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Independent risk factor for surgical site infection after orthopedic surgery

Yingfa Feng, MD[a], Qi Feng, MD[a], Peng Guo, MM[a], Dong-lai Wang, MM[a,*]

Abstract

No significant progress has been made in the study of orthopedic surgical site infection (SSI) after different orthopedic surgery, and the analysis and prevention of risk factors for orthopedic SSI urgently need to be solved. A total of 154 patients underwent orthopedic surgery from April 2018 to December 2020. General information such as gender, age, marriage, diagnosis, surgical site, and anesthesia method was recorded. Statistical methods included Pearson chi-square test, univariate and multivariate logistic regression analyses, and receiver operating characteristic (ROC) curves. Based on Pearson's chi-square test, sex ($P = .005$), age ($P = .027$), marriage ($P = .000$), diagnosis ($P = .034$), and surgical site ($P = .000$) were significantly associated with SSI after orthopedic surgery. However, in the multiple linear regression analysis, only the surgical site ($P = .035$) was significantly associated with SSI after orthopedic surgery. In terms of multivariate logistic regression level, surgical site (odds ratio [OR] = 1.568, $P = .039$) was significantly associated with SSI. ROC curves were constructed to determine the effect of the surgical site on SSI after different orthopedic surgery (area under the curve [AUC] = 0.577, 95% CI = 0.487–0.0.666). In summary, the surgical site is an independent risk factor for SSI after orthopedic surgery, and "trauma" is more likely to develop SSI than spine, arthrosis, and others.

Abbreviations: 95% CIs = 95% confidence intervals, AUC = area under the curve, BUN = blood urea nitrogen, ONFH = osteonecrosis of the femoral head, ORs = odds ratios, ROC = receiver operating characteristic, SSI = surgical site infection.

Keywords: orthopedic, risk factor, surgery, surgical site infection, trauma

1. Introduction

Surgical site infection (SSI), a perioperative infection that occurs in the incision, deep surgical organ, or space, is the most common surgical complication.[1,2] Various orthopedic diseases such as spine, arthrosis, and trauma often require surgical treatment.[3,4] However, it is unclear what orthopedic surgery is more likely to have SSI due to co-immune deficiency, malnutrition, and various opportunistic infections.[5] However, no significant progress has been made in the study of orthopedic SSI, and the analysis and prevention of risk factors for orthopedic SSI urgently need to be solved.[6,7]

Orthopedic surgical sites mainly include spinal surgery, joint surgery, and trauma surgery.[8] Spinal SSI is a severe complication of spinal surgery. It is associated with an increased risk of spinal SSI from multiple factors: previous SSI, obesity, diabetes, increasing age, alcoholism, low albumin levels, smoking, history of cancer, chronic steroids, rheumatoid arthritis, and hypothyroidism.[9] SSI can be classified as superficial, deep, periprosthetic joint infections or severe complications following joint surgery.[10] Currently, there is a lack of research on the risk factors of orthopedic surgery-related SSI, and the surgical site may be one of the risk factors for orthopedic SSI.[11]

In this paper, we intend to explore the independent risk factors of SSI after orthopedic surgery and the effect of the surgical site on SSI using a single multivariate logistic regression model by recruiting several patients undergoing orthopedic surgery.

2. Methods

2.1. Patients and ethics

One hundred fifty-four patients underwent orthopedic surgery from April 2018 to December 2020.

The inclusion criteria were: 18 to 80 years old, undergoing orthopedic surgery and vertebroplasty with prosthesis implantation, and patients without a history of surgery would meet the inclusion criteria. Liver function: total bilirubin ≤ 1.5 × upper limit of expected value; Alanine aminotransferase (ALT) and aspartate aminotransferase ≤ 2.5 × upper limit of expected value. Renal function: serum creatinine ≤ 176.8 μmol/L (2.0 mg/dL). Coagulation function: prothrombin time ≤ 15 s, or international standardized ratio < 1.7. Blood glucose levels were controlled in the range of 2.8 to 22.2 mmol/L (50–400 mg/dL). The subject or agent can provide written informed consent.

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

The Ethics Committee of The Fourth Hospital of Hebei Medical University approved this study. All patients and their families gave informed consent and signed a written informed consent.

[a] Department of Orthopedics, The Fourth Hospital of Hebei Medical University, Shijiazhuang, Hebei, P. R. China.

* Correspondence: Dong-lai Wang, Department of Orthopedics, The Fourth Hospital of Hebei Medical University, 12 Health Road, Shijiazhuang, Hebei 050011, P. R. China (e-mail: dlwdl666@163.com).

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Exclusion criteria were: age < 18 years or > 80 years, poor cardiac function, pulmonary function and liver and kidney function, and inability to tolerate surgery and patients with open fractures requiring emergency orthopedic surgery. Patients with preoperative SSI were excluded. Before surgery, patients with other system infections (such as respiratory and urinary system infections) were excluded. Patients with unstable vital signs were excluded. Patients with malignant tumors in the past 5 years were excluded. Patients with a history of neurological or mental illness were excluded. The researcher believes that the patient is unsuitable for this study. The patient recruitment process and specific measures are shown in Figure 1.

This study was approved by the Ethics Committee of Fourth Hospital of Hebei Medical University, and all patients and their families gave informed consent and signed written informed consent.

2.2. Judgment of postoperative SSI

Observe for post-operative wound infection based on the Surgical Site Infection Prevention Guidelines.[12] All participants underwent orthopedic surgery to clean the prosthesis and were assessed for postoperative SSI.

2.3. Clinical characteristics indicators

General information such as gender (male/female), age (<65/≥65), marriage (yes/no/divorce), diagnosis (fracture/osteonecrosis of the femoral head (ONFH)/removable internal fixation/slipped discs/others), surgical site (spine/arthrosis/trauma/others), and anesthesia method (general/local), glutamic-pyruvic transaminase (ALT), albumin, globulin, creatinine, blood urea nitrogen (BUN), glucose were recorded.

2.4. Statistical methods

Data statistics are presented as sample size and percentage. Pearson chi-square test was used to analyze the relationship between postoperative SSI and related clinical factors in patients. The severity of multicollinearity was determined by calculating the variance inflation factor using a multifactor linear regression model that included all clinically pertinent variables. Univariate and multivariate logistic regression analyses were used to calculate odds ratios (ORs) for each variable based on their statistical results.

Since our study focused on the effect of the surgical site on SSI after orthopedic surgery, we made a judgment by linear fitting. Finally, we constructed receiver operating characteristic (ROC) curves. We applied the area under the curve (AUC) to assess the accuracy and sensitivity of the surgical site for diagnosing the degree of orthopedic surgical wound infection.

All statistical analyses were performed using SPSS software (version 24.0; IBM Corporation, New York). $P < .05$ was considered statistically significant.

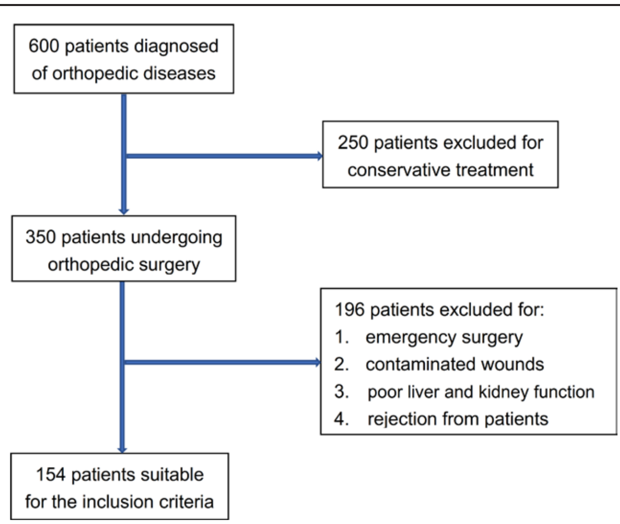

Figure 1. The patient recruitment process and specific measures.

3. Results

3.1. Clinical baseline information

Utilizing clinical feature indicators, Figure 2's proportion map was created. Figure 2A shows that women are more likely than men to experience SSI following orthopedic surgery. Figure 2B shows that HIV patients under 65 are more likely to experience SSI than patients 65 and older. Figure 2C shows that divorced patients are more likely to experience SSI than married and unmarried patients. Figure 2D shows that patients with slipped discs are more likely to experience SSI following orthopedic surgery than patients with fractures, ONFH, and removable internal fixation (Fig. 2F).

3.2. Chi-square result

Pearson's chi-square test results summarized the relationship between relevant parameters of patients and the occurrence of SSI after orthopedic surgery. Among them, sex ($P = .005$), age ($P = .027$), marriage ($P < .001$), diagnosis ($P = .034$), and surgical site ($P < .001$) were significantly associated with SSI after orthopedic surgery. However, there was no significant correlation between the anesthesia method ($P = .221$), glutamic-pyruvic transaminase (ALT) ($P = .677$), albumin ($P = .483$), globulin ($P = .239$), creatinine ($P = .826$), BUN ($P = .826$), glucose ($P = .983$), and SSI after orthopedic surgery (Table 1).

3.3. Multiple linear regression

Association between relevant parameters and SSI by multiple linear regression analysis. Surgical site ($P = .025$) was significantly associated with SSI after orthopedic surgery. However, there was no significant correlation between other relevant parameters and postoperative incision infection after orthopedic surgery (Table 2).

3.4. Univariate logistic proportional regression analysis

The results of univariate logistic regression are shown in Table 3, together with the ORs and 95% confidence intervals (95% CIs) for the study subjects. SSI after orthopedic surgery in patients had a significant association with the following factors, including sex (female vs Male, OR = 3.783, 95% CI: 1.427–10.029, $P = .007$), age (≥ 65 vs < 65, OR = 2.463, 95% CI: 1.094–5.545, $P = .029$), marriage [(Yes vs No, OR = 0.516, 95% CI: 0.238–1.119, $P < .001$), (divorced vs No, OR = 9.775, 95% CI: 2.953-32.352, $P < .001$)], diagnosis [ONFH vs fracture, OR = 2.500, 95% CI: 0.877-7.130, $P = .042$), (removable internal fixation vs fracture, OR = 3.250, 95% CI: 1.190-8.877, $P = .042$), (slipped discs vs fracture, OR = 4.694, 95% CI: 1.613-13.661, $P = .042$), (others vs fracture, OR = 1.950, 95% CI: 0.743-5.117, $P = .042$)], surgical site [(arthrosis vs spine, OR = 1.971, 95% CI: 0.454–8.551, $P = .001$), (trauma vs spine, OR = 6.711, 95% CI: 1.827–24.650, $P = .001$), (others vs spinal, OR = 1.417, 95% CI: 0.273–7.342, $P = .001$)]. There was

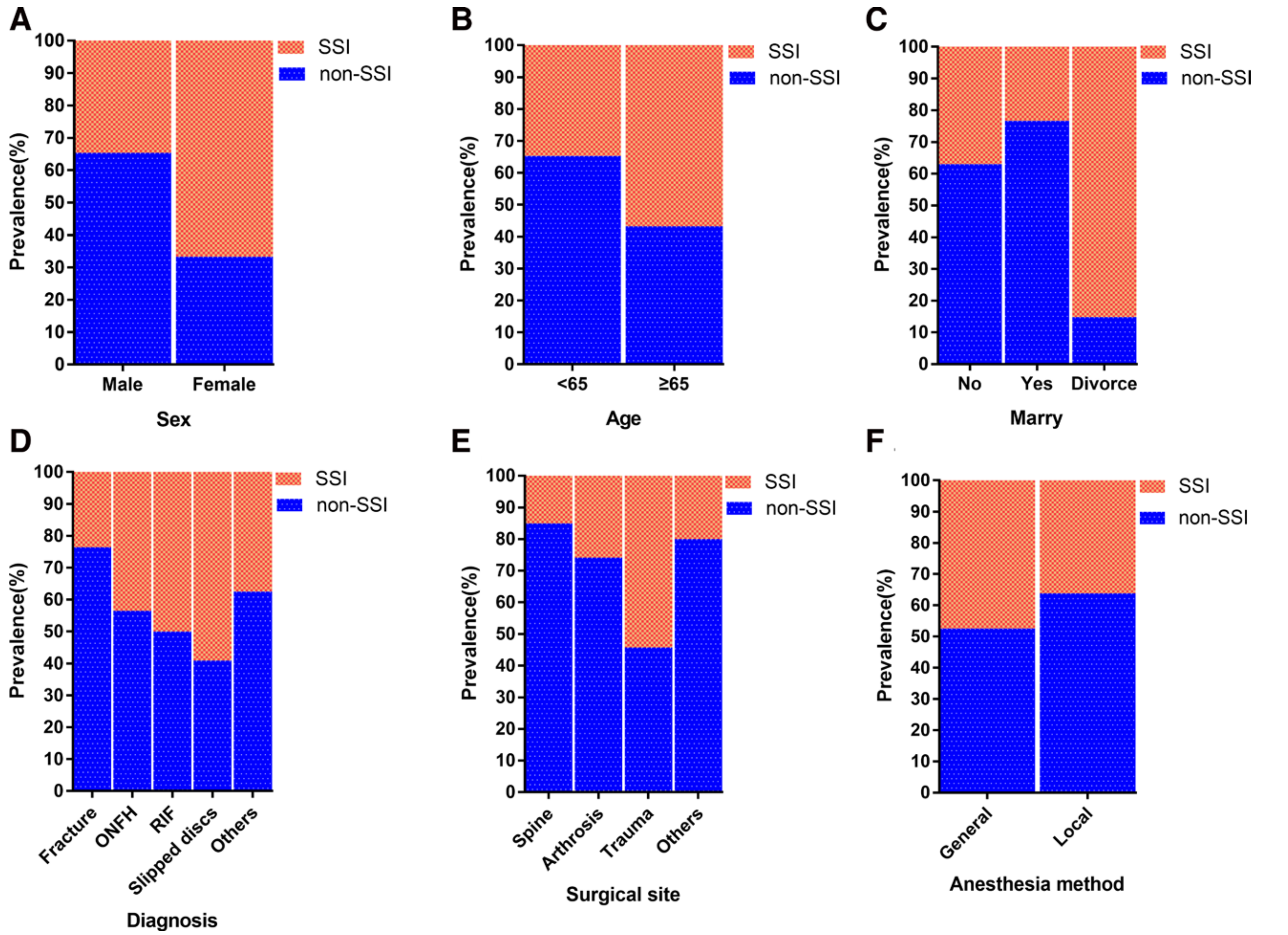

Figure 2. The proportion map was made using clinical feature indicators. (A) Sex. (B) Age. (C) Marry. (D) Diagnosis. (E) Surgical site. (F) Anesthesia method.

no significant correlation between anesthesia, glutamic-pyruvic transaminase (ALT), albumin, globulin, creatinine, BUN, glucose, and postoperative incision infection in orthopedic surgery ($P > .05$) (Table 3).

3.5. Multivariate logistic proportional regression analysis and linear fitting

Effect of relevant parameters on SSI based on multivariate logistic proportional regression analysis. In terms of multivariate logistic regression level, surgical site (OR = 1.665, 95% CI: 1.061–2.611, $P = .027$) was significantly associated with the occurrence of SSI after orthopedic surgery (Table 4). By linear fitting analysis, the surgical site was positively correlated with SSI (abscissa 1 represents spinal surgery, 2 represents joint surgery, 3 represents trauma surgery, and 4 represents surgery at other sites. Ordinate from 1 to 2 represents an increasing incidence of SSI) (Fig. 3).

3.6. ROC curve

ROC curves were constructed to determine the effect of the surgical site on SSI after orthopedic surgery in patients, and the AUC was used to determine the degree of confidence: surgical site (AUC = 0.577, 95% CI = 0.487–0.0.666) (Fig. 4).

4. Discussion

In this study, the Pearson chi-square test showed that surgical site (OR = 1.665, 95% CI: 1.061–2.611, $P = .027$) was significantly associated with SSI after orthopedic surgery. And "trauma" is more likely to develop SSI than spine, arthrosis, and others.

In recent years, with the increase in vehicles, the number of patients undergoing orthopedic surgery due to bone trauma and bone diseases has increased, and postoperative complications have also increased.[13] However, there are few studies on the effect of the surgical site on the occurrence of postoperative SSI, and this study found a positive correlation between surgical site (spine/arthrosis/trauma/others) and the occurrence of SSI in patients.[14] The reasons may be: that spinal and joint surgical incisions are cleaner, and most trauma surgeries are type III incisions, with an extensive range of surgical invasion, resulting in more soft tissue damage, thereby increasing the incidence of SSI.[15] Orthopedic "trauma" surgery patients become a population with nosocomial infections because of the relative length of orthopedic surgery, the widespread use of orthopedic implants, and the many invasive factors.[6] The higher infection rate of the surgical site in arthroplasty may be related to the more incredible surgical trauma, and postoperative local blood supply is affected to a certain extent and is not conducive to postoperative healing and other reasons.

Orthopedic trauma surgery in patients is more likely to develop SSI than the spine, arthrosis, etc. The incidence of post-traumatic infection following open fractures is 7.6%.[16] The types of trauma can be divided into open fracture, scald, cut injury, or damaged injury. Risk factors for SSIs include Gustilo grade, duration of wound exposure, wound size, whether debridement surgery is timely, whether prophylactic antibiotics are used, duration of surgery, season, and length of hospital stay.[17]

Table 1

Relevant characteristics of patients and SSI.

	Parameters		SSI No (%)	SSI Yes (%)	P
Sex	Male	133	87(56.5%)	46(29.9%)	.005*
	Female	21	7(4.5%)	14(9.1%)	
Age	<65	124	81(52.6%)	43(27.9%)	.027*
	≥65	30	13(8.4%)	17(11.0%)	
Marry	No	54	34(22.1%)	20(13.0%)	<.001*
	Yes	73	56(36.4%)	17(11.0%)	
	Divorce	27	4(2.6%)	23(14.9%)	
Diagnosis	Fracture	51	39(25.3%)	12(7.8%)	.034*
	ONFH	23	13(8.4%)	10(6.5%)	
	Removable internal fixation	26	13(8.4%)	13(8.4%)	
	Slipped discs	22	9(5.8%)	13(8.4%)	
	Others	32	20(13.0%)	12(7.8%)	
Surgical site	Spine	20	17(11.0%)	3(1.9%)	<.001*
	Arthrosis	31	23(14.9%)	8(5.2%)	
	Trauma	83	38(24.7%)	45(29.2%)	
	Others	20	16(10.4%)	4(2.6%)	
Anesthesia method	General	38	20(13.0%)	18(11.7%)	.221
	Local	116	74(48.1%)	42(27.3%)	
ALT	<33.20 U/L	93	58(37.7%)	35(22.7%)	.677
	≥33.20 U/L	61	36(23.4%)	25(16.2%)	
Albumin	<44.14 g/L	87	51(33.1%)	36(23.4%)	.483
	≥44.14 g/L	67	43(27.9%)	24(15.6%)	
Globulin	<29.27 g/L	81	53(34.4%)	28(18.2%)	.239
	≥29.27 g/L	73	41(26.6%)	32(20.8%)	
Creatinine	<69.91 μmol/L	83	50(32.5%)	33(21.4%)	.826
	≥69.91 μmol/L	71	44(28.6%)	27(17.5%)	
BUN	<5.50 mmol/L	83	50(32.5%)	33(21.4%)	.826
	≥5.50 mmol/L	71	44(28.6%)	27(17.5%)	
Glucose	<6.11 mmol/L	90	55(35.7)	35(22.7%)	.983
	≥6.11 mmol/L	64	39(25.3%)	25(16.2%)	

Pearson's chi-squared test was used.

ALT = glutamic-pyruvic transaminase, BUN = blood urea nitrogen, ONFH = osteonecrosis of the femoral head, SSI = surgical site infection.

*P < .05.

Table 2

Association between characteristics and SSI via Multiple linear regression analysis.

Characteristics	SSI β	SSI P	SSI VIF
Sex	0.148	.088	0.1255
Age	0.076	.379	1.263
Marry	0.162	.070	1.338
Diagnosis	0.136	.139	1.417
Surgical site	0.189	.025*	1.175
Anesthesia method	−0.065	.438	1.172
ALT	0.037	.657	1.194
Albumin	−0.086	.308	1.191
Globulin	0.146	.072	1.097
Creatinine	−0.028	.733	1.098
BUN	−0.041	.606	1.060
Glucose	−0.028	.732	1.132

β: parameter estimate.

*P < .05.

ALT = glutamic-pyruvic transaminase, BUN = blood urea nitrogen, SSI = surgical site infection, VIF = variance inflation factor.

With the prolongation of survival time of patients, their age increases, their immune function gradually decreases, and their underlying diseases (such as diabetes, uremia, etc) increase, so elderly orthopedic "trauma" surgery patients are more likely to develop SSI.[18]

SSI after "trauma" surgery is one of the severe complications and may reduce patients' quality of life. Serious SSIs may also prolong hospital stays, require surgical debridement or antibiotic treatment, and increase costs for patients and healthcare systems.[19]

The most common pathogens of postoperative SSI after "trauma" surgery are positive bacteria such as Staphylococcus aureus. Broad-spectrum antibacterial drugs such as cefuroxime are mainly used to prevent and treat surgical incision infections in clinical practice.[20] Standardized perioperative management can reduce the incidence of SSI in "trauma" patients. When patients develop an infection after spinal "trauma" surgery, removable internal fixation (maintaining early spinal stability) is generally not considered, and drainage and antibiotics are usually selected. Artificial joint replacement is the most effective treatment for severe joint diseases. SSI after joint surgery is a serious "catastrophic" complication, which aggravates the physical pain and economic burden of patients and affects postoperative functional recovery.[21] At the same time, attention should also be paid to the type of antibiotics, administration time, and addition of antibiotics to the bone cement in the perioperative period.[22] Early debridement, wound coverage, and 2-stage operation can significantly reduce the incidence rate of wound SSI after "trauma" surgery.

Our study has several limitations. Currently, this study is only based on clinical investigation and data analysis, and no basic experiment has been carried out for observation. The biological mechanisms by which the surgical site

Table 3

Correlative parameters' effect on SSI based on univariate logistic proportional regression analysis.

	Parameters		SSI OR	SSI 95%CI	*P*
Sex	Male	133	1		.007*
	Female	21	3.783	1.427–10.029	
Age	<65	124	1		.029*
	≥65	30	2.463	1.094–5.545	
Marry	No	54	1		<.001*
	Yes	73	0.516	0.238–1.119	
	Divorce	27	9.775	2.953–32.352	
Diagnosis	Fracture	51	1		.042*
	ONFH	23	2.500	0.877–7.130	
	Removable internal fixation	26	3.250	1.190–8.877	
	Slipped discs	22	4.694	1.613–13.661	
	Others	32	1.950	0.743–5.117	
Surgical site	Spine	20	1		.001*
	Arthrosis	31	1.971	0.454–8.551	
	Trauma	83	6.711	1.827–24.650	
	Others	20	1.417	0.273–7.342	
Anesthesia method	General	38	1		.223
	Local	116	0.631	0.301–1.323	
ALT	<33.20 U/L	93	1		.677
	≥33.20 U/L	61	1.151	0.594–2.228	
Albumin	<44.14 g/L	87	1		.483
	≥44.14 g/L	67	0.791	0.410–1.525	
Globulin	<29.27 g/L	81	1		.240
	≥29.27 g/L	73	1.477	0.771–2.832	
Creatinine	<69.91 μmol/L	83	1		.826
	≥69.91 μmol/L	71	0.930	0.485–1.781	
BUN	<5.50 mmol/L	83	1		.826
	≥5.50 mmol/L	71	0.930	0.485–1.781	
Glucose	<6.11 mmol/L	90	1		.983
	≥6.11 mmol/L	64	1.007	0.522–1.943	

95% CI = 95% confidence interval, ALT = glutamic-pyruvic transaminase, BUN = blood urea nitrogen, ONFH = osteonecrosis of the femoral head, OR = odds ratio, SSI = surgical site infection.
*$P < .05$.

Table 4

The characteristics and their effect on SSI based on multivariate logistic proportional regression analysis.

Characteristics	SSI OR	SSI 95%CI	*P*
Sex	2.695	0.856–8.480	.090
Age	1.553	0.589–4.096	.374
Marry	1.683	0.947–2.989	.076
Diagnosis	1.211	0.927–1.581	.160
Surgical site	1.665	1.061–2.611	.027*
Anesthesia method	0.691	0.280–1.706	.423
ALT	1.200	0.540–2.666	.655
Albumin	0.665	0.305–1.453	.306
Globulin	2.009	0.941–4.290	.072
Creatinine	0.865	0.407–1.842	.708
BUN	0.839	0.401–1.753	.640
Glucose	0.879	0.408–1.892	.741

95% CI = 95% confidence interval, ALT = glutamic-pyruvic transaminase, BUN = blood urea nitrogen, OR = odds ratio, SSI = surgical site infection.
*$P < .05$.

affects SSI after orthopedic surgery in patients need further exploration.

5. Conclusions

In summary, the surgical site is an independent risk factor for SSI after orthopedic surgery in patients, and "trauma" is more likely to develop SSI than the spine, arthrosis, and others.

Author contributions

Conceptualization: Yingfa Feng, Qi Feng.
Data curation: Peng Guo, Dong-lai Wang.
Formal analysis: Yingfa Feng, Qi Feng, Peng Guo.
Project administration: Yingfa Feng.
Software: Peng Guo.
Writing – original draft: Yingfa Feng, Dong-lai Wang.
Writing – review & editing: Yingfa Feng.

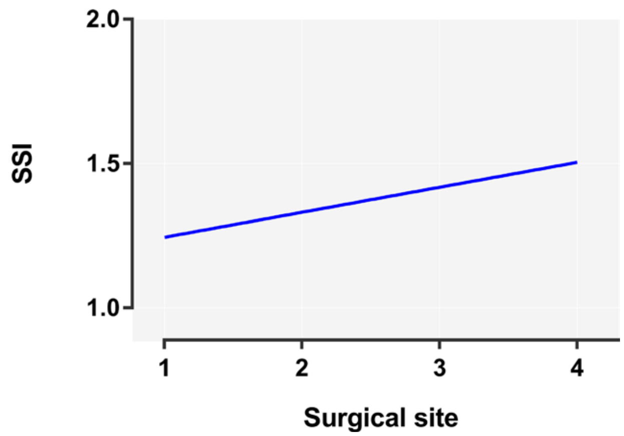

Figure 3. The linear fitting analysis showed that the surgical site was positively correlated with SSI. NOTE: abscissa 1 represents spinal surgery, 2 represents joint surgery, 3 represents trauma surgery, and 4 represents surgery at other sites. Ordinate from 1 to 2 represents an increasing incidence of SSI. SSI = surgical site infection.

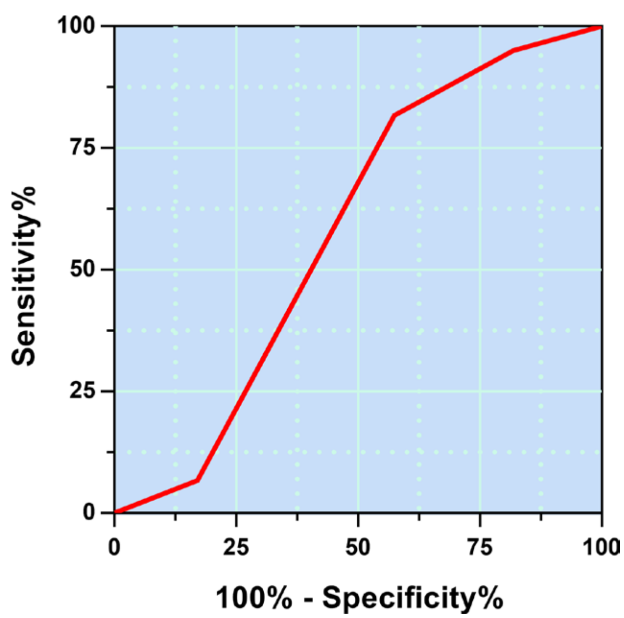

Figure 4. ROC curves were constructed to determine the effect of the surgical site on SSI after orthopedic surgery in immunocompromised patients. ROC = receiver operating characteristic, SSI = surgical site infection.

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