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Incidence and prevention of early postoperative infection in orthopedic surgery

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Abstract

Background: Surgical site infections (SSIs) represent one of the most prevalent complications associated with surgical procedures, leading to extended hospital stays. Specifically, SSIs can prolong hospitalization by an average of 7 to 12 days and significantly elevate the likelihood of readmission, with a 60% increased risk of requiring intensive care unit admission. Furthermore, these infections contribute to heightened healthcare costs and an increased rate of mortality.

Aim of the work: This study aimed to assess the incidence of early postoperative infections in orthopedic surgery and to evaluate prophylactic strategies to mitigate their occurrence.

Patients and methods: This prospective investigation involved 2,369 patients who underwent orthopedic surgical procedures at the Orthopedic Surgery Department, Faculty of Medicine, Tanta University, from March 2023 to March 2024. The patients were categorized into two groups: Group A comprised 1,546 patients who received emergency surgical interventions at the Emergency Hospital of Tanta University. Group B included 823 patients who underwent elective surgery at Tanta University Hospitals.

Results: In this study, the incidence of SSIs was (14.18%). 63.9% of them suffer from superficial infection, while 36.1% suffer from deep infection that needs surgical intervention. The incidence of infection following elective orthopedic surgery was (8%) while that following emergency surgeries was (17.4%).

Keywords: Surgical site infections, orthopedic device related infections and Methicillin Resistant *Staphylococcus aureus*

Introduction

Surgical site infections (SSIs) are characterized as infections that manifest within 30 days following a surgical procedure in the absence of an implant, or within one year if an implant is present post-operation, impacting either the incision or the deeper tissues at the surgical site [1].

Surgical site infections (SSIs) are characterized as infections that manifest within 30 days following a surgical procedure in the absence of an implant, or within one year if an implant is present post-operation, impacting either the incision or the deeper tissues at the surgical site [2]. Furthermore, SSIs impose considerable financial and psychosocial burdens, alongside significant morbidity [3].

The prevalence of SSIs in orthopedic procedures is notably high, ranging from 5% to 10%, influenced by various factors such as the site and severity of the injury [4]. Additional risk factors contributing to the heightened incidence of SSIs include open fractures, compartment syndrome, prolonged operative time, tobacco use, external fixation, and certain systemic conditions such as human immunodeficiency virus, rheumatoid arthritis, diabetes mellitus, hemophilia, and sickle cell anemia [5].

SSIs can be categorized into superficial, deep, and organ infections. In orthopedic cases, these infections often present subtly, necessitating a high degree of suspicion to avoid delays in treatment. Diagnosis relies on clinical assessments, laboratory tests, and imaging techniques, with a critical component being a well-founded index of suspicion [6]. Diagnosing postoperative wound infections poses challenges for several reasons, the foremost being the tendency to deny the existence of a problem, which can stem from concerns regarding the quality of surgical work [7].

Several preventive measures are currently considered as surgical hand preparation, sterile gowns and gloves, good preparation of the skin with shaving of hair, antibiotic prophylaxis, the surgeon's skills, decrease operative time and postoperative hospital stay and the deferral of elective surgical procedures is recommended in instances of active remote infections postponing elective operation in case of active remote infection [8].

Aim of the work: The objective of this research was to assess the frequency of early postoperative infections in orthopedic surgeries and to identify preventive strategies aimed at minimizing such occurrences.

Patients and methods

This prospective investigation involved 2,369 patients who underwent orthopedic surgical interventions at the Orthopedic Surgery Department of the Faculty of Medicine, Tanta University. Informed written consent was secured from all participants involved in the study.

Inclusion criteria: The studied patients included early postoperative infection within 1 month, closed fractures and both superficial and deep infection.

Exclusion criteria: Patients with late postoperative infections and those presenting with open fractures were excluded from this study. The remaining patients were categorized into two distinct groups. Group A comprised 1,546 individuals who received emergency surgical intervention at the Emergency Hospital of Tanta University. In contrast, Group B consisted of 823 patients who underwent elective surgical procedures at Tanta University Hospitals. Data collection was conducted using a standardized form that documented various variables, including the patient's name, age, sex, diagnosis, co-morbidities, smoking history, type of implant used, duration of the surgical procedure, and the category of the surgeon (either consultant or junior consultant).

In all cases, first-generation cephalosporin prophylactic antibiotics were administered at the time of anesthesia induction. Additionally, the sterilization of implants and surgical equipment was performed using an autoclave in the operating theatre.

The diagnosis of infection

- General examination for signs of toxemia
- Local examination for signs of infection as redness, hotness and tenderness and if there is sinus discharging pus.

Investigations

- Laboratory investigations include CBC, CRP and ESR.
- Radiological investigation as US shows turbid fluid collection.
- Microbiology report of culture and sensitivity.

Ethical considerations

The Research Ethics Committee of the Faculty of Medicine at Tanta University granted approval for the study. To ensure participant privacy and data confidentiality, individuals were provided with the choice to decline participation if they wished. Each participant was assigned a unique code number, while their names and addresses were securely stored in a designated file.

For the statistical analysis, data were entered into a computer and processed using the IBM SPSS software package, version 20.0 (Armonk, NY: IBM Corp). Qualitative data were summarized using counts and percentages. The Kolmogorov-Smirnov test was employed to assess the normality of the data distribution. Quantitative data were characterized by their range (Minimum and maximum), mean, standard deviation, median, and interquartile range (IQR). A p-value of less than 0.05 was considered statistically significant, determined through the Chi-square test.

In total, 2, 369 patients participated in this study, all of whom underwent orthopedic surgeries at the Orthopedic Surgery Department of the Faculty of Medicine, Tanta University, between March 2023 and March 2024. The patients were categorized into two distinct groups: Group A consisted of 1,546 patients who received emergency surgery at the Emergency Hospital of Tanta University, while Group B comprised 823 patients who underwent elective surgery. 1471 (62%) were males and 898 (38%) were females. Three hundred thirty six (14.18%) patients developed infections. Out of these 336 patients who developed infection, 215 (63.98%) patients had superficial infection, while 121 (36.01%) patients had deep infection. The age of the patients was more than 60 years in 70 (20.83%) patients, 40 - 60 years in 118 (35.12%) patients and 20 - 40 years in 83 (24.70%) patient, less than 20 years in 65 (19.35%) patients (Table 1).

In 186 (55.35%) of infected patients, procedure time was more than 5 hours, in 118 patients (35.11%) was 3-5 hours and in 32 patients (9.52%) was less than 3 hours. Two hundred five (61%) patients were smokers, while 131 (39%) were nonsmokers, 116 (34.52%) patients were diabetic, 17 (5%) were hepatic, 62 (18.45%) patients were cardiac and hypertensive, while 12 (3.57%) patients were renal.

Methods of treatment for group A

The difference between methods of treatment was considered statically significant as p value <0.001.

Table 1: Distribution of the emergency cases according to methods of treatment

Group A					
Methods of treatment			Infected cases		P. value
	No.	%	No.	%	
Platting	721	46.6	163	60.6	
Minimally invasive	320	20.7	39	14.5	<0.001
Nailing	505	32.7	67	24.9	

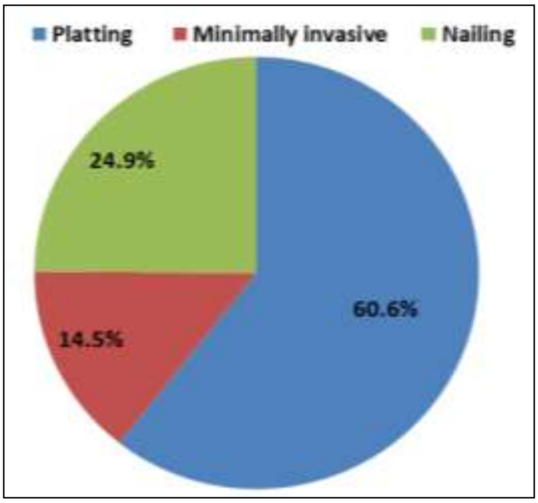

Fig 1: Distribution of infected cases of group A according to methods of treatment

Table 2: Distribution of the elective cases according to orthopedic units, Tanta University

Group B		
Orthopedic units	**No.**	**%**
Spine & oncology unit		
Total	32	3.9%
Infected (% from total unit)	3	9.4%
Pelvis & arthroplasty unit		
Total	158	19.2%
Infected (% from total unit)	33	20.9%
Pediatric & Deformity unit		
Total	207	25.0%
Infected (% from total unit)	12	5.8%
Hand & Microsurgery unit		
Total	123	14.9%
Infected (% from total unit)	9	7.3%
Foot & Ankle unit		
Total	113	13.7%
Infected (% from total unit)	7	6.2%
Arthroscopy unit		
Total	190	23.1%
Infected (% from total unit)	3	1.6%

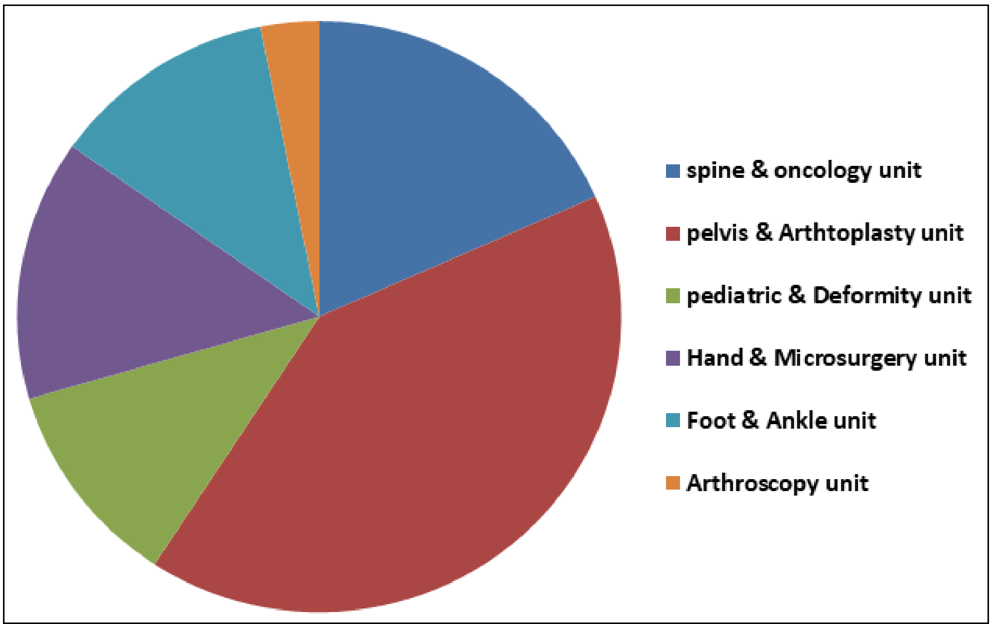

Fig 2: Distribution of infected cases according to orthopedic units, Tanta University

Table 3: Distribution of studied cases according to infection

	Group A		Group B	
	No.	**%**	**No.**	**%**
Infected cases	269	17.4	67	8.1
Superficial	172	63.9	43	64.2
Deep	97	36.1	24	35.8

The baseline characteristics

The difference between the baseline characteristics (age, sex, smoking and general condition) of patients of the studied groups was statistically significant (P. value <0.05) to age, smoking and diabetes and liver diseases, as these diseases lower the immunity.

Table 4: Distribution of infected cases according to the baseline characteristics

	Group A			Group B		
	No.	**%**	**P value**	**No.**	**%**	**P value**
Gender						
Male	92	34.2	0.216	57	85.1	0.31
Female	177	65.88		10	14.9	
Age (Years)						
<20	48	17.8		17	25.4	
			<0.001			<0.001
20-<50	74	27.5		9	13.4	
50-< 60	106	39.4		12	17.9	
>60	41	15.2		29	43.3	
Min.-Max.	5.0-95.0			1.0-85.0		
Mean ± SD.	40.22 ± 19.04			43.60 ± 25.75		

Median (IQR)	42.0 (26.0-52.0)			53.0 (18.50-65.0)		
Smoking						
Non smoker	92	34.2	<0.001	28	41.8	<0.001
Smoker	177	65.8		39	58.2	
General condition						
DM	102	37.9	<0.001	14	20.9	0.003
HTN	19	7.1	0.935	6	9.0	0.373
Cardiac	18	6.7	0.1	19	28.4	0.085
Hepatic	16	5.9	0.02	1	1.5	0.04

Causative organisms

This study showed that the most common organism causing SSIs is *Staphylococcus aureus*.

Table 5: Distribution of infected cases according to organisms

	Group A		Group B	
Organism	**No.**	**%**	**No.**	**%**
Staphylococcus aureus	221	82.2	57	85.1
Pseudomonas	28	10.4	-	-
Klebsiella	11	4.1	6	9.0
E-coli	8	3.0	4	6.0
Diphtheria	1	0.4	-	-

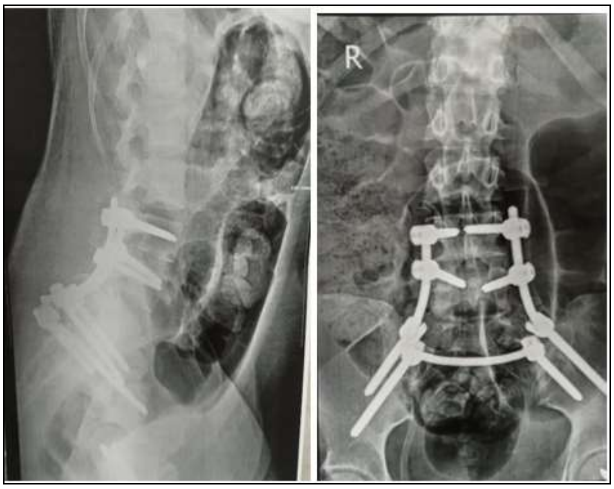

Fig 3: Post-operative x-ray of case No. 1, Group B

Skin condition

The difference between infected cases according to skin condition was considered significant for skin incision over abrasion and ecchymosis as P. value was <0.001.

Table 6: Distribution of infected patients according to skin condition in emergency cases only (Group A)

Group A			
Skin condition	**No.**	**%**	**P value**
Abrasions and ecchymosis	169	62.8	<0.001
Clear	100	37.2	

Operative time

The operative time was calculated for all patients of the studied groups from the start of skin incision till the end of the last suture on the skin. The difference between the operative time for patients of the studied groups was statistically significant (P. value <0.001).

Table 7: Distribution of infected cases according to duration of operations

	Group A			Group B		
Duration of operation	**No.**	**%**	**P. value**	**No.**	**%**	**P. value**
<2h	8	3		2	3.0	
2h-3h	19	7.1	0.001	3	4.5	0.001
>3h - <5h	97	36.1		21	31.3	
>5h	145	53.9		41	61.2	

Fig 4: Clinical photograph of early infection in case No. 1, Group B

Case presentations

Case 1, Group B: Female patient aged 16y, presented falling from height with fracture shaft femur, bi-malluler ankle fracture and spino-pelvic dissociation. After one month ORIF of spino-pelvic dissociation was done. After 3 weeks, the patient presented with deep infection and wound dehiscence with TLC 15.000, CRP 82 and ESR over 100 (Surgical debridement, irrigation and local antibiotic was added).

Risk factors in this patient were long time of operation as it extended for 6 hours and bad hygiene of the patient.

Case 2, Group A

Female patient aged 55y, diabetic and cardiac presented in RTA with tri-malleolar ankle fracture and ORIF was done at the same day. The patient presented with deep infection after 3 weeks with TLC 18500, ESR first hour 68 and second hour 93 and CRP 115 (Surgical debriment was done).

Risk factors in this patient were uncontrolled diabetes, bad care of the wound and risky skin condition at time of surgery as there were sever edema and ecchymosis.

Fig 9: Post-operative x-ray of case No. 5, Group A

Fig 10: Post-operative early infection in case No. 5, Group A

Discussion

In this study, advanced age of the patients, smoking and associated comorbidities are major risk factors for SSIs, and also long operative time and skin condition at time of surgery are risk factors for development of SSIs.

The current study reports an incidence of surgical site infections (SSIs) at 14.18%, a figure significantly exceeding the accepted standard for postoperative wound infections, which is typically below 1%. This infection rate is markedly higher than those reported in other studies, such as the findings of Dhillon KS and Kok CS [9], who documented an infection rate of 6.8%. Similarly, Onche I and Adedeji O [10] reported a rate of 7.5%, while Ngim *et al.* [11] found a rate of 9.38%.

When examining the relationship between SSIs and patient age, a statistically significant correlation was observed. Specifically, the incidence of SSIs was 16.56% among patients over 50 years of age, in contrast to 11% in those younger than 50. This finding aligns with the research conducted by Afifi IK and Baghagho EA [12] which indicated a higher incidence of SSIs in patients over 50 years old within a cohort of 158 individuals. Additionally, Shah *et al.*, [13] identified age over 60 as a significant risk factor for postoperative deep wound infections. The increased infection rates associated with advancing age may be attributed to several factors, including diminished healing capacity, malnutrition, malabsorption, heightened catabolic processes, and compromised immune function [14].

Furthermore, the analysis of SSI incidence in relation to comorbidities revealed a statistically significant association with diabetes. In this study, the infection rate among diabetic patients was found to be 28.43%. Patel *et al.*, [15] eported that in their investigation of postoperative deep wound infections, 36.4% of the 22 diabetic patients developed SSIs, compared to only 13.5% among non-diabetic patients. This observation is further supported by findings from the National Academy of Sciences, which indicated a higher rate of SSIs in diabetic individuals [16].

Additionally, univariate analysis conducted by Afifi IK and Baghagho EA [12]. On 121 patients demonstrated a significant association between diabetes mellitus and the occurrence of SSIs. Individuals with diabetes mellitus are particularly vulnerable to surgical site infections (SSI) as a result of compromised immune function, inadequate microvascular circulation, and diminished capacity for wound healing. Furthermore, diabetes can adversely affect the healing process through microangiopathic alterations that lead to localized tissue ischemia and lower concentrations of antibiotics within the affected tissues. Consequently, maintaining strict control of serum glucose levels may help reduce the occurrence of SSI [17].

Regarding liver diseases, it was statically significant. This correspond to the study performed by Freire *et al.*, [18] showed that the end-stage liver disease is recognized as a significant risk factor for surgical site infections (SSIs), particularly among patients with prolonged hospital stays or a history of multiple admissions. Such circumstances suggest a heightened exposure to antimicrobial agents, which correlates with an increased likelihood of developing SSIs. The administration of antibiotics has been identified as a contributing factor to SSIs, potentially serving as an indicator of patients undergoing surgical procedures while being infected with or colonized by multidrug-resistant bacteria.(18), and also due to impaired protein synthesis that is used for production of antibodies and also decreased albumin synthesis that leads to impairment of wound healing.

Regarding operative time, it was statically significant in this study. These findings align with the results reported by other researchers [15]. Patel *et al.* [15] conducted a study involving 200 surgical patients and discovered that an extended operative duration was associated with an elevated risk of surgical site infections (SSI). This increased risk may be attributed to the prolonged exposure of tissues to the surrounding environment, which heightens the potential for airborne contamination. In this study, *Staphylococcus aureus* is the predominant organism causing SSIs. Similar results were seen by other researchers [19, 20], however, Li *et al.*, [21] and Phillips *et al.*, [22] reported Coagulase-negative staphylococci as a most common microorganism causing SSIs.

Smokers have a higher incidence of SSIs following orthopedic surgeries compared with non-smokers. Smoking significantly increases the incidence of SSIs in this study. This correspond to the study performed by Durand *et al.*, [23] on a total of 4,046 patients were enrolled in seventeen French centers.

Within the population of smokers, various elements contribute to a heightened likelihood of experiencing postoperative complications. Substances such as nicotine, nitric oxide, and carbon monoxide have a direct impact on the wound healing mechanisms [24]. Smoking is associated with endothelial dysfunction, inflammatory responses, and the advancement of atherothrombotic conditions. Additionally, individuals who smoke exhibit signs of a compromised systemic immune response, characterized by diminished immunoglobulin levels, an altered ratio of CD4 to CD8 cells, and decreased phagocytic activity [25].

Regarding skin condition, this study shows that skin incision on abrasion or ecchymosis increase the incidence of infection and this is correspond to the study conducted by Maksimović *et al.*, [19], that have documented that preoperatively hair shaving was significantly associated with SSIs. This study also confirms the fact that shaving causes micro abrasions of the skin leading to increased risk of SSIs.

Regarding method of fixation, this study result shows that patients treated by plate had infection rate 60.6%, while those treated with nailing had infection rate 24.9% and those with minimally invasive procedures include wires, cannulated screws and external fixator had infection rate 14.5%, that may be due to long skin incision and exposure to the environment and improper handling of tissues. Our result doesn't correlate with study performed by Rundgren *et al*., [26] study involved a cohort of 31,807 patients and revealed that the incidence of surgical site infections (SSIs) was 5% in individuals who underwent plate fixation, 12% in those who received percutaneous pinning, and 28% in patients treated with external fixation.

Recommendations

Prophylactic measures to decrease infection as much as possible include

I. Factors related to the patients

General condition of the patients

A closed fracture is urgent but not emergent, except in some conditions as compartment syndrome and absent pulse or nerve injury.

Patients should be prepared well before surgery as good control of diabetes as it decreases immunity.

Hepatic patient also should be controlled prior to surgery as liver disease decreases production of proteins from which antibodies are formed and albumin that help in wound healing so increase chance of infection.

Any systemic disease should be controlled before surgery.

- **Smoking:** It decreases wound healing and promotes wound complications as wound dehiscence and infection.
- **Skin condition:** Any clothes of the patient should be removed before entry to operation room. Hair should be removed as it is a good media for bacteria to colonize then wash the skin by betadine shower. Skin incision on risky skin as sever ecchymosis or abrasions should be avoided, as this increases risk of infection and wound complications.

II. Factors related to operation room

- Dressing room should be the first room to be entered in the operation theater.
- Every hospital should have its own clothes and crocs that have been sterilized by its own and every one enter the operation room should wear that clothes even workers or C-arm guys.
- Air conditioning should be cleaned periodically.
- In-between surgeries, the room should be sterilized well to avoid transfer of infection.
- Infected and open cases should be operated in separate room and at the end of the day.

III. Factors related to nurses

Nurses should be learned how to sterilize well and should be followed by their head nurse and even doctors.

IV. Factors related to surgeons

- Firstly, the surgeon is the most responsible person in the operation room. They should follow every single person at the operation room.
- The first thing to learn to junior resident is how to sterilize well.
- Doctors should prevent any person from entering operation room without wearing the scrub uniform of the hospital, masks and overheads.
- Doctors should order to close the door of operation room after their sterlization and before skin incision and the door must not open during surgery.

During surgery

- The doctors should ask for prophylactic dose of broad spectrum antibiotics and another dose should be given to the patient every 3 hours.
- Doctors should avoid skin incision in suspicious skin as abrasion, ecchymosis or sever edema because it may leads to wound complications as dehiscence and infection.
- Good handling of tissues, dissection in intramuscular plans not through muscles.
- Doctors should avoid improper use of diathermy proper hemostasis.
- Doctors should keep tissues wet with wash by saline periodically during surgery.
- Long, complicated, revision cases should be operated by senior staff member to avoid long time of operation that increases risk of infection.

V. Factors related to implant

- Implants must be sterilized in the hospital and do not allow sterilization outside the hospital.
- Implants should be sterilized by trained qualified person and they should be followed by infection control specialists.
- Infection control specialists should prevent use of color indicator that allow color change rapidly before full cycle of sterilization and any one do this should be punished.
- If company personel is needed in the operation room, they must wear the uniform scrub of the hospital, masks and overheads.

After surgery

- Patient general condition should be followed carefully and stabilized as soon as possible.
- Post-operative estimation of hemoglobin level is a must to avoid anemia that lowers immunity and affects wound healing.
- The wounds should be followed carefully by the medical staff.
- Avoid abuse of antibiotics.
- Drains and catheter should be removed before the patient leaves the hospital.
- Patients and their relatives should be informed how to follow the wound and should be learned wound dressing.
- Close follow up is mandatory to discover wound complications as early as possible.

Conflict of Interest
Not available

Financial Support
Not available

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