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ORIGINAL ARTICLE

Incidence and severity of postoperative complications following oral, periodontal, and implant surgeries: A retrospective study

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Abstract

Background: Incidence and severity of postoperative complications are key elements in determining the risk-benefit relationship of any surgical procedure. The aim of this retrospective study was to assess and categorize the postoperative complications that occur following, and are associated with, oral, periodontal, and implant surgeries.

Methods: A total of 3,900 patients who underwent surgical procedures including, but not limited to, sinus floor elevation, guided tissue regeneration, crown lengthening, implant placement, soft tissue graft, open flap debridement or surgical removal of impacted teeth were included. Postoperative complications were recorded and graded based on impedance to routine daily activity and favorable surgical outcomes. Regression models were generated to evaluate correlations between complication types, as well as between patient/surgical characteristics and the incidence of complications.

Results: Surgical removal of impacted teeth and lateral sinus floor elevation had the highest incidence and severity of complications. Postoperative dentinal hypersensitivity (5.7%) was the most frequent complication, followed by excessive pain (4.1%), and moderate postoperative bleeding (3.5%). Based on the devised grading system described in this paper, the complications were 11.1% of Grade I, 3.3% of Grade II, 8.3% of Grade III, 0.1% of Grade IV, and no complications recorded under Grades V or VI.

Conclusions: Surgical removal of impacted teeth and lateral sinus floor elevation are more prone to more severe complications compared with other procedures. Additionally, complications that do not impede favorable surgical outcomes and/or routine daily activity are the most likely to occur. Smoking and diabetes are generally associated with postoperative complications.

KEYWORDS

guided tissue regeneration, infection, oral surgery, pain, postoperative complications, sinus floor augmentation

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1 | INTRODUCTION

Following surgery, any deviation from the expected course of normal healing is known as a postoperative complication. In order to evaluate the risk-benefit relationship of commonly performed surgical procedures, the key elements assessed are the incidence and severity of postoperative complications, as well as the associated patient-reported outcomes.

Oral surgical procedures are often accompanied by a multitude of complications including pain, swelling, and morbidity.[1] These are the result of inflammatory processes induced by the surgical wound healing such as induction of cyclooxygenase-2 pathway, upregulation of interleukin-1 beta (IL-1β), release of prostanoids, lipoxins, ω3- eicosapentaenoic acid-derived resolvins of the E-series, docosahexaenoic acid-derived resolvins of the D series, protectins, maresins, and increased neuronal excitability in the spinal cord.[2,3] The known factors associated with postoperative discomfort, swelling, or bleeding, based on previous evidence, include, but are not limited to, the duration of intervention,[4–6] surgical extension,[7] postoperative smoking,[8] surgeon expertise,[7] nature of surgical intervention,[4,6] the use of periodontal wound dressing,[9] patient sex,[10] presurgical stress,[11] and various other psychosocial factors.[12,13] Furthermore, antibiotic use has been experimentally associated with accelerated healing, reduced patient discomfort, and less incidence of postoperative infection.[5,14–16]

To the best of our knowledge, the current literature lacks a clear analysis assessing the rates of postoperative complications associated with various types of dental surgeries. Hence, the aim of the present retrospective study was to assess and categorize the postoperative complications that occur following oral, periodontal, and implant surgeries.

2 | MATERIALS AND METHODS

The present study was approved per exemption criteria described in 32CFR§219.101, paragraph b.4 by the University of Michigan Institutional Review Board for Human Studies (Study ID: HUM00145680) to be conducted at the Department of Periodontics and Oral Medicine within the same institution. This retrospective investigation enrolled all patients who had oral and periodontal surgeries between January 1990 and July 2018 at the University of Michigan School of Dentistry (Ann Arbor, MI).

The physical and digital records that fall under the predetermined eligibility criteria were screened and evaluated by three investigators (HA, RDG, and MT). Any disagreements that arose during the evaluation and data collection process were resolved through discussion with the supervising investigator (HLW). All surgeries were performed at the university. Operating surgeons carrying out the procedures were primarily the graduate students working under the direct supervision of faculty with the appropriate clinical expertise.

2.1 | Inclusion criteria

Patients who were included had undergone any one of the following surgical procedures: transcrestal sinus lift, lateral sinus lift (SFEl), guided tissue regeneration (GTR), guided bone regeneration (GBR), crown lengthening (CL), implant placement (IP), gingivectomy, free gingival graft (FGG), connective tissue graft (CTG), open flap debridement (OFD), osseous surgery (OS), mandibular bony impaction tooth removal, or maxillary bony impaction tooth removal. Also, patients must have had a record of postoperative follow-up of ≥6 weeks to be included.

2.2 | Exclusion criteria

The following patients were excluded: 1) patients with ambiguous or incomplete charts; 2) patients who failed to attend follow-up appointments; 3) patients with follow-up(s) conducted via telecommunication without having personally attended even just the initial 2-week follow-up appointment; 4) patients treated or postoperatively evaluated in centers outside the University of Michigan School of Dentistry; 5) patients with inaccessible files due to bad debt, destroyed record, or are deceased; and 6) patients who performed two of the included surgical procedures simultaneously, such as IP and grafting (to avoid a synergistic effect from being a confounding factor).

2.3 | Data acquisition

An initial count of 300 patient charts per included surgical procedure was obtained for preliminary screening. Three hundred patients for each surgical procedure were consecutively selected. Each chart was carefully reviewed by two investigators (HA and RDG). As part of the data collection process, all relevant patient information, including age, sex, presence of a smoking habit (≥1 cigarette/d), diagnosed diabetic condition (validated via the patient's medical records), and use/prescription of surgical wound dressing,* antibiotics, and/or chlorhexidine (CHX), were obtained. All operator notes pertaining to the surgical procedure, the 2-week recall appointment and all postoperative follow-up visits until 6 weeks, were screened to identify the conditions of the surgical procedure, as well as the incidence and type of reported post-surgical complications.

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TABLE 1 Classification of postoperative complications

Grade	Description
Grade 1	Localized complication(s) accompanied by no adverse effects on the success of the surgery.
Grade 2	Localized complication(s) accompanied by adverse effects on the success of the surgery.
Grade 3	Localized or systemic complication(s) that impairs the patient's daily routine but does not require hospitalization.
Grade 4	Localized or systemic complication(s) that impairs the patient's daily routine and requires hospitalization.
Grade 5	Localized or systemic complication(s) that inflicts irreversible damage to ≥1 anatomical structures.
Grade 6	Localized or systemic complication(s) that lead to death.

2.4 | Classification of postoperative complications

Based on severity and impedance of daily activities, the recorded postoperative complications were allotted to one of six grades (Table 1).

2.4.1 | Grade I complications

Grade I represents localized complication(s) accompanied by no adverse effects on the success of the surgery. Localized minor complications such as postoperative dentinal hypersensitivity, oral candidiasis, angular cheilitis, exaggerated swelling, defined as postoperative enlargement of tissues that exceeds the normal limits associated with a given surgical procedure, delayed wound healing, defined as an unusual deviation from the normal course of healing, and mild postoperative bleeding, defined as the presence of a small amount of blood in the oral cavity, usually mixed with saliva, were considered as Grade I complications.

2.4.2 | Grade II complications

Grade II represents localized complication(s) accompanied by adverse effects on the success of the surgery. Localized complications such as flap dehiscence, membrane exposure, localized infection of the surgical site, graft necrosis, and nasal discharge following sinus augmentation were considered as Grade II complications.

2.4.3 | Grade III complications

Grade III is localized or systemic complication(s) that impairs the patient's daily routine but does not require hospitalization. Localized or systemic complications such as fever, skin rash, neuropraxia/paresthesia, trismus, osteomyelitis, septicemia, sinusitis, alveolar osteitis, ecchymosis, fever, excessive and severe bleeding, defined as spontaneous or continuous heavy bleeding from the surgical site, prolonged exaggerated swelling, defined as exaggerated swelling with no signs of remission, persisting for a longer time than 2 weeks, were considered as Grade III complications.

2.4.4 | Grade IV complications

Grade IV represents localized or systemic complication(s) that impairs the patient's daily routine and require hospitalization. Major complications that required immediate hospitalization such as drug-induced anaphylaxis or septicemia were considered as Grade IV complications.

2.4.5 | Grade V complications

Grade V is localized or systemic complication(s) that inflicts irreversible damage to ≥1 anatomical structures. Major complications that led to irreversible damage such as neurotmesis and axonotmesis were considered as Grade V complications.

2.4.6 | Grade VI complications

Grade VI is localized or systemic complications that lead to death. Death was considered a Grade VI complication.

2.5 | Statistical analyses

Simple binary logistic regression models were performed to evaluate the correlation between complications (total number of incidence and degree of event) and the various types of surgery. Odds ratio values and 95% confidence intervals were determined based on IP surgery (procedure showing less complications) being the category of reference. To evaluate the effect of sex, age, smoking, diabetes, surgical wound dressing application, CHX, and antibiotics on the probability of a given complication, estimation of a multiple binary logistic regression model was run. Any P value <0.05 is indicative of a statistically significant relationship.

3 | RESULTS

3.1 | Study sample characteristics

The investigated sample comprised 3,900 patients (51.3% females, 48.7% males) equally distributed into 13 groups (n = 300 per group) based on surgical intervention. The average age of the sample was 54.8 ± 16.0 years, with a range of 17 to 91 years and a median of 58 years. Individuals with a diabetic condition and a smoking habit comprised an estimated 6.1% and 9.4% of the total included patient population, respectively. Surgery distribution by anatomic location was 65.2% in the maxilla and 34.8% in the mandible. Surgical wound dressing was used in 28.5% of the total interventions and CHX was prescribed for 63.4% of the total. Similarly, 69.7% of the patients received antibiotics: amoxicillin alone

(50.2% of the total), amoxicillin with clavulanate (11.4% of the total) or clindamycin (6.1% of the total). A total of 20.1% of patients (n = 784) presented with some type of complication, while 3% presented with ≥2 concurrent complications.

3.2 | Overall complication rate

Figure 1 provides the overall incidence of each complication and the number of complications within each grade (Fig. 1). Overall, postoperative dentinal hypersensitivity (5.7%) was the most frequent complication, followed by excessive pain (4.1%) and moderate postoperative bleeding (3.5%). In terms of grades, 11.1% of Grade I, 3.3% of Grade II, 8.3% of Grade III, 0.1% of Grade IV, and no complication was recorded for Grades V or VI. The incidence of complications for different grades is shown in Figure 2.

3.3 | Complications based on surgical intervention

- Transcrestal sinus lift (see supplementary Figure S1 in online *Journal of Periodontology [JOP]*)

In total, 22.7% of these patients developed some type of complication, but usually only one (21.7%). Also, 10.7% presented with Grade I complications, 2.3% with Grade II and 10.3% with Grade III. Age appeared to significantly increase the probability of having postoperative swelling ($P = 0.015$), with a specific impact of an additional 5% per year. Furthermore, diabetes mellitus (DM) demonstrated a four-fold increase in risk of postoperative swelling (odds ratio [OR] = 3.94, $P = 0.022$). The antibiotic regimen significantly influences the likelihood of this complication occurring ($P = 0.044$). The discrepancy was greatest between taking amoxicillin alone versus not taking any drug (OR = 0.31, $P = 0.083$). The trend is strong and suggests that amoxicillin reduced the probability of incidence by 60%.

- Lateral sinus lift (see supplementary Figure S2 in online *JOP*)

In total, 30% of these patients developed some type of complication; 13.6% presented with complications of Grade I, 10% of Grade II, and 14.3% of Grade III. One patient (0.3%) presented with a Grade IV complication. Diabetes was observed as a factor of developing postoperative swelling (OR = 5.8; $P = 0.014$), mild postoperative bleeding (OR = 4.9; $P = 0.003$), delayed wound healing (OR = 38.6; $P < 0.001$), membrane exposure (OR = 6.69; $P = 0.030$), and flap dehiscence (OR = 7.62; $P = 0.002$). Furthermore, smoking increased the rate of nasal discharge (OR = 10.6; $P = 0.023$) to 6.5% from 1.5% (percentage associated with non-smokers).

- Guided bone regeneration (see supplementary Figure S3 in online *JOP*)

In total, 18% of these patients developed some type of complication. It is a surgery where it is common to develop ≥2 complications (7.6% of cases). Also, 10.7% of the patients presented with Grade I complications, 10% with Grade II, 6% with Grade III, and one patient (0.3%) with Grade IV. The likelihood of postoperative swelling seemed to decrease with increasing age (OR = 0.96, $P = 0.015$), with every additional year reducing the risk by 4%. A diagnosed diabetic condition also enhanced this complication's rate of incidence (OR = 6.1; $P = 0.044$), specifically from 4.6% to 10%. Antibiotic administration was revealed to be important in reducing swelling with the use of any antibiotic drug reducing the likelihood of complication but the amoxicillin + clavulanate combination being the most evident ($P = 0.022$). Amoxicillin also stood out as beneficial in this respect ($P = 0.050$). In terms of mild postoperative bleeding, diabetic conditions enhanced its occurrence (OR = 9.6; $P = 0.018$) from 1.4% with non-diabetics to 10% with diabetics.

Smoking contributed significantly to postoperative membrane exposure (OR = 9.5; $P = 0.001$) and rate of infection (OR = 10.8; $P < 0.001$), increasing the likelihood from 2.9% to 20% for the former and 5% to 35% for the latter. Similarly, flap dehiscence (OR = 8; $P = 0.002$) and excessive pain (OR = 11.1; $P = 0.001$) both exhibited a significant increase in rate with smoking from 3.9% to 20% and 2.5% to 20%, respectively.

- Guided tissue regeneration (see supplementary Figure S4 in online *JOP*)

In total, 13.3% of these patients developed some type of complication, but never more than one. Also, 4.7% presented complications of Grade I, 6% of Grade II, and 2.7% of Grade III. A smoker appeared to be at an eight-fold increased risk of delayed wound healing (OR: 7.64; $P = 0.022$) and a greater than eight-fold increased risk of developing an infection (OR = 8.47, $P = 0.014$) compared with a non-smoker. On the contrary, the use of CHX demonstrated benefit in avoiding such a complication (OR = 0.25, $P = 0.025$), where the percentage of affected patients was 10.6% without and 2.6% with its use.

- Impacted mandibular third molar extractions (see supplementary Figure S5 in online *JOP*)

In total, 47.3% of these patients developed some type of complication, usually only one (34.7%); however, quite a few (12.6%) exhibited more than one concurrent complication. Also, 22.6% of the patients presented with Grade I complications, 3% with Grade II, and 31% with Grade III. The use of surgical wound dressing (OR = 0.29, $P = 0.016$) and CHX

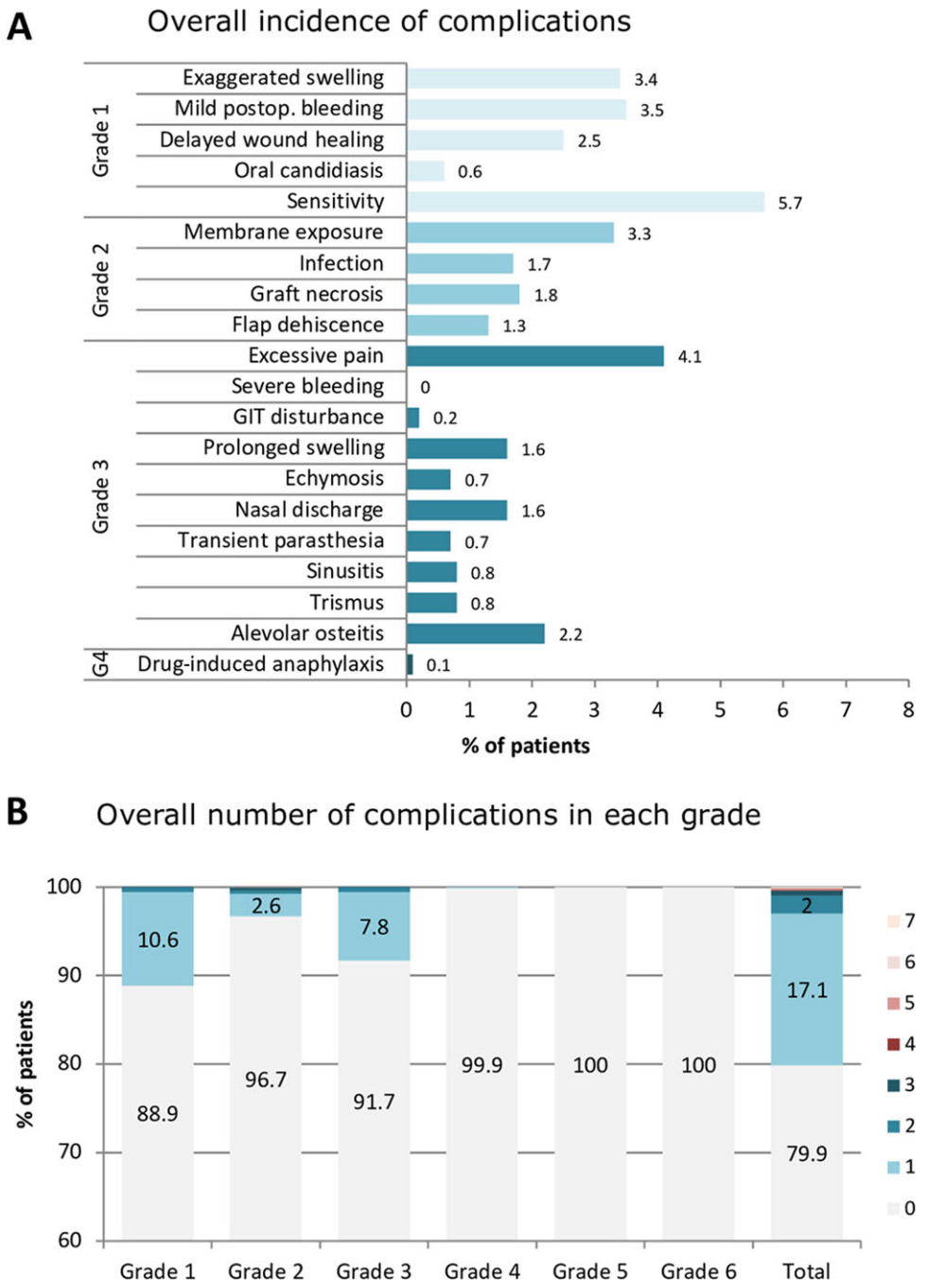


FIGURE 1 **A**) Overall incidence of each complication in all surgeries. **B**) Overall number of complications within each grade. GIT, gastrointestinal tract

use (OR = 0.35, $P = 0.010$) significantly reduced the probability of post-surgical bleeding. In addition, a patient diagnosed with DM was at an eight-fold increased risk of developing this complication (OR: 8.04; $P = 0.008$). Age increased the risk of prolonged, exaggerated swelling. It was estimated that each additional year increased the odds by 5% (OR = 1.05; $P = 0.025$).

- Impacted maxilla third molar extractions (see supplementary Figure S6 in online *JOP*)

In total, 31.7% of these patients developed some type of complication, usually only one (26%). Also, 13.3% of the patients presented with Grade I complications, 4% with Grade II, and 19.7% with Grade III. For this surgery, age significantly reduces the likelihood of excessive pain and ecchymosis (OR = 0.97, $P = 0.031$ and OR = 0.92, $P = 0.039$, respectively). DM increased the risk of this complication by more than five folds (OR = 5.12; $P = 0.022$). Finally, the use of surgical wound dressing decreased the risk of alveolar osteitis (OR = 0.16, $P = 0.037$).

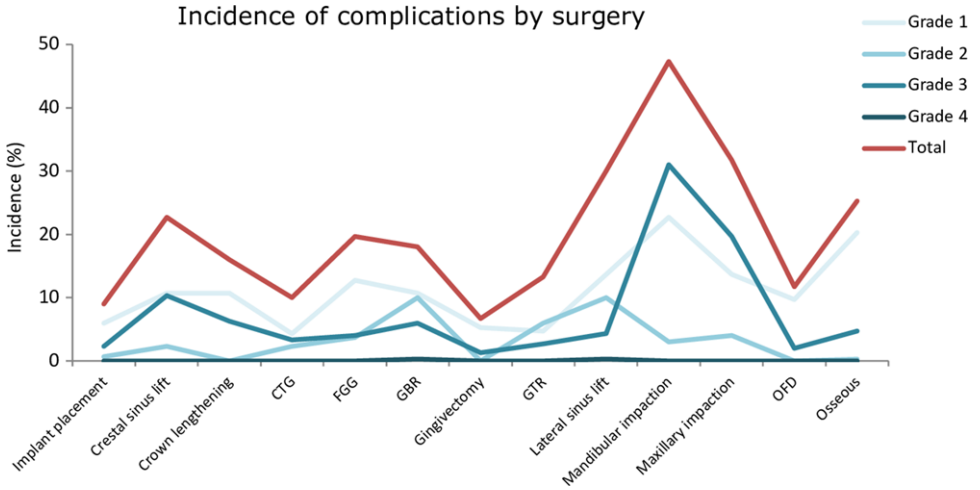


FIGURE 2 Incidence of complications by surgery

- Open flap debridement (see supplementary Figure S7 in online *JOP*)

In total, 11.7% of these patients developed some type of complication, with none presenting more than one. Also, 9.7% of the patients presented with Grade I complications, while 2% presented with Grade III complications. Age significantly increased the probability of mild postoperative bleeding (OR = 1.10, $P = 0.030$), while the use of CHX decreased the incidence of this complication (OR = 0.13, $P = 0.059$). Additionally, DM increased the risk of delayed wound healing (OR = 6.57; $P = 0.044$).

- Osseous surgery (see supplementary Figure S8 in online *JOP*)

In total, 25.3% of these patients developed some type of complication. Also, 20.3% presented with complications of Grade I, 0.3% of Grade II, and 4.7% of Grade III. No factors demonstrated a significant impact on any of the presented complications.

- Connective tissue grafts (see supplementary Figure S9 in online *JOP*)

In total, 10% of these patients developed some type of complication, but usually only one (9.7%). Also, 7% presented with complications of Grade I, 2.3% of Grade II, and 3.3% of Grade III. In this category, the use of any type of antibiotic had a significant positive effect on delayed wound healing ($P = 0.049$).

- Free gingival grafts (see supplementary Figure S10 in online *JOP*)

In total, 19.7% of these patients developed some type of complication, usually only one (19%). 12.7% presented complications of Grade I, 3.7% of Grade II, and 4% of Grade III. The presence of a diabetic condition significantly increases the risk of developing delayed wound healing (OR = 25, $P = 0.013$). On the other hand, the use of CHX has shown a beneficial impact on occurrence of this complication (OR = 0.03, $P = 0.003$), where the incidence rate associated with use versus non-use was 12.8% and 0.6%, respectively.

- Gingivectomy (see supplementary Figure S11 in online *JOP*)

In this group, 5.3% of patients presented with a Grade I complication. None showed a Grade II and 1.3% showed a Grade III complication. In total, 6.7% of the patients developed some type of complication, but never more than one. No factors were found to have a significant impact on any of the complications.

- Crown lengthening (see supplementary Figure S12 in online *JOP*)

In total, 16% of these patients developed some type of complication, but usually only one (15%); 10.7% presented with Grade I complications, and 6.3% presented with Grade III complications. A positive correlation between the probability of developing gastrointestinal disturbance and clindamycin use was observed, where 40% of patients on clindamycin developed the complication versus 0% who were on other antibiotics ($P < 0.001$).

- Implant placement (see supplementary Figure S13 in online *JOP*)

A total of 9% of these patients developed a complication, most commonly just one complication (8.3%). Of the total incidence rate, moderate bleeding was the most frequent event (3.7%), with generally very low rates.

4 | DISCUSSION

This study provides a thorough analysis of the type and severity of possible complications that may occur following surgery routinely performed in a periodontal office, which constitutes a considerable factor in treatment planning and patient decision making. To classify the impact of certain complications on surgery outcome and patient wellbeing, we propose a six-level grading system with ascending level of severity. Overall, the majority of the reported complications pertained to Grade I, with diagnosed postoperative root sensitivity being the most common in this category and 5.7% of the patients reporting discomfort derived from exposed dentine in response to osmotic stimuli after surgery. This outcome was especially evident subsequent to resective surgeries, namely CL (6.7%) and OS (12.3%), where the root remains partially exposed to the oral environment. It must be considered that a stimulation test to assess increased sensitivity could not be performed in a retrospective study, and so only patient reports of perceivably increased root sensitivity were recorded. This may elucidate the lower observed rate of occurrence as compared with studies that have investigated a less invasive procedure—non-surgical therapy—and reported 9%[17] and 31%[18] increase in patients who experienced root sensitivity following stimulation.

Mild postoperative bleeding was the second most common Grade I complication, reported as a bleeding sensation in 3.5% of the patients. This rate of occurrence is higher than that of a classical paper by Curtis and coworkers (1985) where only one patient (0.3%) demonstrated bleeding occurrence after periodontal surgery.[4] However, in our proposed grading system, bleeding is differentiated into mild (Grade I) and severe (Grade III), whereas the study by Curtis et al. had no mention of categorizing the extent of bleeding, in which case only severe bleeding may have been considered. If that is the case, our findings report comparable outcomes, because no patient within our sample was observed to have experienced severe (Grade III) bleeding following surgery.

Regarding the prevalence of infections (Grade II), the type of surgery had an evident impact (Fig. 2). With less invasive procedures, such as IP, OFD, OS, gingivectomy, and CL, no infections were reported, while more invasive surgeries like GTR (4%), SFEl (6%), and GBR (7%) saw a higher prevalence. In the present study, and across all surgery groups, no association between infection prevalence and the type of administered antibiotic was found. However, smoking seemed to be positively correlated with postoperative infections in GBR (OR = 10.8) and GTR (OR = 8.47), but not SFEl. The incidence of sinus complications in the present paper (6%) is slightly higher than those reported from a series of previous published articles. In fact, Moreno Vasquez and coworkers reported an incidence of 3.9%,[19] while another articles this incidence ranged from 1%[20] to 5%.[21,22]

Cigarette smoking has been widely associated with an impact on host response by decreasing neutrophil and phagocytosis functions.[23] Moreover, the risk of subgingival infection in individuals with current smoking is reportedly 2.3 times more than in non-smokers or individuals with a past history of smoking.[24] In this investigation, smoking was also associated with a higher membrane exposure rate (OR = 5.4), flap dehiscence (OR = 8.0), and excessive pain (OR = 11.1) in GBR procedures. This was in addition to delayed wound healing in GTR (OR = 7.6) and nasal discharge (OR = 10.6) in SFEl.

In this study, we regarded severe pain as a Grade III complication, given how it can hinder routine daily activity, which was reported in 4.1% of the patients. In the literature, scientific articles have typically used either the visual analog scale or the amount of ingested analgesic (i.e., ibuprofen) to objectively evaluate pain severity.[25,26] Contrarily, excessive pain, in this paper, was reported by returning patients who had consumed an undefined amount of case-specific analgesics, where no pain scale was made available in the treatment notes of the retrospective cases. Considering that fact, excessive pain was most reported subsequent to extracting impacted mandibular (12.3%) and maxillary (5.3%) molars, as well as SFE (7.7%). Previous literature has indicated that pain following third molar removal can be influenced by various factors such as procedural complexity,[27] duration of surgery,[28] and a lack of operator expertise.[29] The compounding effect of the aforementioned factors may have caused the greater incidence of severe/excessive pain, considering the academic setting of the surgical procedures, as compared with the 4.8% reported by Lee et al., where 546 impacted third molar extractions were performed in a private clinical setting.[30]

Another finding that noticeably stands out in this study is the association between diabetes and post-surgical complications. In fact, DM was directly associated with increased postoperative swelling, delayed wound healing (OR = 25 in FGG and 38.6 in SFE), mild postoperative bleeding, and flap dehiscence. On the molecular level, the mechanism by which this may occur is extensively elaborated in the literature as physiologic alteration induced by hyperglycemic state (uncontrolled diabetes). Such events have implicated modification in 1) the function of neutrophils, monocytes, and macrophages, 2) connective tissue metabolism, 3) normal osseous healing, 4) the formation of advanced glycation end products, and 5) the production of proinflammatory cytokines such as IL-1β and TNF-α.[31]

Our results further suggest that the use of periodontal wound dressing is associated with decreased postoperative swelling, flap dehiscence, mild postoperative bleeding, and a decreased prevalence of alveolar osteitis when placed after third molar extractions. In general, the use of periodontal wound dressing has been classically encouraged as a barrier to protect the surgical wound, increase soft

tissue adaptation,[32,33] promote patient comfort,[34] and stimulate antibacterial function as a role of its eugenol content.[35]

Finally, in light of the controversy surrounding the effect of CHX on wound healing,[36,37] the use of CHX displayed a beneficial effect on delayed wound healing in FGG and GTR, in addition to a reduction in mild postoperative bleeding in OFD and mandibular third molar extractions.

Despite the inclusion of 3,900 patients, the present paper is not exempt from limitations. First, retrospective observational studies are incapable of discerning cause-and-effect relationships. Also, we were not able to define various levels of smoking exposure and diabetes severity (controlled or not controlled). Furthermore, no objective scale(s) to measure pain and sensitivity was used, being parameters such as an unscheduled return visit to the clinic due to pain used to evaluate different levels of pain. All the included procedures were performed within an academic setting by graduate students with expert faculty supervision, potentially increasing the number of complications. On the other hand, we were able to evaluate a considerable number of patients and procedures, finding associations between various clinical factors and the incidences of post-surgical complications.

5 | CONCLUSIONS

The incidence and severity of complications varies between surgical procedures; however, bony surgical removal of impacted teeth and SFEl are more prone to severe complications. In addition, complications that do not impede the surgical outcome or the patient's routine daily activity are the most likely complications to occur. Smoking and diabetes are revealed, in general, as factors associated for postoperative complications.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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