

Research Article

Association of Pre-Operative Glycaemic Control with Surgical Site Infection Following Orthopaedic Implant Surgery

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ABSTRACT

Background: Poor preoperative glycaemic control may increase the risk of surgical site infection (SSI) following orthopaedic implant surgery. This study aimed to assess the association between preoperative glycaemic parameters and SSI.

Materials and Methods: This prospective observational study included 140 patients undergoing orthopaedic implant surgery. Patients were categorized as non-diabetic (n=60), diabetic with adequate glycaemic control (n=40), and diabetic with inadequate glycaemic control (n=40). Preoperative HbA1c, fasting blood glucose, and postprandial blood glucose levels were assessed and correlated with postoperative SSI.

Results: SSI occurred in 18 (12.9%) patients, with infection rates of 5.0%, 10.0%, and 27.5% across the three groups, respectively. Mean HbA1c was higher among patients with SSI than those without infection ($8.1 \pm 1.6\%$ versus $6.4 \pm 1.4\%$). HbA1c showed the strongest positive correlation with SSI ($r=0.382$), followed by fasting ($r=0.326$) and postprandial blood glucose ($r=0.294$).

Conclusion: Inadequate preoperative glycaemic control was associated with increased SSI following orthopaedic implant surgery. Glycaemic optimization and perioperative monitoring may help reduce postoperative infections.

Keywords: Glycaemic Control, HbA1c, Surgical Site Infection, Orthopaedic Implant Surgery, Diabetes Mellitus.

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycaemia and represents a growing public health concern worldwide. Its clinical consequences extend beyond metabolic disturbances, particularly among patients undergoing orthopaedic surgical procedures [1]. Poor glycaemic control has been associated with impaired wound healing, delayed fracture union, nonunion, surgical site infections (SSIs), and implant-related complications. These adverse outcomes are attributed to microvascular dysfunction, oxidative stress, impaired immune responses, and the accumulation of advanced glycation end-products (AGEs), which interfere with tissue repair and bone metabolism [1]. Diabetes also adversely affects bone regeneration and fracture healing, increasing the likelihood of

delayed union and other postoperative complications [2,3]. Consequently, preoperative glycaemic assessment and optimization are important considerations for improving postoperative outcomes following orthopaedic surgery. Surgical site infection remains a significant complication following orthopaedic implant surgery despite advances in surgical techniques, antimicrobial prophylaxis, and infection prevention measures. The presence of implants, including plates, screws, intramedullary nails, and prosthetic devices, facilitates bacterial adherence and biofilm formation, making implant-associated infections particularly difficult to manage [4]. These infections may lead to prolonged hospitalization, repeated surgical interventions, delayed fracture healing, implant failure, and increased healthcare expenditure [5]. Hyperglycaemia further

increases susceptibility to infection by impairing immune function, reducing tissue perfusion, and compromising wound healing mechanisms. Studies involving total knee arthroplasty have demonstrated an increased risk of postoperative infection among diabetic patients [6]. Similarly, Iorio et al. [7] investigated the relationship between diabetes, HbA1c, and infection following total joint arthroplasty, highlighting the clinical importance of glycaemic assessment in orthopaedic patients. Preoperative glycaemic status is commonly assessed using fasting blood glucose, postprandial blood glucose, and glycated haemoglobin (HbA1c). HbA1c reflects average blood glucose concentrations over approximately two to three months and serves as an indicator of long-term glycaemic control. Previous studies have demonstrated an association between elevated preoperative HbA1c levels and increased postoperative infection risk. Hikata et al. [8] reported that elevated HbA1c was associated with surgical site infection following posterior thoracic and lumbar spinal instrumentation surgery. Similarly, Gabriel et al. [9] observed an increased likelihood of SSI among patients with preoperative HbA1c levels of 8.0% or higher following noncardiac surgery. Reich et al. [10] also identified poor diabetic control as an important predictor of surgical site infection in orthopaedic trauma patients. However, evidence regarding the association between preoperative glycaemic control and SSI following orthopaedic implant surgery remains inconsistent. Greene et al. [11] reported that HbA1c was not a reliable independent predictor of surgical site infection among orthopaedic trauma patients. In contrast, Anderson et al. [12] identified admission hyperglycaemia as a significant risk factor for deep surgical site infection in orthopaedic trauma patients. These differences may reflect variations in patient characteristics, fracture severity, surgical procedures, implant types, and glycaemic assessment methods. Furthermore, a universally accepted preoperative HbA1c threshold for predicting SSI across orthopaedic implant procedures remains inadequately established. Considering the clinical burden of

surgical site infections and the potential influence of hyperglycaemia on postoperative recovery, evaluating preoperative glycaemic status may help identify patients at increased risk of infection. Therefore, the present study was undertaken to evaluate the association between preoperative glycaemic control and surgical site infection following orthopaedic implant surgery, with the aim of improving risk stratification, perioperative management, and postoperative outcomes.

MATERIALS AND METHODS

This hospital-based prospective observational study was conducted in the Department of Orthopaedics at a tertiary care teaching hospital over a period of 18 months to evaluate the association between preoperative glycaemic control and surgical site infection (SSI) following orthopaedic implant surgery. A total of 140 adult patients undergoing elective or emergency orthopaedic implant surgery were enrolled consecutively. Both diabetic and non-diabetic patients were included.

Inclusion Criteria

1. Patients aged 18 years and above.
2. Patients undergoing orthopaedic surgery requiring implant placement.
3. Patients willing to provide written informed consent and participate in postoperative follow-up.

Exclusion Criteria

1. Patients with pre-existing infection at the operative site.
2. Patients undergoing surgery for active osteomyelitis or infected nonunion.
3. Patients undergoing revision surgery for established implant-related infection.
4. Patients with significant immunodeficiency or receiving long-term immunosuppressive therapy.
5. Patients unwilling to participate or unavailable for follow-up.

Study Groups

Patients were categorized into three groups according to diabetic status and preoperative glycaemic control.

Group	Criteria
Group A	Non-diabetic patients
Group B	Diabetic patients with adequate glycaemic control (HbA1c <7%)
Group C	Diabetic patients with inadequate glycaemic control (HbA1c ≥7%)

Data Collection and Preoperative Assessment

After obtaining written informed consent, demographic and clinical details, including age, sex, body mass index (BMI), smoking history, diabetic status, duration of diabetes, comorbidities, and antidiabetic treatment, were recorded. Preoperative glycaemic assessment included fasting blood glucose (FBG), postprandial blood glucose (PPBG), and glycated haemoglobin (HbA1c). HbA1c levels were used to categorize glycaemic control among diabetic patients.

Surgical Procedure and Perioperative Management

Patients underwent orthopaedic implant surgery according to clinical indications, including fracture fixation using plates, screws, or intramedullary nails. Standard protocols for surgical asepsis, antibiotic prophylaxis, glycaemic monitoring, and postoperative wound care were followed. Surgical site, implant type, duration of surgery, and relevant intraoperative findings were documented.

Postoperative Assessment and Follow-up

Patients were monitored for surgical site infection during hospitalization and postoperative follow-up for 90 days. Wounds were assessed for erythema, swelling, tenderness, purulent discharge, and wound dehiscence. SSI was classified as superficial incisional, deep incisional, or organ/space infection according to Centers for Disease Control and Prevention (CDC) criteria. Microbiological cultures were obtained whenever clinically indicated. Infection rates were compared among the three groups.

Outcome Measures

The primary outcome was the incidence of SSI and its association with preoperative HbA1c levels. Secondary outcomes included the association of FBG and PPBG with SSI, comparison of infection rates among the three groups, and evaluation of other potential infection-related risk factors.

Statistical Analysis

Data were analyzed using SPSS. 26 statistical software. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages. One-way ANOVA or Kruskal–Wallis tests were used for continuous variables, and Chi-square or Fisher's exact tests for categorical variables. Logistic regression

analysis was used to assess the association between glycaemic parameters and SSI, with adjustment for potential confounders where feasible. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 140 patients were divided into Group A (non-diabetic, $n=60$), Group B (adequate glycaemic control, $n=40$), and Group C (inadequate glycaemic control, $n=40$). Mean age was significantly higher in Group C (51.4 ± 13.1 years) compared to Group B (47.6 ± 11.8 years) and Group A (43.2 ± 12.5 years) ($p=0.006$). Sex distribution, BMI, and smoking history were comparable among the groups ($p>0.05$), whereas hypertension was significantly more prevalent in Group C (40.0%) ($p=0.018$) (Table 1). Preoperative glycaemic parameters differed significantly among the groups. Mean HbA1c was highest in Group C ($8.6 \pm 1.1\%$), followed by Group B ($6.4 \pm 0.3\%$) and Group A ($5.5 \pm 0.4\%$). Similarly, fasting blood glucose (168.5 ± 32.6 vs. 116.8 ± 15.4 vs. 94.6 ± 11.8 mg/dL) and postprandial blood glucose (238.6 ± 45.2 vs. 162.5 ± 24.8 vs. 128.4 ± 18.6 mg/dL) were significantly higher in Group C ($p<0.001$) (Table 2). The overall incidence of surgical site infection (SSI) was 12.9% (18/140). SSI incidence was significantly higher in Group C (27.5%) compared to Group B (10.0%) and Group A (5.0%) ($p=0.003$), indicating an association between inadequate glycaemic control and increased SSI occurrence (Table 3, Figure 1). Patients with SSI had significantly higher mean HbA1c ($8.1 \pm 1.6\%$ vs. $6.4 \pm 1.4\%$; $p<0.001$), fasting blood glucose (156.8 ± 38.4 vs. 118.6 ± 32.5 mg/dL; $p=0.001$), and postprandial blood glucose (224.5 ± 52.6 vs. 165.8 ± 48.2 mg/dL; $p<0.001$) compared to those without SSI (Table 4). Among 18 SSI cases, superficial incisional SSI was most common (66.7%), followed by deep incisional (27.8%) and organ/space SSI (5.6%). Group C accounted for the majority of deep incisional infections (4/5) and the only organ/space infection. However, the distribution of SSI types did not differ significantly among the groups ($p=0.858$) (Table 5, Figure 2). Correlation analysis revealed significant positive associations between SSI occurrence and HbA1c ($r=0.382$), fasting blood glucose ($r=0.326$), and postprandial blood glucose ($r=0.294$), with all p-values <0.001 . HbA1c demonstrated the strongest correlation with SSI occurrence (Table 6, Figure 3).

Table 1. Comparison of Demographic and Baseline Characteristics among the Study Groups

Parameters	Group A (n=60)	Group B (n=40)	Group C (n=40)	p-value	Statistical test
Mean age (years)	43.2 ± 12.5	47.6 ± 11.8	51.4 ± 13.1	0.006	One-way ANOVA
Sex				0.876	Pearson Chi-square test
Male	39 (65.0%)	25 (62.5%)	24 (60.0%)		
Female	21 (35.0%)	15 (37.5%)	16 (40.0%)		
Mean BMI (kg/m ²)	24.6 ± 3.2	25.4 ± 3.5	26.1 ± 3.8	0.105	One-way ANOVA
Smoking history	12 (20.0%)	10 (25.0%)	14 (35.0%)	0.236	Pearson Chi-square test
Hypertension	9 (15.0%)	12 (30.0%)	16 (40.0%)	0.018	Pearson Chi-square test

Table 2. Comparison of Preoperative Glycaemic Parameters among the Study Groups

Glycaemic parameters	Group A (n=60)	Group B (n=40)	Group C (n=40)	p-value	Statistical test
Mean HbA1c (%)	5.5 ± 0.4	6.4 ± 0.3	8.6 ± 1.1	<0.001	One-way ANOVA
Mean fasting blood glucose (mg/dL)	94.6 ± 11.8	116.8 ± 15.4	168.5 ± 32.6	<0.001	One-way ANOVA
Mean postprandial blood glucose (mg/dL)	128.4 ± 18.6	162.5 ± 24.8	238.6 ± 45.2	<0.001	One-way ANOVA

Table 3. Association of Preoperative Glycaemic Control with Surgical Site Infection

Study groups	SSI present	SSI absent	Total	p-value	Statistical test
Group A – Non-diabetic	3 (5.0%)	57 (95.0%)	60	0.003	Pearson Chi-square test
Group B – Adequate glycaemic control	4 (10.0%)	36 (90.0%)	40		
Group C – Inadequate glycaemic control	11 (27.5%)	29 (72.5%)	40		
Total	18 (12.9%)	122 (87.1%)	140		

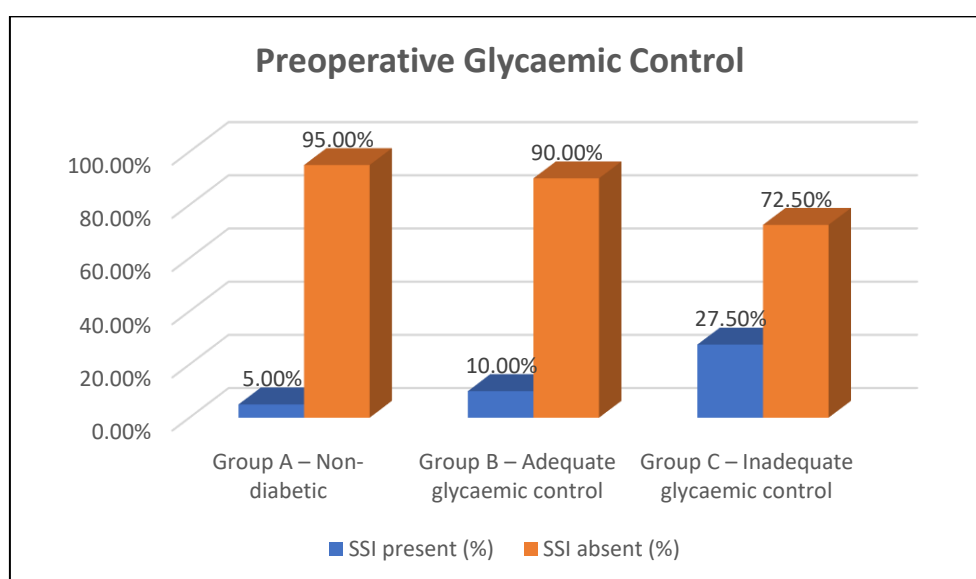


Figure 1. Association of Preoperative Glycaemic Control with Surgical Site Infection

Table 4. Comparison of Preoperative Glycaemic Parameters between Patients With and Without Surgical Site Infection

Parameters	SSI present (n=18)	SSI absent (n=122)	p-value	Statistical test
Mean HbA1c (%)	8.1 ± 1.6	6.4 ± 1.4	<0.001	Welch's t-test
Mean fasting blood glucose (mg/dL)	156.8 ± 38.4	118.6 ± 32.5	0.001	Welch's t-test
Mean postprandial blood glucose (mg/dL)	224.5 ± 52.6	165.8 ± 48.2	<0.001	Welch's t-test

Table 5. Distribution of Types of Surgical Site Infection According to Preoperative Glycaemic Control

Type of SSI	Group A (n=3)	Group B (n=4)	Group C (n=11)	Total (n=18)	p-value	Statistical test
Superficial incisional SSI	3 (100.0%)	3 (75.0%)	6 (54.5%)	12 (66.7%)	0.858	Fisher-exact test
Deep incisional SSI	0 (0.0%)	1 (25.0%)	4 (36.4%)	5 (27.8%)		
Organ/space SSI	0 (0.0%)	0 (0.0%)	1 (9.1%)	1 (5.6%)		
Total	3 (100%)	4 (100%)	11 (100%)	18 (100%)		

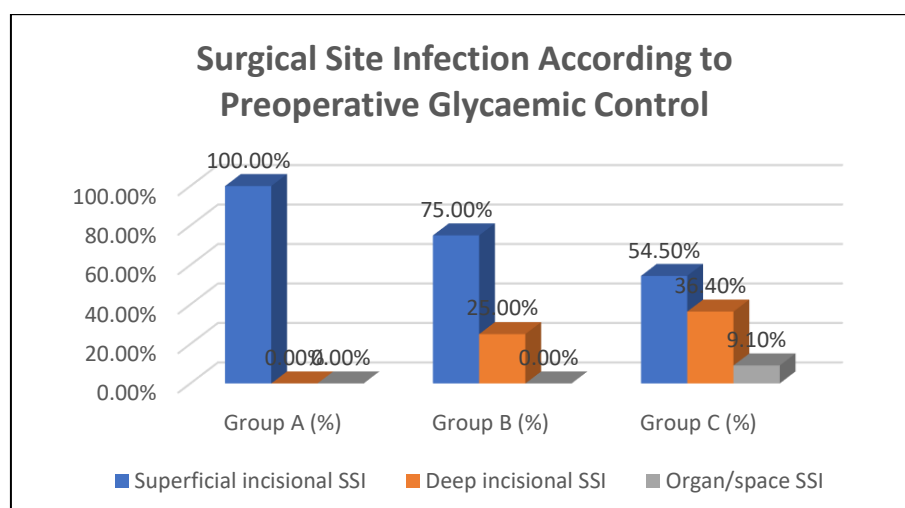


Figure 2. Distribution of Types of Surgical Site Infection According to Preoperative Glycaemic Control

Table 6. Correlation of Preoperative Glycaemic Parameters with Surgical Site Infection (n=140)

Parameters	Correlation coefficient (r)	p-value	Statistical test
HbA1c vs SSI	0.382	<0.001	Pearson Correlation
Fasting blood glucose vs SSI	0.326	<0.001	
Postprandial blood glucose vs SSI	0.294	<0.001	

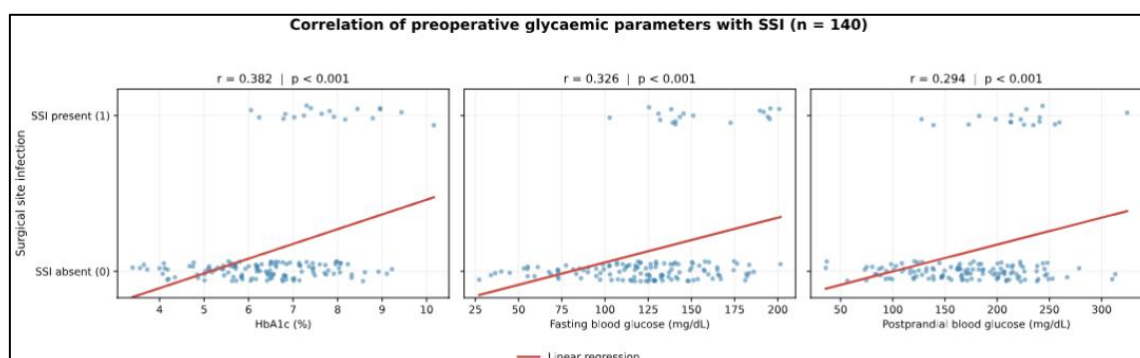


Figure 3. Correlation of Preoperative Glycaemic Parameters with Surgical Site Infection (n=140)

DISCUSSION

The present study included 140 patients, comprising 60 (42.9%) non-diabetic patients, 40 (28.6%) diabetic patients with adequate glycaemic control, and 40 (28.6%) diabetic patients with inadequate glycaemic control. The mean HbA1c levels were $5.5 \pm 0.4\%$, $6.4 \pm 0.3\%$, and $8.6 \pm 1.1\%$, respectively. Giori et al. [13] evaluated 404 diabetic patients undergoing total joint arthroplasty and reported that surgery was delayed in 59 patients because HbA1c exceeded 7%. Of these, only 35 (59%) subsequently achieved the target. Their findings highlighted the difficulty of achieving strict preoperative glycaemic control. In the present study, SSI occurred in 18 (12.9%) patients, with infection rates of 5.0%, 10.0%, and 27.5% in Groups A, B, and C, respectively ($p=0.003$). Kheir et al. [14] evaluated 24,857 total joint arthroplasties and reported an overall periprosthetic joint infection rate of 1.59%, with significantly higher infection rates among diabetic patients than non-diabetic patients (2.39% versus 1.46%, $p=0.001$). Similarly, Richards et al. [15] reported SSI in 21 (2.7%) of 790 orthopaedic trauma patients. These findings supported the association between impaired glycaemic control and postoperative infection. The mean HbA1c was higher among patients who developed SSI than among those without infection ($8.1 \pm 1.6\%$ versus $6.4 \pm 1.4\%$, $p<0.001$). Furthermore, 11 (61.1%) of the 18 infected patients belonged to the inadequately controlled diabetic group. Giori et al. [13] reported that among 59 patients whose surgery was delayed because HbA1c exceeded 7%, only 35 (59%) achieved the recommended target after a median of 141 days. Although our findings suggested increased SSI with HbA1c $\geq 7\%$, their study emphasized the practical limitations of strict glycaemic targets before surgery. In the present study, mean fasting blood glucose was higher among patients with SSI than those without SSI (156.8 ± 38.4 versus 118.6 ± 32.5 mg/dL). Similarly, mean postprandial glucose was 224.5 ± 52.6 mg/dL and 165.8 ± 48.2 mg/dL, respectively. Richards et al. [15] reported SSI rates of 4.4% among patients with repeated glucose levels ≥ 200 mg/dL compared with 1.6% among those without repeated hyperglycaemia ($p=0.02$). Repeated hyperglycaemia independently predicted SSI (OR 2.7; 95% CI 1.1–6.7). Likewise, Kheir et al. [14] identified postoperative blood glucose of 137 mg/dL as an optimal threshold for predicting periprosthetic joint infection. These findings were consistent

with the higher infection frequency observed among hyperglycaemic patients in the present study. Among the 18 patients with SSI, 12 (66.7%) developed superficial incisional infection, 5 (27.8%) developed deep incisional infection, and 1 (5.6%) developed organ/space infection. In Group C, 4 (36.4%) patients with SSI developed deep infection and 1 (9.1%) developed organ/space infection. Kheir et al. [14] demonstrated an association between postoperative hyperglycaemia and periprosthetic joint infection, while Richards et al. [15] reported increased SSI risk with perioperative hyperglycaemia. Although their infection classifications differed, both studies highlighted the clinical importance of hyperglycaemia in postoperative orthopaedic infections. The present study demonstrated positive correlations between SSI and HbA1c ($r=0.382$), fasting blood glucose ($r=0.326$), and postprandial blood glucose ($r=0.294$), with $p<0.001$ for all parameters. Richards et al. [15] similarly reported that a hyperglycaemic index ≥ 1.76 was independently associated with SSI (OR 4.9; 95% CI 2.0–11.8). Kheir et al. [14] also observed a significant association between postoperative glucose levels and periprosthetic joint infection ($p=0.028$). These findings suggested that glycaemic parameters may be useful indicators of postoperative infection risk. Although poor glycaemic control was associated with higher SSI incidence in the present study, excessive glucose reduction may also be harmful. Johnston et al. [16] evaluated 2,285 cardiac surgical patients and reported postoperative hypoglycaemia in 488 (21.4%) patients. Hypoglycaemia was associated with increased operative mortality (adjusted OR 4.88; 95% CI 2.67–8.92).

CONCLUSION

The present study suggested that inadequate preoperative glycaemic control was associated with an increased incidence of surgical site infection following orthopaedic implant surgery. Elevated HbA1c, fasting blood glucose, and postprandial blood glucose levels were associated with higher postoperative infection rates. Preoperative glycaemic assessment and appropriate perioperative glucose management may help reduce infectious complications and improve surgical outcomes.

LIMITATIONS

The study was limited by its relatively small sample size, single-centre setting, and inclusion

of different orthopaedic implant procedures, which may affect generalizability.

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