smoking (*n*, %)	66 (22)	52 (17)	0.064
Steroid use (*n*, %)	15 (5)	10 (3)	0.231
Hypertension (*n*, %)	109 (37)	100 (32)	0.166
Diabetes mellitus (*n*, %)	56 (19)	79 (25)	0.073
Malignant tumor (*n*, %)	5 (2)	5 (2)	0.834
Rheumatoid arthritis (*n*, %)	11 (4)	9 (3)	0.541
Obstructive lung disease (*n*, %)	16 (5)	14 (4)	0.570
Coronary artery disease (*n*, %)	18 (6)	15 (5)	0.459
Diagnosis (*n*, %)			
Degenerative disease	272 (93)	291(92)	0.704
Spine injury	13 (4)	17 (5)	
Spinal tumor	9 (3)	7 (2)	
Region (*n*, %)			
Cervical	81 (28)	98 (31)	0.179
Thoracic	30 (10)	43 (14)	
Lumbar	183 (62)	174 (55)	
Surgical approach (*n*, %)			
Anterior	4 (1)	4 (1)	0.793
Posterior	290 (99)	311 (99)	
Instrumentation (*n*, %)	87 (30)	96 (30)	0.812
Revision (*n*, %)	35 (12)	39 (12)	0.857
Number of decompression levels (*n*, %)			
1–2	55 (27)	45 (21)	0.015
3	51 (25)	35 (16)	
4–6	46 (46)	128 (58)	
≥7	5 (2)	11 (5)	
Number of fusion levels (*n*, %)			
1–2	50 (57)	51 (53)	0.686
3	10 (11)	15 (16)	
4–6	20 (23)	19 (20)	
≥7	7 (8)	11 (11)	
Estimated blood loss (g) (range)	171.8 (2–1,951)	237.4 (4–3,338)	0.006
Duration of operation (min) (range)	164.0 (2–744)	197.7 (39–775)	<0.001
Transfusion (*n*, %)	59 (20)	93 (30)	0.007
Packed red blood cells (*n*, %)	16 (5)	25 (8)	0.220
Autologous blood (*n*, %)	43 (15)	68 (22)	0.026
SSI (*n*, %)	8 (3)	0 (0)	0.009
Superficial (*n*, %)	2 (1)	0 (0)	0.449
Deep (*n*, %)	6 (2)	0 (0)	0.033

Data are presented as *n* (%) or mean (range)

observed prospectively. The time to closure was measured in seconds and the time to close the wound per 10 cm in length was calculated. The cost of wound closure was determined also.

Statistical analysis

Statistical analysis was performed using Student's *t* test, χ^2 test. Statistical significance was defined as $p < 0.05$.

Results

No patients showed adverse reaction such as an acute inflammation of erythema, warmth and pain for 2-octyl-cyanoacrylate use. Eight patients using staples (group 1) acquired SSIs (two patients with superficial SSIs and six with deep SSIs). There was no case of SSI in patients using 2-octyl-cyanoacrylate (group 2). Group 1 showed statistical significance with increased infection rates ($p < 0.01$). The red blood cell count was significantly lower ($p < 0.05$) in group 2 than in group 1, and the number of decompression levels ($p < 0.05$), estimated blood loss ($p < 0.01$) and duration of operation ($p < 0.001$) were significantly higher in group 2 than in group 1 (Table 1). In the comparison of patient characteristics in those with and without SSI in group 1, the rates of diabetes mellitus ($p < 0.001$), malignant tumor ($p < 0.05$), instrumentation surgery ($p < 0.001$) and transfusion, especially packed red blood cells ($p < 0.001$) were significantly higher in patients with SSI (Table 2).

When characteristics of infected patients were classified as instrumented and non-instrumented cases, there were no statistical significant differences in each factor (Table 3).

In six of the eight patients with SSIs, methicillin-resistant *staphylococcus aureus* (MRSA) was isolated from cultures obtained from surgical wounds. Superficial SSIs were treated with debridement. Deep SSIs occurred in the instrumented area in four patients; two of these four-patients underwent removal of instrumentation (Table 4).

In both non-infection group and infection group, CRP and leukocyte count increased on postoperative day 3 and decreased on postoperative day 7. On postoperative day 10, CRP and leukocyte count increased again in infection group; however, non-infection group showed more decrement in CRP and leukocyte count. The mean value of CRP in infection group on pre-operation, postoperative day 3, 7 and 10 were 1.0 ± 1.9 mg/dl, 8.6 ± 2.8 mg/dl, 5.8 ± 4.2 mg/dl and 7.4 ± 9.5 mg/dl. Non-infection group values of CRP were 0.6 ± 1.6 mg/dl, 7.4 ± 4.7 mg/dl, 2.7 ± 2.3 mg/dl, 0.9 ± 1.4 mg/dl, respectively (Fig. 1). The mean measured leukocyte count in infected group on pre-operation, postoperative day 3, 7 and 10 were $6{,}675.0 \pm 2{,}594.9$, $9{,}885.7 \pm 3{,}799.7$, $7{,}925 \pm 4{,}428.1$ and $9{,}828.6 \pm 4{,}525.4$ while the count in non-infected group were $6{,}708.3 \pm 1{,}907.4$, $8{,}032.6 \pm 2{,}120.9$, $6{,}216.3 \pm 1{,}764.6$ and $5{,}768.2 \pm 1{,}391$, respectively (Fig. 2). CRP on postoperative day 7, 10 and leukocyte count on postoperative day 10 revealed significantly higher in infection group than those in non-infection group.

The average time to close 10 cm wound was 48.0 ± 12.6 s in group 1 and 19.9 ± 10.7 s in group 2. Closing time using 2-octyl-cyanoacrylate was significantly faster than that using staples ($p < 0.001$). The cost of a single-use skin stapler (35 clips) was $38.5 while a set of 2-octyl-cyanoacrylate was $25.0. One set of 2-octyl-cyanoacrylate can be used for wound upto 12–13 cm in length. Since we usually use staples with 5–6 mm pitch, 12–13 cm wound was closed by 20–26 clips. Therefore, at least to this length of the wound, the use of 2-octyl-cyanoacrylate has a more cost-effectiveness than the use of staples.

Discussion

This cohort study found that in spinal surgery, wound closure using staples (group 1) was associated with a higher rate of SSI than wound closure using 2-octyl-cyanoacrylate (group 2), although the patients of group 2 had significant higher risk factors for surgical site infections than the patients in group 1. The only difference in SSI is the method of wound closure between two groups. Concerning the two groups, the patients are almost the same and all surgeries were performed by only two surgeons to avoid bias.

Several studies have reported disadvantages for wound closure with staples in terms of SSIs in orthopedic surgery [13, 28–30]. Another report emphasized that wound closure with staples, having a time-saving merit, might have a psychological benefit for surgeons and operating staff, especially after long-duration surgery [28, 31, 32].

Smith et al. [13] have reported a significantly higher risk of wound infection when wounds are closed with staples rather than sutures in orthopedic surgery. In hip surgery, the risk of developing a wound infection was four times greater after staple closure than suture closure. Smith et al. [13] recommended against the use of staples for wound closure in hip or knee surgery. Poor results for wound closure with staples are attributable to poor technique in clip placement, resulting in overlapping or inverted wound edges. This consequently leads to oozing from the wound edges, delayed healing and possible sites for infection [32]. There is a strong correlation between superficial wound infection and the probability of developing deep wound infection in hip and knee joint replacement [33]. Therefore, preventing superficial wound infection might decrease the rate of deep wound infection.

The benefits of wound closure with 2-octyl-cyanoacrylate include less procedure-related pain and time-savings. A hard barrier formed from these monomers sloughs off after the wound matures; there is no need to remove a non-absorbable suture, resulting in savings in time and resources for patients and medical staff [21]. In a study with bilateral reduction mammoplasties, operative times, rates of wound dehiscence, hypertrophic scar revisions and cellulitis were decreased with the use of 2-octyl-cyanoacrylate compared with suture closure [24]. Wound closure using 2-octyl-cyanoacrylate has also been reported to be

Table 2 Characteristics of patients with and without SSI in group 1

	Infected group ($n = 8$)	Non-infected group ($n = 286$)	p value
Gender (*n*, %)			
Male	4 (50)	147 (51)	0.938
Female	4 (50)	139 (49)	
Age at surgery (years) (range)	68.5 (52–83)	65.2 (15–91)	0.281
Body mass index (kg/m^2) (range)	23.6 (16.6–28.1)	23.5 (11.3–34.7)	0.315
Serum albumin (g/dl) (range)	4.3 (3.5–4.7)	4.2 (2–5.2)	0.606
Red blood cells ($\times 10^4$ µl) (range)	442.6 (397–496)	427.2 (271–652)	0.419
Smoking (*n*, %)	0 (0)	66 (23)	0.123
Steroid use (*n*, %)	0 (0)	15 (5)	0.506
Hypertension (*n*, %)	3 (38)	106 (37)	0.980
Diabetes mellitus (*n*, %)	4 (50)	52 (18)	<0.001
Malignant tumor (*n*, %)	1 (13)	4 (1)	0.017
Rheumatoid arthritis (*n*, %)	0 (0)	10 (3)	0.590
Obstructive lung disease (*n*, %)	0 (0)	15 (5)	0.506
Coronary artery disease (*n*, %)	1 (13)	17 (6)	0.446
Diagnosis (*n*, %)			
Degenerative disease	6 (75)	266 (93)	0.144
Spine injury	1 (13)	12 (4)	
Spinal tumor	1 (13)	8 (3)	
Region (*n*, %)			
Cervical	1 (13)	80 (28)	0.130
Thoracic	3 (38)	27 (9)	
Lumbar	4 (50)	179 (62)	
Surgical approach (*n*, %)			
Anterior	0 (0)	4 (1)	0.736
Posterior	8 (100)	282 (99)	
Instrumentation (*n*, %)	7 (88)	80 (28)	<0.001
Revision (*n*, %)	1 (13)	34 (12)	0.958
Number of decompression levels (*n*, %)			
1–2	1 (100)	54 (26)	N/A
3	0 (0)	51 (25)	
4–6	0 (0)	96 (47)	
≥7	0 (0)	5 (2)	
Number of fusion levels (range)			
1–2	1 (14)	49 (61)	0.238
3	2 (29)	8 (10)	
4–6	3 (43)	17 (21)	
≥7	1 (14)	6 (8)	
Estimated blood loss (g) (range)	295.6 (5–1,014)	158.3 (2–1,951)	0.101
Duration of operation (min) (range)	245.4 (78–425)	161.7 (22–744)	0.102
Transfusion (*n*, %)	6 (80)	53 (18)	<0.001
Packed red blood cells (*n*, %)	4 (50)	12 (4)	<0.001
Autologous blood (*n*, %)	2 (30)	41 (14)	0.400

Data are presented as *n* (%) or mean (range)

associated with a low risk of SSI in spinal surgery [25, 26]. The low infection rate of wounds closed with 2-octyl-cyanoacrylate is possibly a result of antibacterial effects, particularly against gram-positive organisms [34] and the creation of an effective barrier to microbial penetration by gram-positive and gram-negative motile and non-motile species [35]. In addition, the avoidance of repeatedly compromising the skin barrier with a suture needle during the suturing process has been attributed to lowering the risk of infection [25].

Table 3 Characteristics of infected patients classified as instrumented and non-instrumented cases

	Instrumented cases ($n = 6$)	Non-instrumented cases ($n = 2$)	p value
Gender (n, %)			
Male	2 (33)	2 (100)	0.214
Female	4 (67)	0 (0)	
Age at surgery (years) (range)	68.5 (66–83)	57.5 (52–63)	0.067
Body mass index (kg/m^2) (range)	24.0 (20.4–28.1)	21.4 (16.6–26.1)	0.617
Serum albumin (g/dl) (range)	4.4 (4.1–4.7)	3.9 (3.5–4.3)	0.309
Red blood cells ($\times 10^4$ µl) (range)	457 (414–496)	400 (397–403)	0.067
Smoking (n, %)	0 (0)	0 (0)	N/A
Steroid use (n, %)	0 (0)	0 (0)	N/A
Hypertension (n, %)	2 (33)	1 (50)	0.893
Diabetes mellitus (n, %)	4 (67)	0 (0)	0.214
Malignant tumor (n, %)	1 (17)	0 (0)	0.750
Rheumatoid arthritis (n, %)	0 (0)	0 (0)	
Obstructive lung disease (n, %)	0 (0)	1 (50)	0.250
Coronary artery disease (n, %)	1 (17)	0 (0)	0.750
Diagnosis (n, %)			
Degenerative disease	5 (83)	2 (100)	0.750
Spine injury	0 (0)	0 (0)	
Spinal tumor	1 (17)	0 (0)	
Region (n, %)			
Cervical	0 (0)	0 (0)	0.536
Thoracic	2 (33)	0 (0)	
Lumbar, ilium	4 (67)	2 (100)	
Surgical approach (n, %)			
Anterior	0 (0)	0 (0)	N/A
Posterior	6 (100)	2 (100)	
Revision (n, %)	0 (0)	1 (50)	0.250
Number of decompression or fusion levels (n, %)			
1–2	1 (17)	2 (100)	0.108
3	2 (33)	0 (0)	
4–6	3 (50)	0 (0)	
≥7	0 (0)	0 (0)	
Estimated blood loss (g) (range)	235 (50–1014)	250.5 (5–496)	0.868
Duration of operation (min) (range)	230 (150–335)	251.5 (78–425)	0.888
Transfusion (n, %)	5 (83)	1 (50)	0.464
Packed red blood cells (n, %)	3 (50)	1 (50)	0.786
Autologous blood (n, %)	2 (33)	0 (0)	0.536

Data are presented as n (%) or median (range)

Many factors increase the risk of SSI in spinal surgery. Patient-based risk factors are reported to be age [8], history of spinal surgery [36], previous SSI [1, 8], smoking [8, 36], steroid use [37], diabetes mellitus [8, 36, 38, 39], obesity [8, 39, 40], chronic obstructive pulmonary disease [39], coronary heart disease [39], malignant tumor [41], anemia [42] and malnutrition [5]. Risk factors related to the surgical procedure are surgical level [6], number of fusion levels [36], transfusion [40], estimated blood loss [1, 40] and surgical duration [43]. In the current study, the red blood cell count was significantly lower in patients in group 2, while the number of decompression levels, estimated blood loss, duration of operation and transfusion rate were significantly higher in group 2. As anemia, an increased number of decompression levels, increased estimated blood loss, increased duration of operation time and transfusion are risk factors for SSI, patients in group 2 were more at risk for SSI than those in group 1. Nevertheless, no SSI occurred in group 2. In group 1, patients who developed SSI had more risk factors for SSI than those who did

Table 4 Characteristics of patients with SSI

Age (years)	Gender	Type of SSI	Diagnosis	Operative procedure	Instrumentation of SSI site	Treatment for SSI	Microorganism
63	M	Deep	LDH	L4/5 discectomy	–	Debridement	Unknown
83	F	Deep	LSS	L2–5 PLF	+	Debridement	MRSA
68	F	Deep	LSS	L4–5 PLF	+	Removal of instrument	Unknown
69	F	Superficial	LSS	L2–5 PLF	+	Debridement	MRSA
52	M	Deep (Ilium, donor site)	C1/2 dislocation, CSM	OCT fusion	–	Debridement	MRSA
66	F	Deep	Spinal metastasis	T4–9 PLF	+	Removal of instrument	MRSA
67	M	Superficial	T12, L1 fracture	T10–L3 PLF	+	Debridement	MRSA
80	M	Deep	T12 fracture	T10–L3 PLF	+	Debridement	MRSA

CSM cervical spondylotic myelopathy, *F* female, *LDH* lumbar disc herniation, *LSS* lumbar spinal stenosis, *M* male, *MRSA* methicillin-resistant *Staphylococcus aureus*, *OCT* occipito-cervico-thoracic, *PLF* posterolateral fusion, *SSI* surgical site infection

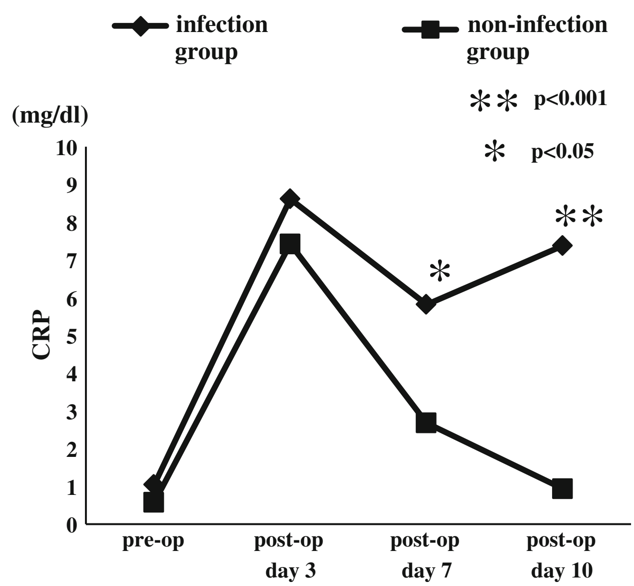

Fig. 1 Mean values of CRP with and without postoperative infection. On postoperative days 7 and 10, CRP values showed significantly higher in infection group than those in non-infection group

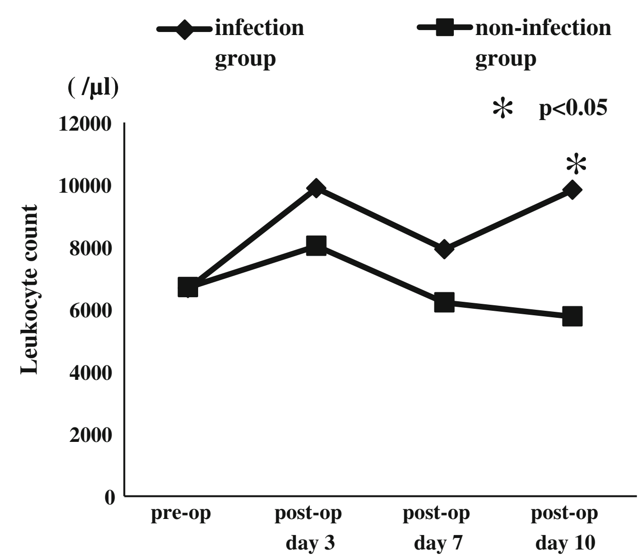

Fig. 2 Mean values of leukocyte count with and without postoperative infection. On postoperative day 10, leukocyte count showed significantly higher in infection group than that in non-infection group

not develop an infection; the group of patients who developed SSI showed higher rates of diabetes mellitus, malignant tumor, instrumentation surgery and transfusion.

In this study for antimicrobial prophylaxis, the initial dose of CEZ and SBT/ABPC administrated was 1 and 1.5 g in all patients of group 1 and group 2. In our series there was no significant difference in BMI between infected patients and non-infected patients in group 1. However, obesity has consistently been reported as a risk factor for SSI [39]. Since standard doses of antimicrobial agents may result in low serum and tissue concentrations in obese patients, highest dose of prophylactic antimicrobial agent (for CEZ minimal initial dose of 2 g) was proposed to be used for bariatric surgical prophylaxis [44].

Early detection and immediate treatment for SSI are essential to obtain a good result. In this study the serial monitoring of CRP as an infection marker was useful for early detection of SSI. On the postoperative days 7 and 10, CRP showed a significant difference between infection group and non-infection group while leukocyte count revealed no significant difference on postoperative day 7. Similar results were reported previously. Kang et al. [45] mentioned that CRP value revealed a characteristic increase and decrease pattern after spinal surgery in patients with normal clinical course with regard to early infectious complications; therefore abnormal response at 5 or 7 days after surgery was the sign of SSI.

In our series, six of the eight (75 %) cases of SSI were due to MRSA. Recently, a consecutive series of 3,218 patients undergoing posterior lumbar instrumented surgery was reviewed by Koutsoumbelis et al. [39]. In this series, 34 % of SSIs revealed positive MRSA culture, indicating an increasing prevalence of this organism. According to other report [46] of 239 SSIs cases of spinal surgery methicillin-resistant organisms (*S. aureus* or *S. epidermidis*) were present in 82 (34.3 %) cases. Patients undergoing revision surgery were more likely to have an infection caused by methicillin-resistant staphylococci than those undergoing primary surgery (47.4 vs. 28.0 %). Spinal infection due to MRSA has been shown to be more difficult to treat and especially may increase mortality and morbidity when disseminated [47]. Management of SSI in posterior spinal surgery without instrumentation needs surgical debridement with removal of all necrotic tissue with surgical closure over drains [48] while SSI in instrumented surgery both interbody and posterior instrumentation can be left in place in the setting of early postoperative infections [5, 39, 49]. However, postoperative spine wound infection with positive culture for MRSA predicts a high tendency of failure to suppress the infection with a single irrigation and debridement [50].

Prospective study of the time and cost evaluation revealed that closure of the wound in length of 10 cm with 2-octyl-cyanoacrylate could save 28 s and $13.5. Because the use of 2-octyl-cyanoacrylate has a more time saving and cost-effectiveness than the use of staples in wound closure of 10 cm in length, from a time saving and a cost effective points of view, 2-octyl-cyanoacrylate can be used.

Preventive measures for SSI used in this study (i.e. antimicrobial prophylaxis, skin preparation of the surgical field, using double gloves during surgery and intraoperative lavage with saline) were the same in both groups. The only difference that influenced the higher SSI rate in group 1 is the method of wound closure. This study found that in spinal surgery, wound closure using 2-octyl-cyanoacrylate was associated with a lower rate of SSI than wound closure with staples.

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