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Surgical Site Infections in Oral and Maxillofacial Surgeries: Prevalence and Associated Risk Factors

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Abstract

Purpose: Surgical Site Infections (SSIs) are one of the most important complications following surgical procedures and can lead to devastating consequences. Based on the CDC-NHSN criteria, this retrospective study aims to identify the prevalence of SSIs and the risk factors associated with their development Following Oral and Maxillofacial (OMF) surgeries.

Methods: The sample size included 493 patients who underwent OMF surgeries in Prince Mohammad bin Abdulaziz Hospital (PMAH) in Riyadh, Saudi Arabia, over 6 years, from January 1st, 2015, to December 31st, 2020. The rate of surgical site infections in our cohort was 10.3% throughout the study. Risk factors were classified as patient-related, admission-related, and procedure-related factors.

Results: The rate of SSIs in the patient sample was measured at an average of 10.3% over the 6 years of the study. Analysis showed significant associations between multiple factors and the occurrence of SSIs, including age, male sex, diabetes mellitus, diagnosis, wound classification, and ASA score.

Conclusion: The findings presented in this study provide valuable insight into the pre-operative evaluation of OMF surgery patients and the prevention of SSIs.

Keywords: Maxillofacial surgery; Dentoalveolar surgery; Surgical site infection; Risk factors

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Introduction

Surgical Site Infection (SSI) is defined as an infection at the site of a surgical incision occurring within 30 days of an operation and can be classified as [1] superficial, including the skin and subcutaneous tissue, [2] deep, including the underlying muscle and fascia, or [3] space SSI, including any organs or tissues other than the muscle or fascia [1]. SSIs are the most common healthcare-associated infections and lead to several adverse consequences, including increased wound healing time, increased usage of antibiotics, longer hospital stays, and overall higher healthcare-associated costs [2]. A large cohort study conducted in a tertiary hospital in Saudi Arabia identified gram-negative bacteria as the most common causative organisms in SSIs, most commonly *Escherichia coli*, followed by *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Acinetobacter baumannii* [3].

Numerous SSI risk factors have been identified and can be classified as patient-related or procedure-related factors [4]. Age, male sex, smoking, and comorbid conditions, such as diabetes mellitus and obesity, are patient-related characteristics that increase the risk of surgical site infections [4-8]. Procedure-related risk factors, such as the duration of surgical scrubbing, skin anti-septic procedure, and the duration and type of operation, play a key role in determining the risk of SSI development [4,9].

A review of the existing literature describes rates of surgical site infections that vary from 8.6% following orthognathic surgery to 23% following oral cancer treatment [5,10]. In maxillofacial surgeries alone, the SSI rate varied from 2.15% to 30.8% [11,12]. Identifying the risk factors for SSIs Following Oral and Maxillofacial Surgeries (OMFS) is critical in the development of preventive measures to improve outcomes [13]. In this study, we aim to determine the prevalence of Surgical

Table 1: Exclusion criteria.

General Exclusions
Sex: 'Other'.
Outpatient procedures and resulting SSIs.
Present at Time of Surgery (PATOS) is 'Yes.'
SSIs that are reported as Superficial Incisional Secondary (SIS) or Deep Incisional Secondary (DIS).
Exclusions due to potential data quality issues or outliers
Age at the time of procedure is greater than 109 years.
Closure technique is missing.
ASA score is missing or 6.
Sex is missing.
Adult patients ≥ 18 years: if BMI is less than 12 kg/m^2 or greater than 60 kg/m^2.
Pediatric patients <18 years: if BMI less than 10.49 kg/m^2 or greater than 65.79 kg/m^2.
Procedure duration less than 5 minutes

Site Infection (SSI) after oral and maxillofacial surgeries in Prince Mohammad bin Abdulaziz Hospital (PMAH), Saudi Arabia, over six years based on the National Healthcare Safety Network (NHSN) guidelines.

Methods

This study is a retrospective observational cross-sectional study that was conducted based on the CDC-NHSN criteria. Data was collected through medical records in one setting: Prince Mohammad Bin Abdulaziz Hospital (PMAH) in Riyadh, Saudi Arabia, and spanned 6 years, from January 1st, 2015 to December 31st, 2020.

The sample size covered all oral and maxillofacial procedures, amounting to 838 procedures, as provided by the hospital. The exclusion criteria in Table 1 were applied during the data collection process on different levels ending with a final sample size of 493, as described in the chart flow of data collection in Figure 1.

The data collection process took around five months and was carried out by one investigator. The data was mainly qualitative with some quantitative values. They were extracted from different medical records, compiled in an Excel sheet, and covered the patient and operation variables. All collected data were reviewed, rechecked, and anonymized before data analysis. No interventions were done since this was an observational study.

Statistical analysis

Our data were analyzed using Microsoft® Excel® for Microsoft 365 MSO (Version 2203) and Jamovi - the statistical software program version 2.2.2.0. The prevalence rate of SSI was calculated from the number of detected SSI divided by the total number of surgical procedures multiplied by 100. This rate was also calculated for different types of maxillofacial surgeries and different years. Further statistical analysis was performed on sociodemographic variables, clinical characteristics of patients, admission variables, and operation variables. Multiple comparisons, including the operative factors, the usage of antibiotics, and others, were analyzed to investigate any significant relationship to the SSI types. The chi-square test and p-value <0.05 were the best choices for our categorical variables' association investigation, and Pearson's r-correlation test was calculated for continuous variables.

Results

Surgical site infection rate

Out of the 493 patients included in this retrospective study, 59 SSI cases were identified. Eight cases were excluded for the following reasons: (1) out of the defined surveillance period of 90 days; and (2) not fulfilling organ/space SSI criteria.

The surgical site infection rate over six years ranged from 6% to 21.4%, with an average rate of 10.3% (51 of the 493 cases). Cases were classified as superficial (58.8%), deep (27.5%), and organ/space SSIs (13.7%).

SSI cases were diagnosed within a mean of 17.9 days after the procedure (range 2-85, standard deviation of 17.8, and a 95% CI of 13.0-22.8). While the surveillance period was set as 90 days, 90% of SSI cases were diagnosed within the first 30 days. The remaining 10% of cases that were diagnosed after 30 days were four deep SSIs and one Organ/space SSI case.

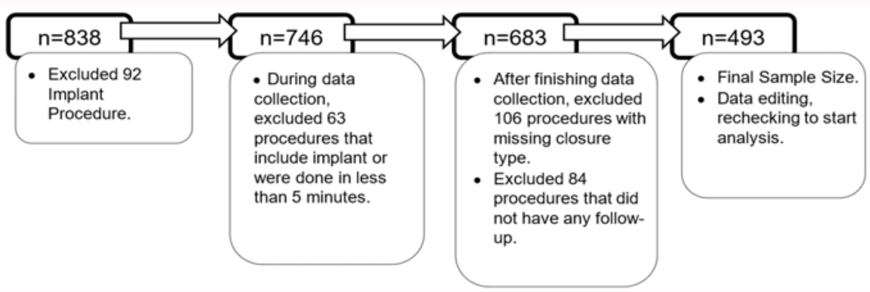

Figure 1: Chart flow of sample size during data collection.

Table 2.1: Associations of patient variables & SSI cases.

Patient Variables		***Total***	***SSI Rate***	***p-value***	***Contingency coefficient****
Sex	Male	334	12.80%	0.002^S	0.212 (Low)
	Female	159	8.90%		
Age	≤ 10	24	16.60%	<0.001^S	0.290 (Low)
	11-20	138	5.10%		
	21-30	225	11.11%		
	31-40	63	12.80%		
	41-50	21	28.57%		
	51-60	17	11.76%		
	>60	5	0.20%		
Weight Status	Underweight	51	5.88%	0.197^NS	
	Healthy Weight	242	9.10%		
	Overweight	114	14.91%		
	Obesity	86	10.46%		
Tobacco Use	Yes	135	12.60%	0.220^NS	
	No	358	9.50%		
Diabetes Mellitus	Prediabetes	2	0.00%	<0.001^S	0.247 (Low)
	Type I	9	22.22%		
	Type II	8	37.50%		
	No	474			

The frequencies of different patient variables over the total sample size.
S A significant association between variable and SSI development with p-value <0.05.
NS A non-significant association between variable and SSI development with p-value >0.05.
*Contingency coefficient done for significant p-value association.

Table 2.2: Associations of procedure variables & SSI cases.

Procedure Variables		***Frequency***	***Percent%***	***p-value***	***Correlation coefficient****
Number of OR Trips	Single	471	9.60%	<0.001^S	0.200 (Low)
	Multiple	22	27.30%		
ASA Score	1	233	6.90%	(<0.001)^S	0.341 (Low)
	2	225	15.60%		
	3	30	26.70%		
	4	5	80%		
Wound Classification	I= Clean	202	5.90%	(<0.001)^S	0.279 (Low)
	II= Clean-contaminated	277	13.40%		
	III= Contaminated	1	100%		
	IV= Dirty/Infected	1	0%		
	Missing	12			

The frequencies of different patient variables over the total sample size.
S A significant association between variable and SSI development with p-value <0.05.
NS A non-significant association between variable and SSI development with p-value >0.05.
*Contingency coefficient done for significant p-value association

Risk factors and SSI association

A major aim of this study was to investigate any risk factors contributing to the SSIs following oral and maxillofacial surgeries. The following section identifies the association between SSIs and multiple patient and procedure variables.

Patient variables: Patient characteristics and their association with the development of surgical site infections are detailed in Table 2. Several variables, including male sex, increasing age, and the presence of co-morbid diabetes mellitus, showed significant association with SSIs. In contrast, analysis of weight status and SSI development did not show a significant association. Although the SSI rate in the smoking group was higher than that of the non-smoking group, statistically, no significant association was found.

Unfavorably, the missing data on oral hygiene status was very high (91%), with only 44 cases remaining with complete documentation. Thus, this variable also gave a non-significant association with p>0.05. Regarding mouthwash use, we found that 68% of patients used chlorhexidine mouthwash with a mean of 10.2 days and a standard deviation of 6.53. There was a non-significant association between mouthwash use and SSI cases, with a p-value >0.05. Furthermore,

Table 3: Isolated bacteria from SSI of OMF surgery.

Gram- Stain	Oxygen Usage	Bacteria	Frequency	Percent %
Gram-Negative	Aerobic	*Achromobacter denitrificans*	1	2
		Pseudomonas aeruginosa	3	6
	Anaerobic	*Anaerobic Gram-Negative Rod*	3	6
		Veillonell species	1	2
	Facultative-anaerobic	*Eikenella corrodens*	2	4
		Enterobacter cloacae complex	1	2
		Fusobacterium nucleatum	1	2
		Klebsiella pneumoniae	5	10
		Mixed Gram-Negative Organisms	2	4
		Proteus hauseri	2	4
		Serratia marcescens	1	2
Gram-Positive	Aerobic	*Aerobic Gram-Positive Rods*	1	2
		Staphylococcus coagulase-negative	3	6
	Anaerobic	*Anaerobic Gram-Positive Rods*	1	2
		Anaerobic Gram-Positive Cocci	5	10
	Facultative-anaerobic	*Actinomyces odontolyticus*	2	4
		Enterococcus faecalis	2	4
		Gemella haemolysans	1	2
		Staphylococcus aureus	5	10
		Streptococcus anginosus	1	2
		Streptococcus constellatus	3	6

the association between the time of starting mouthwash use (pre-operative *vs.* post-operative) and the development of infections showed no significant association.

Admission and procedure variables: The 493 OMF surgeries followed in our study were divided into: (1) maxillofacial trauma (50.1%), (2) dentoalveolar surgery (37.1%), and (3) minor head and neck lesions procedures (12.8%). Among the 51 SSI cases, we found the highest SSI prevalence occurred in head and neck lesion procedures with a rate of 14.3%, followed by maxillofacial trauma surgeries, with a rate of 10.5%, and dentoalveolar surgeries, with a rate of 8.7%. Results revealed no significant association between the type of surgery and SSI cases (p>0.05). Similarly, the duration of surgery in minutes – observed at an average of 243, 109, and 166 min for dentoalveolar surgeries, head & neck lesion surgeries, and maxillofacial trauma surgeries respectively – was not significantly associated with the development of SSIs.

Patients included in the study's sample were admitted with a wide range of diagnoses, with the most common being road traffic accidents (30.2%). Other diagnoses included skeletal asymmetry (22.9%), assault (9.5), falls (9.1%), cleft lip and palate (5.7%), impacted teeth (3.7%), etc. Patient diagnosis had a moderately significant association with SSI development, with a contingency coefficient of 0.435. In contrast, the procedure itself and the place of the surgery had low significant associations with contingency coefficients of 0.296 and 0.270, respectively. While 6.5% of procedures were combined with a secondary procedure in the same OR trip, there was no significant association with SSIs.

Several procedure-related variables showing significant association with SSI occurrence are detailed in Table 2.

The length of pre-operative stays in days ranged from 0 to 39 days, with a mean of 2.10 ± 5.15 for all cases, compared to 3.08 ± 5.90 for the 51 cases that developed surgical site infections. While the SSI rate compared to the length of pre-operative stay varied through our classification (0 days, 12.5%; 1-3 days, 8.7%; 4-6 days, 13%; 7-10 days, 13%; >0 days, 37.5%), no significant association was found.

Isolated pathogens and antibiotic use

Wound cultures were documented in 34 of the 51 SSI cases. Table 3 shows the frequencies of causative organisms.

All patients received antibiotics except for 3 procedures. The most commonly used antibiotics included cefazolin (32.5%), amoxicillin/clavulanate (21.5%), cefuroxime (17.6%), clindamycin (6.0%), and cephalexin (5.8%). Antibiotic courses were classified as short-course (prophylaxis) and long-course (treatment course). Only 6% of patients received prophylaxis alone, while the majority received a treatment course, with a mean length of antibiotic use observed as 8.95 ± 5.93. The type of antibiotic course and SSIs showed a non-significant association with a p-value >0.05.

Discussion

Surgical site infections are one of the most important complications following surgical procedures, and their rate and etiologies vary depending on the type of procedure [4]. In oral and maxillofacial surgeries, this complication can have devastating consequences. For instance, SSIs following major surgery for oral cancer treatment led to delays in wound healing, which in turn causes delays in receiving adjuvant therapy and subsequent increased risk for recurrence and increased morbidity and mortality [13]. Furthermore, the development of SSIs has been shown to increase the length of hospital stay and accompanying healthcare-associated costs [8]. As such, it is critical to identify the risk factors contributing to the occurrence of surgical site infections and develop preventive measures to tackle this burden.

Despite the existence of literature studying the risk factors for OMFS-related SSIs, most studies have limitations, including (1) small sample size, (2) variations in baseline patient characteristics, or (3) lack of standardization of definitions. This, in turn, leads to a reduction in statistical power, generalizability, and comparability of findings. Rigorous analytical techniques were applied to evaluate risk factors and outcomes for all SSIs following OMF surgeries. A large sample size was included in the study (n=493), and a wide array of patient-related and procedure-related variables were collected and analyzed. A detailed retrospective data collection procedure was employed, and an internationally accepted definition of SSIs following NHSN criteria and guidelines was used.

In comparison to existing literature, where the rate of SSIs following OMF surgeries ranged from 0.5% to 30%, the rate of SSIs in this study's patient population was 10.3% [5,10-12,14]. Analysis of the rate of SSIs in different types of procedures supports the hypothesis that SSIs are procedure-specific. For instance, dentoalveolar surgeries were associated with the lowest rate of SSIs, while head and neck lesion surgeries were associated with the highest, both of which are findings that are consistent with previous studies [14,15].

Identification of causative organisms through culture and sensitivity tests is critical for the proper selection of antibiotics [16]. However, this practice is not highly followed by OMF surgeons, which may in part be related to the high success rate of infection eradication, despite the lack of organism identification or use of resistant antibiotics [17,18]. The observed success can be explained by the fact that OMF infections arise from a mixed microbiome, so a bactericidal effect on some bacteria may result in the eradication of the entire infection [17,18]. Alternatively, surgical drainage can change the environment of these infections and improve recovery with or without antibiotic use [17,18]. Of the entire patient population that developed SSIs, only 34 wound swab cultures were documented over the six-year period of the study. This aspect of SSI care requires more attention to monitor the dynamic microbiome changes and high bacterial resistance rates. Results found 84% of bacterial infections to be caused by anaerobic bacteria, which is in contrast to other studies that found only 9.1% of OMF infections were caused by anaerobes [17]. This change in OMF infection microbiome should flag the need for more attention to culture and sensitivity testing prior to treatment.

Risk factors for the development of surgical site infections vary and can include patient-related, admission-related, and procedure-related variables. Previous studies have consistently shown an association between the male sex and a higher risk for SSI, and this study corroborated these findings [6,19]. Likewise, analysis of age variables revealed a significant association, another finding consistent with the existing literature [5,6,20]. A significant association with diabetes mellitus was an expected finding, which has been consistently documented as a risk factor for surgical site infections [5,7,20,21].

The literature has shown an association between certain body mass index groups, particularly underweight and obese groups, and the development of postoperative surgical site infections [22,23]. The results of this study contradict these established associations, as there was no significant association between weight status and SSIs. While studies have long demonstrated a strong association between smoking and SSI occurrence, others have shown conflicting data that oppose these findings [5,8,24]. Analysis of this study's data found no association between smoking and SSIs, a finding that may be explained by the routine recommendation of smoking cessation at least four weeks preceding procedures by OMF surgeons.

Oral hygiene and the use of mouthwash are two dental variables that have been demonstrated to play a key role in the development of SSIs following OMF surgeries [25]. The use of pre-operative antiseptic mouthwash has been shown to reduce intraoral bacteria, thus leading to a significant reduction in post-operative infections in oral cancer patients [25]. Unfortunately, due to a high percentage of missing data regarding oral hygiene status (91%), a significant association was not found. Of the patients who used mouthwash (68%), only 9.5% used it pre-operatively. These data gave us a non-significant association with SSIs.

Existing research documents the highest prevalence of SSIs in dirty (class IV) wounds at a rate of 15% to 30%, followed by contaminated (class III) wounds at a rate of 6% to 10%, clean-contaminated (class II) wounds at a rate of 3% to 4%, and clean (clean I) wounds at a rate of 1% to 2% [4,26]. This contrasts with the higher rates in our study, which found the prevalence of SSIs to be 0% in dirty wounds, 100% in contaminated wounds, 13.4% in clean-contaminated wounds, and 5.9% in clean wounds. The SSI occurrences in classes III and IV may be negligible since the frequency was just one for each of the classes. Still, the similarity in classes I and II and the significant association found suggest that these classifications will lead to higher infection rates [4,27]. Furthermore, higher ASA classifications have demonstrated an association with longer hospital stays and a higher rate of postoperative complications, such as surgical site infections, following OMF surgeries [24,28]. This finding is consistent with findings in this study, which found a significant association between higher ASA and SSI rates.

The significant associations found in relation to diagnosis, procedure type, and place of surgery were consistent with previous studies identifying SSIs as procedure-specific [15]. In addition, comparable to existing studies, the results of this study showed a significant association between the number of operations performed and a higher risk of the development of infections following [29]. One of the critical risk factors for surgical site infections is the duration of surgery. Studies have shown that durations exceeding the 75^{th} percentile for a specific procedure are significantly associated with SSIs [2,21]. Curiously, no significant association was found in our study. This discrepancy may be explained by the fact that extreme outlier procedures were not excluded, as no specified cutoff point has been defined yet for OMF surgeries.

Guidelines have recommended shortening the length of pre-operative stay to reduce the risk of hospital-acquired infections [9]. Analysis of our data did not support these guidelines, as there was a non-significant association between the length of pre-operative stay and the development of SSIs. Newer studies have suggested that this factor may no longer play a significant role in the occurrence of SSIs [30,31]. Nevertheless, this recommendation remains logical, as a shorter hospital stay is more cost-efficient for the patient and the healthcare facility.

The use of long courses of antibiotics in the majority of the study's sample (93.7%) is questionable, as it opposes current guidelines, which find an increased risk of *C. difficile* infections and no correlation with reduction in SSIs [4,27]. Although there are particular indications for long-course antibiotic therapy in OMF surgeries, there is not strong evidence to explain the high usage observed in this study, especially with the high risk of bacterial resistance seen recently. Such findings give rise to the recommendation of providing antimicrobial resistance education programs to dentists and OMF surgeons, as corroborated by other studies [32,33].

Several limitations of the study should be recognized, with the main ones being missing data and poor documentation, especially given the retrospective nature of the study. The missing data in some categories was massive and led to a reduction in the power of detection of any statistical significance. Despite the retrospective nature of this study and being a single-center study, we believe its breadth makes it generalizable. However, it would undoubtedly benefit from a more extensive, prospective, multicenter investigation.

Conclusion

The rate of oral and maxillofacial surgical site infections is significant, and risk factors for their development need to be recognized and managed accordingly. Age, sex, and patient comorbidities were significantly associated with the development of SSIs following OMF surgeries. Similarly, several procedure-specific factors, such as the number of operations, wound classification, and ASA classification were associated with a higher risk of infections. Further investigations are warranted to provide a more comprehensive understanding of the risk factors contributing to SSIs after OMF surgeries. For instance, determining a cutoff point for the duration of OMF surgeries is likely to impact clinical judgment for better patient management. Additionally, duplicating this study in a prospective design to include patients from multiple centers and re-investigating risk factors, such as oral hygiene status, mouthwash use, and specific OMF procedures and diagnoses, is recommended and will provide valuable insight into the prediction and prevention of SSIs.

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