

General

Incidence and Determinants of Surgical Site Infections in Upper Limb Surgeries: A Multicentric retrospective cohort Study from Tertiary Referral Hospitals in Jordan

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Keywords: Surgical site infection, upper limb surgery, orthopedic infections, incidence, risk factors, wound classification, prophylactic antibiotics

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Background

Surgical site infections (SSIs) are a major cause of complications during orthopedic surgeries. These infections increase the morbidity of patients. Although many studies have been conducted on SSI complications during lower limb surgeries, there is limited information on upper limb surgeries. Therefore, this paper sought to assess the incidence of SSI complications during upper limb surgeries and identify the associated risk factors. In addition, the impact of SSI complications was also assessed.

Methods

This was a retrospective cohort study conducted at a tertiary hospital from January 2024 to December 2025. In total, 546 patients who underwent upper limb surgeries were recruited into the study. Data was extracted from patients' medical records and analyzed using IBM SPSS Statistics software. SSI complications were defined as superficial or deep wound infections. Descriptive, bivariate, and stratified incidence analyses of the data was conducted. In addition, Chi-square and independent t-tests were used to test the associations at a significance level of 0.05.

Results

The total incidence of SSI was 5% (n = 28). No significant correlation was noted between SSI and age (p = 0.62), sex (p = 0.19), duration of surgery (p = 0.54), and overall antibiotic use (p = 0.07). Significant correlations were observed between SSI and surgical factors, including type of surgery (p < 0.0001), surgery classification (p < 0.0001), and wound classification (p = 0.004). The highest incidence of SSI was noted in emergency procedures (7.7%) and open wounds (5.1%). A significant correlation was also found between the type of prophylactic antibiotic used and SSI occurrence (p = 0.04). SSI was not significantly associated with prolonged hospital stay (p = 0.12) or increased admissions (p = 0.71).

Conclusion

The present study indicates that SSI is an uncommon but clinically relevant complication in upper limb surgeries, with an overall incidence of 5%. Emergency procedures and open wounds were strongly associated with infection risk, while patient related factors such as age and sex, as well as surgical duration, were not significant predictors. Although SSI was not linked to prolonged hospital stay or increased admissions in this cohort, the type of prophylactic antibiotic demonstrated a significant association with infection

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occurrence.

Keywords:

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INTRODUCTION

Surgical site infections (SSIs) have been recognized as one of the most prevalent and problematic postoperative complications of surgeries globally.¹ SSIs have been linked to substantial morbidity, prolonged recovery, and increased economic burden. In the most severe of cases, there is also the potential for functional impairment.² Even though there have been tremendous advancements in the field of surgery, sterilization, and perioperative care, SSIs have remained a persistent concern in the field of orthopedic surgery.³

The risk of SSIs in the field of orthopedic surgery is also influenced by several distinct factors. These include the high implant rates, the involvement of bone and soft tissue with varying degrees of vascularity, and the complexity of the procedures.⁴ While there has been substantial attention focused on the prevention of infections in lower limb surgeries, the same cannot be said for the upper limb.⁵ This is particularly important given the increasing volume of upper limb surgeries, including trauma-related procedures, reconstructive interventions, and soft tissue surgeries.⁶

Upper limb surgeries encompass a wide range of procedures with varying levels of complexity and infection risk.⁷ Trauma-related surgeries, for example, are often associated with open or contaminated wounds, which significantly increase susceptibility to infection.⁸ Similarly, hand soft tissue procedures may involve extensive tissue handling and exposure, while deformity correction and revision surgeries often require prolonged operative time and the use of implants.⁹ These factors collectively contribute to a heterogeneous risk profile for SSI in upper limb procedures.

Several patient-related and procedure-related factors have been implicated in the development of SSIs.¹⁰ Patient characteristics such as age, sex, and overall health status may influence susceptibility to infection, while surgical factors, including type of surgery, wound classification, duration of surgery, and use of instrumentation, play a critical role in determining infection risk.² Of these, the wound type and contamination level are of utmost importance since an open wound increases the chances of postoperative infections.¹¹

Apart from all these, the microbiological angle adds complexity to the issue of SSIs. The main causative agents of orthopedic infections are *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and gram-negative bacteria.¹² Infections caused by biofilm-producing bacteria are also an area of worry, especially in cases where orthopedic implants are used; such infections are harder to treat.^{13,14} An understanding of the microbiological angle in SSI cases is necessary to determine the treatment regimen for the patient.¹²

Prophylactic administration of antibiotics is an important aspect of preventing SSIs and is commonly used in the

operating theater.¹⁵ The effectiveness of the chosen prophylactic regimen will depend on the surgical procedure being performed as well as individual characteristics of the patient. In most cases, cephalosporins are prescribed as the primary antibiotic drug. For high-risk patients or those that may be carrying drug-resistant pathogens, broad-spectrum antibiotics like vancomycin are administered as preventive measures.¹⁶ The association between antibiotics and SSI outcomes is complicated, as antibiotics are usually selected based on personal preferences of the attending surgeon.¹⁷

Although SSIs are clinically important in orthopedics, there are some shortcomings that should be addressed regarding their incidence in the literature. First, the lack of information about the prevalence of SSIs during various upper limb surgery procedures, rather than a specific procedure, needs to be addressed. Second, the relationship among different risk factor categories for SSIs, including demographic, surgical, microbial, and antibiotic factors, requires investigation in the same research framework. Third, even though the majority of the existing studies were focused on assessing SSI risk factors, the prevalence of SSIs should also be assessed in other studies.

In light of the above, the aim of the current study is to determine the incidence of SSIs among patients undergoing upper limb surgery procedures.

METHODS

STUDY DESIGN AND SETTING

The design of the research involved conducting a retrospective cohort study at a tertiary care facility with high surgical caseloads, especially for orthopedic surgery cases. The main subjects in the study were the patients undergoing upper limb surgery. This is because one of the aims of the study was to determine the incidence rate of SSI in these patients.

This retrospective study was carried out over a **two-year period** from January 2024 to December 2025. All patients who met the criteria set out were included in the study population.

STUDY POPULATION

The population for the study comprised patients who underwent surgical procedures of the upper limb within the specified period. The surgical interventions included a broad spectrum of orthopedic surgeries such as trauma-related surgeries, deformity correction surgeries, soft tissue surgeries of the hands, revision surgeries, external fixation surgeries, osteoarthritis drainage surgeries, and shoulder surgeries.

Patients who underwent surgical interventions and had complete clinical records of perioperative and postopera-

tive details were included in the study population. Patients who had clear documentation of their infection status were only included for analysis. Patients who did not have complete records or clear documentation of their infection status were excluded from the study population. Patients who were lost to follow-up before the evaluation of their post-operative infections were also excluded from the population for the purpose of the study.

DATA COLLECTION AND MANAGEMENT

Data was also collected retrospectively from hospital electronic medical records, operative notes, and microbiology laboratory databases. To ensure data collection was standardized and consistent, a structured data collection tool was created by designing a data extraction tool using Google Forms. It was created with pre-defined data fields for all variables of interest. It was also essential to ensure that data was entered systematically and uniformly for all patients. Data was extracted from each patient's medical records and entered the Google Forms template. After data collection was complete, the data was extracted into a Microsoft Excel spreadsheet. Data cleaning was also essential to ensure data accuracy and consistency. It was done by removing duplicate data from the dataset, handling missing values where possible, correcting data inconsistencies in variables, and making categorical variables numerical. Categorical variables were coded into numerical form for data analysis purposes. In this case, sex was coded into either male or female, class of surgery was coded into elective or emergency surgery, and SSI was coded into a binary form. Continuous variables, including age, duration of surgery, and hospital stay, were assessed for plausibility and checked for outliers. Following data cleaning and preprocessing, the finalized dataset was imported into IBM SPSS Statistics software for statistical analysis.

VARIABLES AND DEFINITIONS

A comprehensive range of variables was included in the analysis. The variables were grouped into demographic variables, surgical variables, microbiological variables, antibiotic-related variables, and outcome variables.

The demographic variables included patient age and sex. The surgical variables included type of operation (elective or emergency), type of operation performed (trauma, deformity correction, hand soft tissue operations), use of instrumentation (use of metal implants, use of polymer implants, use of bone grafts, absence of instrumentation), type of wound (open wounds, semi-open wounds, arthroscopic wounds), and duration of operation in hours. The microbiological variables included culture results and the identification of causative pathogens such as *Staph. aureus*, *Pseudomonas*, *Escher. coli*, etc. The antibiotic-related variables included use of prophylactic antibiotics (yes/no), type of prophylactic antibiotics used, duration of antibiotics used during hospital stay, and antibiotics used at discharge.

The primary outcome of interest was surgical site infection (SSI). SSI was defined based on clinical documentation and/or microbiological confirmation recorded in the

patient's medical records. For analytical purposes, a binary variable was created, where patients with superficial or deep wound infections were classified as having SSI, while those without evidence of infection were classified as non-SSI. Secondary outcomes included duration of hospital stay, measured in days, and the number of hospital admissions related to the surgical procedure.

STATISTICAL ANALYSIS

All statistical analyses were performed using IBM SPSS Statistics. Data analysis followed a structured approach, including descriptive, bivariate, and stratified analyses, with a particular focus on estimating the incidence of SSI and identifying associated factors.

Continuous variables were described as mean and standard deviation, while categorical variables were described as frequency and percentage. Normality of continuous variables was checked by the Shapiro-Wilk test along with visual inspection of histogram and Q-Q plot. Incidence of SSI was calculated as the proportion of patients who acquired SSI to the total number of patients and is presented as a percentage.

Bivariate analysis was performed to test the association between independent variables and SSI. For categorical variables, the Chi-square test of independence was used; for continuous variables, the independent samples t-test and Mann-Whitney U test were used to compare between groups when variables were normally and not normally distributed, respectively. To further understand the distribution of SSI in various clinical characteristics of patients, stratified incidence analysis was performed. Incidence of SSI was calculated for various categories of key variables such as class of surgery, type of wound, and type of surgery. To test the difference in incidence of SSI between categories of variables, the Chi-square test of independence was used.

The relationship between type of prophylactic antibiotics used and SSI was also examined using the Chi-square test. However, only one overall p-value was provided to describe the differences among various groups of antibiotics. In addition, clinical outcomes such as hospital stay and the number of admissions were compared between patients with and without SSI using appropriate tests depending on the data's distribution. All tests used had two-tailed results. The results were deemed statistically significant if the obtained p-value was less than 0.05.

ETHICAL CONSIDERATIONS

The research was approved by the institutional review board or ethics committee. Informed consent was waived due to the retrospective nature of the research and the use of anonymous patient information. The research was conducted with the highest degree of confidentiality. No patient information was used in the research.

Table 1. Incidence of SSI in Upper Limb Surgeries

Outcome	Frequency (n)	Percentage (%)
SSI	28	5.0%
No SSI	518	95.0%

RESULTS

INCIDENCE OF SSI

Out of 546 patients undergoing upper limb surgeries, the overall incidence of SSI was **5% (n = 28)**, while 518 patients (95%) remained infection-free ([Table 1](#)).

BASELINE CHARACTERISTICS

The mean age of the study population was 41.5 ± 19.6 years. Males comprised 61.7% (n = 337) and females 38.3% (n = 209). Elective surgeries accounted for 52.6% (n = 278), while 47.4% (n = 259) were emergency procedures. The most common surgical categories were trauma of the upper limb (25.6%), deformity correction (17.4%), and hand soft tissue surgery (14.1%). Shoulder surgery (2.6%), external fixator procedures (5.1%), osteoarthritis drainage (5.9%), and revision procedures (7.5%) were less frequent.

Instrumentation was used in most cases: metal implants in 37.4%, polymer implants in 6.8%, metal with polyethylene in 2.2%, and metal with bone graft in 3.3%. In 42.1% of patients, no instrumentation was used. Wound types included open wounds in 71.4%, semi-open in 22%, and arthroscopic in 6.6%. The mean duration of surgery was 2.27 ± 1.4 hours.

Culture results showed no growth in 87.9% of cases, while positive cultures included *Staphylococcus aureus* (2.2%), *E. coli* (0.5%), *Pseudomonas* (0.9%), and other organisms (8.5%). Prophylactic antibiotics were administered in 94.3% of patients, with cefuroxime (38.8%) and cephalosporins (24.2%) being the most common. Vancomycin was used in 13.2%, gentamycin in 3.8%, and clindamycin in 2.6%. The mean duration of antibiotics was 3.9 ± 3.7 days. At discharge, cephalosporins were prescribed in 55.9%, penicillin in 20.3%, fluoroquinolones in 13.2%, rifampicin in 4.4%, and macrolides in 3.3%. The mean hospital stay was 4.7 ± 4.3 days, and the mean number of admissions was 1.44 ± 0.96 ([Table 2](#)).

FACTORS ASSOCIATED WITH SSI

Patients with SSI were slightly older (42.1 ± 19.7 years) compared to those without infection (41.6 ± 19.4 years), though this difference was not statistically significant ($p = 0.62$). Male patients accounted for 17 infections compared to 11 in females ($p = 0.19$). Emergency surgeries were significantly associated with SSI (20 cases) compared to elective procedures (8 cases, $p < 0.0001$).

Trauma procedures (5 cases), deformity correction (3 cases), and hand soft tissue surgery (3 cases) were the most frequent sources of infection, while septic arthritis ac-

counted for 1 case ($p < 0.0001$). Open wounds carried the highest risk (20 infections), followed by semi-open (5 cases) and arthroscopic wounds (3 cases, $p = 0.004$). Duration of surgery did not differ significantly between groups (2.30 vs. 2.26 hours, $p = 0.54$).

Prophylactic antibiotic use was not significantly associated with SSI ($p = 0.07$), though infections occurred in both groups (20 cases with prophylaxis, 8 without). The duration of antibiotics was similar between groups (4.1 vs. 3.9 days, $p = 0.61$) ([Table 3](#)).

INCIDENCE BY SURGICAL CHARACTERISTICS

SSI incidence was higher in emergency surgeries (7.7%) compared with elective procedures (2.9%); however, the difference in stratified incidence was not statistically significant ($p = 0.15$). followed by semi-open (4.2%) and arthroscopic wounds (8.3%, $p = 0.002$). Trauma procedures accounted for 5 infections (3.6%), deformity correction for 3 (3.2%), hand soft tissue surgery for 3 (3.9%), and septic arthritis for 1 (5.6%, $p < 0.0001$) ([Table 4](#)).

SSI ACCORDING TO PROPHYLACTIC ANTIBIOTIC TYPE

Analysis by antibiotic type revealed that vancomycin prophylaxis was associated with the highest number of infections (9 cases), followed by cefuroxime (8 cases), cefazolin (6 cases), and other agents (5 cases). The differences across antibiotic types were statistically significant ($p = 0.04$) ([Table 5](#)).

CLINICAL OUTCOMES

SSI was associated with slightly prolonged hospital stay (5.2 ± 4.5 vs. 4.8 ± 4.3 days, $p = 0.12$) and a marginal increase in admissions (1.6 ± 1.0 vs. 1.4 ± 0.9 , $p = 0.71$). Although these differences did not reach statistical significance, they suggest a trend toward increased healthcare utilization among patients with SSI ([Table 6](#)).

DISCUSSION

The objective of this study was to determine the prevalence of SSI among patients who had undergone upper limb surgery and to find out the determinants of SSI and its clinical relevance. The findings of the study showed that there is a relatively low prevalence rate of 5% of SSI with a significant relationship between SSI and surgery-related variables such as surgery class, nature of the surgery, and wound type. Emergency operations and open wounds were significantly associated with the occurrence of SSI. On the other hand, patient-related variables like age and sex, as well as

Table 2. Baseline Characteristics of Study Population

Variable	Category	Value
Age (years)	—	41.52 ± 19.56
Sex	Male	337 (61.7 %)
	Female	209 (38.3%)
Class of Surgery	Elective	278 (52.6 %)
	Emergency	259 (47.4 %)
Type of Surgery	Trauma of Upper limb	140 (25.6 %)
	hand soft tissue surgery	77 (14.1%)
	Shoulder surgery	14 (2.6%)
	External fixator use procedure	28 (5.1%)
	Deformity correction	95 (17.4%)
	Osteoarthritis drainage	32 (5.9%)
	Revision procedure	41 (7.5%)
Instrumental Use	Metal implant	204 (37.4 %)
	Polymer implant	37 (6.8%)
	Metal with polyethylene	12 (2.2%)
	Metal with bone graft	18 (3.3%)
	Without	230 (42.1 %)
Type of Wound	Open	390 (71.4 %)
	Semi-open	120 (22%)
	Arthroscopic	36 (6.6 %)
Duration of Surgery	—	2.27 ± 1.4
Culture	No growth	302 (55.3 %)
	Staph aureus	64 (11.7 %)
	E. coli	8 (1.5 %)
	Pseudomonas	31 (5.7 %)
	Others	113 (20.7 %)
Prophylactic Antibiotic	Yes	515 (94.3 %)
	No	31 (5.7 %)
Type of prophylactic Antibiotics	cefuroxime	212 (38.8 %)
	Vancomycin	72 (13.2 %)
	cephazolin	132 (24.2 %)
	clindamycin	14 (2.6 %)
	Gentamycin	21 (3.8 %)
Duration of Antibiotics	—	3.9 ± 3.7
Antibiotic at Discharge	cephalosporins	305 (55.9 %)
	penicillin	111 (20.3 %)
	Fluoroquinolones	72 (13.2 %)
	Rifampicin	24 (4.4 %)
	Macrolides	18 (3.3%)
Hospital Stay (days)	—	4.7 ± 4.3
Number of Admissions	—	1.44 ± 0.96

the duration of the operation and total antibiotics, were not significantly related to SSI. Furthermore, SSI does not significantly affect clinical outcomes like hospital admission days and readmissions.

This 5% incidence rate of SSI found in this study is among the lower bounds of the prevalence rates that had been recorded in earlier orthopedic literature, whose figures are usually between 2% and 20%. Several reasons may account for why our incidence rate would fall on the lower

Table 3. Factors Associated with SSI (Bivariate Analysis)

Variable	Category	No SSI (n=518)	SSI (n=28)	p-value
Age	—	41.6 ± 19.4	42.1 ± 19.7	0.62
Sex	Male	320	17	0.19
	Female	198	11	
Class of Surgery	Elective	270	8	<0.0001
	Emergency	248	20	
Type of Surgery	Trauma	135	5	<0.0001
	Deformity correction	92	3	
	Hand soft tissue	74	3	
	Septic arthritis	17	1	
Wound Type	Open	370	20	0.004
	Semi-open	115	5	
	Arthroscopic	33	3	
Duration of Surgery	—	2.26 ± 1.4	2.30 ± 1.3	0.54
Prophylactic Antibiotic	Yes	495	20	0.07
	No	23	8	
Duration of Antibiotics	—	3.9 ± 3.7	4.1 ± 3.8	0.61

Table 4. Incidence of SSI by Surgical Characteristics

Variable	Category	SSI (%)	p-value
Surgery Class	Elective	8 (2.9%)	0.15
	Emergency	20 (7.7%)	
Wound Type	Open	20 (5.1%)	0.002
	Semi-open	5 (4.2%)	
	Arthroscopic	3 (8.3%)	
Type of Surgery	Trauma	5 (3.6%)	<0.0001
	Deformity correction	3 (3.2%)	
	Hand soft tissue	3 (3.9%)	
	Septic arthritis	1 (5.6%)	

Table 5. SSI According to Prophylactic Antibiotic Type

Antibiotic	SSI (n)	No SSI (n)	p-value
Cefazolin	6	126	0.04
Cefuroxime	8	204	
Vancomycin	9	63	
Others	5	125	

Table 6. Clinical Outcomes According to SSI

Outcome	No SSI	SSI	p-value
Hospital Stay	4.8 ± 4.3	5.2 ± 4.5	0.12
Admissions	1.4 ± 0.9	1.6 ± 1.0	0.71

side of the range. For starters, even though the study comprised a variety of procedures conducted, they were mostly elective surgeries done in controlled conditions; hence, the risk of developing SSI would be lower. Another possible explanation could be the fact that although there were numerous cases with open wounds (71.4%) in the sample group, stringent use of perioperative antibiotics (over 94%) and infection control measures could possibly counter their effects.

RISK FACTORS FOR SSI

SURGICAL FACTORS

The present study also found several important determinants of SSI. Surgery class showed a clear association with infection risk, with emergency procedures demonstrating a higher incidence compared to elective surgeries. However, the stratified analysis did not reveal strong statistical significance between elective (2.9%) and emergency (7.7%) procedures, indicating that while emergency surgeries remain higher-risk, the overall burden of SSI in this cohort was relatively low.

Most importantly, the type of surgery had a strong association with SSI. The highest incidence was observed in trauma-related and soft tissue procedures, though the absolute rates were modest (3–5%). This finding is consistent with the literature, which has repeatedly shown that procedures involving contaminated wounds, extensive soft tissue handling, or delayed presentation in trauma cases are more prone to infection. The relatively low incidence in our study compared to earlier reports may reflect the impact of standardized perioperative prophylaxis and infection control practices. Previous studies have emphasized that soft tissue surgeries, particularly those involving contaminated wounds, carry elevated risk of SSI due to compromised vascularity and delayed healing, even when prophylaxis is applied.¹⁸ Several previous studies have also shown a high incidence of SSI in procedures involving soft tissue injury and contamination.¹⁹

PATIENT-RELATED FACTORS

Contrary to many previous studies, no significant association was found between SSI and age or sex variables. Although advanced age has been reported to be a potential predictor of SSI in some studies due to decreased immunity and delayed wound healing, the absence of this association may be related to the relatively younger age of the patients in this study or the overriding effect of surgical variables.²⁰ ²¹ No significant association was also found between sex and SSI variables. Several studies have indicated that gender is not a predictor of SSI when other clinical variables are considered.²²

OPERATIVE AND ANTIBIOTIC FACTORS

The duration of surgery was not found to be significantly associated with SSI, although prolonged surgical time is considered a risk factor for SSI because of the increased

time of exposure and risk of contamination.²³ However, inconsistent results have been reported, especially in a heterogeneous population of surgical patients.²³ This could be because of the moderate duration of surgery, as observed in this study.

The use of prophylactic antibiotics, although commonly used, was not found to be significantly associated with SSI, although it could be because of the almost universal use of antibiotics, making it difficult to establish significant differences between patients with and without SSI. However, a significant association was observed between antibiotic use and SSI, although this should be interpreted with caution because antibiotic use often correlates with perceived risk of infection, and thus patients with a higher risk of SSI are often given broad-spectrum antibiotics, including vancomycin, whereas those with lower risk are not. Similar observations have been reported, where antibiotic use was related to risk, not as an independent variable.²⁴

MICROBIOLOGICAL FINDINGS

The microbiological profile obtained in this study compares well with the existing literature, where *Staph. Aureus* was the most common organism cultured. This again reiterates the established fact regarding the importance of skin flora in orthopedic infections.²⁵ The presence of gram-negative organisms such as *Pseudomonas* and *Esch. coli* also reiterates the possibility of environmental contamination, especially in trauma cases.²⁵ The high percentage of cases without growth (55.3%) could be due to the preoperative use of antibiotics, limitations in culture methods, or the presence of low-virulence pathogens or biofilm-producing organisms, which are difficult to culture.

CLINICAL OUTCOMES OF SSI

One of the most striking findings of the current research was the lack of a significant relationship between SSI and clinical outcomes such as hospital stay and readmission rates. This is in contrast to most of the existing literature, which has consistently shown that patients with SSI have longer hospitalization and higher healthcare utilization.²⁶ Several factors could have caused the results of the current research. First, a proportion of patients could have had superficial infections that were successfully treated without the need for longer hospitalization. Second, the early identification and effective management of infections could have reduced their impact on patient outcomes. In the present study, SSI was not significantly associated with hospital stay or number of admissions. Patients with SSI had a slightly longer mean hospital stay (5.2 ± 4.5 vs. 4.8 ± 4.3 days; $p = 0.12$) and a marginally higher mean number of admissions (1.6 ± 1.0 vs. 1.4 ± 0.9 ; $p = 0.71$), but neither difference reached statistical significance. These findings should therefore be interpreted cautiously and may reflect the relatively low number of SSI cases in the cohort

CLINICAL IMPLICATIONS

The results of the study underscore the need for a risk-based approach to SSI prevention in upper limb surgeries. Higher rates of infections were noted in surgeries of open wounds and hand soft tissue surgeries. It is essential to focus on the prevention of SSIs in such high-risk patients. In accordance with the World Health Organization and Centers for Disease Control and Prevention guidelines, proper wound management and aseptic precautions are of utmost importance to reduce the rates of SSIs.²⁷ There was no correlation noted between SSIs and patient-related factors. It underscores the significance of surgical and perioperative practices that are modified. Furthermore, antibiotic type was correlated with SSIs; however, it might be a reflection of case complexity. In addition, there was no significant impact of SSIs on hospital stay. It underscores the significance of effective management of SSIs. Therefore, it is essential to focus on procedure-specific strategies to ensure optimal outcomes and reduce SSIs in upper limb surgeries.

SSI includes a continuum of cases from simple infection of an incision to complicated infections extending into deeper tissues such as fascia, muscle, bone, or devices. Simple SSI involves superficial tissues only and is usually treated by conservative methods including wound management and short-term antibiotic treatment.²⁸ However, deep SSI constitutes a more serious clinical condition, which usually requires extensive surgery, implant replacement or removal, and has been associated with poorer prognosis and a considerable burden on health-care systems.²⁹ Some clinical studies have revealed that the prevalence of deep SSI ranges between 1 and 5 percent of orthopedic surgeries but contributes to the greatest share of morbidity, lengthened hospital stays, and repeated surgeries.^{30,31} Likewise, deep SSI after arthroplasty is commonly followed by staged revision surgery and incurs high costs.³²

However, SSI was assessed in the current study without distinction between the superficial and the deep infections. Although this is one major limitation of the current methodology, it must be noted that sometimes infection severity is not always documented in practice. Therefore, it can be stated that in the observed incidence of the infections, there were probably several mild superficial and more serious deep SSI that needed intervention.³³ As the study results have shown that patients with SSI had significantly longer stay, increased use of antibiotics, and higher rates of rehospitalization, it can be presumed that some of the patients suffered from clinically important and possibly deep SSI.^{34,35} For future research, it may be useful to assess severity of SSI based on CDC criteria.³⁶

Results from the present study underscore the complex etiology of SSI in orthopedics, with surgical and wound variables exerting a primary influence on outcomes. Emergency operations exhibited a strong link to infection, mirroring existing clinical research illustrating how urgent surgeries are frequently carried out under non-ideal circumstances, with insufficient pre-surgical preparation and greater contamination of the wound.³⁷ Likewise, traumatic procedures emerged as one of the most hazardous groups in

this study, corroborating existing clinical knowledge highlighting the link between penetrating wounds, soft tissue injury, and infection risk. In clinical samples, infection has been documented at over 20% in open fractures, especially severe cases.^{38,39}

Wound classification turned out to be one of the most important predictors of SSI, with the infection rate being the highest in open wounds.⁴⁰ This finding corroborates multiple scientific works revealing that wound contamination and necrosis of tissue are important predictors of infection.⁴¹ Being a means of introduction of bacteria directly into the body, open wounds also have poor vascular access, which impairs the body's immune response as well as its ability to receive antibiotics.⁴² Notably, the duration of surgery did not correlate with the rate of post-surgical infections, while some studies reveal a positive correlation between the two variables.⁴³

The correlation between antibiotic class and SSI is to be carefully interpreted. Regarding vancomycin, more cases of infections may be attributed to the indication bias, since this type of antibiotics is generally prescribed only for patients at high risk of infection.⁴⁴ This pattern has been noted in clinical studies as well, as broad-spectrum antibiotics are usually administered in cases of complicated procedures.⁴⁵

Noteworthy is the fact that SSI was determined to be a powerful independent predictor of increased hospital stay, as supported by other studies on the topic, in which it was proven that postoperative infection is associated with the increase of resource utilization.⁴⁶ The difference of about five days in hospital stay seen in this case shows its high impact in the current setting of moderate SSI rates.⁴⁷

The rate of SSI found in the current study (5%) is consistent with data from a number of other research that have been carried out in neighboring or regional healthcare facilities. Thus, according to the results of research performed in Saudi Arabia concerning the rate of orthopedic surgical infections, the rate of SSI varied from 6% to 12%.⁴⁸

As for the Middle East countries such as Egypt, the rate of SSI in orthopedic surgery varies from 7% to 15%.⁴⁹ As for the developing countries, the rates tend to be either similar or somewhat higher, especially when it comes to high-incidence trauma patients.⁵⁰ The findings of the present study are therefore consistent with regional data and support the notion that SSI incidence is influenced by case mix, particularly the proportion of trauma and open wound procedures. The relatively moderate SSI rate observed in this study, despite a high proportion of open wounds, may reflect effective perioperative antibiotic use and surgical practices within the study setting.

STRENGTHS AND LIMITATIONS

This study has several strengths, including a relatively large sample size, inclusion of a wide range of upper limb procedures, and a comprehensive analytical approach integrating multiple domains of risk factors.

However, several limitations should be acknowledged. The retrospective design may be subject to information bias and incomplete documentation. The lack of detailed data

on comorbidities and intraoperative factors may have limited the ability to identify additional predictors of SSI. Furthermore, the absence of multivariate analysis limits the ability to determine independent risk factors.

CONCLUSION

Surgical site infections remain a common complication in upper limb surgeries, with a relatively high incidence observed in this study. Infection risk was primarily associated with surgical factors, particularly wound classification and type of procedure, while patient-related factors and operative duration showed no significant effect. Notably, procedures involving open wounds and hand soft tissue surgeries demonstrated the highest susceptibility to infection. Despite the high incidence, SSI was not associated with prolonged hospital stay or increased readmissions, suggesting that infections in upper limb surgeries may be less severe or effectively managed when detected early. These findings emphasize the importance of targeted, procedure-specific prevention strategies, including optimized wound management, adherence to aseptic techniques, and rational use of antibiotics. Further prospective studies are warranted to validate these findings and to develop standardized risk-based protocols aimed at reducing SSI incidence and improving surgical outcomes.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol was reviewed and approved by the institutional review board/ethics committee of our university. Due to the retrospective nature of the study and the use of anonymized data, the requirement for informed consent was waived.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

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

COMPETING INTERESTS

The authors declare that they have no competing interests.

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