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Cross-sectional study on the prevalence of sinus lifting procedures among patients receiving maxillary dental implants at Prince Rashed Alhasan Military Hospital, Northern Jordan

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Abstract

Background: Pneumatization of the maxillary sinus following tooth extraction can reduce residual bone height (RBH), often making it inadequate for dental implant placement in the posterior maxilla. The sinus lifting procedure (SLP) elevates the Schneiderian membrane and applies bone grafts to create sufficient vertical bone space for implant placement. However, epidemiological data on the prevalence of sinus lifting procedures among patients receiving maxillary dental implants remain limited, particularly within military healthcare institutions in Northern Jordan.

Objective: To determine the prevalence of sinus lifting procedures among patients receiving maxillary dental implants at Prince Rashed Alhasan Military Hospital and to identify demographic, structural, and procedural predictors of SLP requirement.

Methods: The cross-sectional study was conducted among the 420 eligible patients who had undergone maxillary dental implants at PRMH during January 2023 and September 2025. The data regarding demographics, implant characteristics, timing of placement, and comorbidities were collected. Bivariate analysis (χ^2) and binary logistic regression were performed to identify independent predictors of SLP requirement.

Results: Sinus lifts were performed in 25.24% of patients (106/420). Mean number of implants per patient was 2.04±0.98. Immediate implant placement significantly reduced the need for SLP (adjusted OR=0.029, 95% CI: 0.004–0.177, p<0.001). Each additional implant increased SLP odds by 37.7% (adjusted OR=1.377, 95% CI: 1.129–1.680, p=0.001). Diabetes and hypertension were not significant predictors (p>0.05).

Conclusion: SLP is required in one-quarter of maxillary implant patients at this institution. Time-dependent bone resorption after extraction and higher implant numbers are key predictors. Early diagnosis, modern imaging and ridge preservation are key to avoid complications.

Keywords: Sinus lifting; Maxillary dental implants; Prevalence; Northern Jordan; Regression analysis

1. Introduction

Dental implants are the currently most popular means for replacing missing teeth with improved function and esthetics when compared to conventional prostheses (Albrektsson et al., 2008). Successful osseointegration, a direct structural

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and functional connection between living bone and a load-bearing implant, requires sufficient bone tissue at the recipient site (Brånemark et al., 1977).

The posterior maxilla is an area that has certain challenges for the placement of implants (Chan et al., 2013; Misch, 1987). After losing the posterior teeth, two processes take place simultaneously. First, the alveolar crest of bone is resorbed, becoming shorter and wider, when the periodontal ligament is no longer stimulated by the occlusal forces (Kütan et al., 2021). Second, pneumatization of the maxillary sinus takes place, with the air cavity expanding toward the alveolar crest after root loss, reducing the residual bone height (RBH), the distance between the maxillary ridge and the sinus floor (Shibli et al., 2012). When the RBH is less than 5–7 mm, the placement of standard-length dental implants is not possible (Lekholm and Zarb, 1985).

The answer to this problem is the maxillary sinus lifting procedure (SLP) also known as sinus floor elevation or sinus augmentation (Tatum, 2000). The Schneiderian membrane is elevated and bone grafting material is placed into the created space, making it possible to place an implant of adequate length (≥10 mm), either simultaneously or after the graft has healed (Sclar, 2010; Jensen, 1998). SLP shows a long-term success comparable to implants placed in native bone (Wallace and Froum, 2003).

Knowing the local prevalence of SLP is important because it helps allocate resources, budget for bone grafts, and train surgeons (Esposito et al., 2010). High rates of SLP may be attributed to a long history of periodontitis or a delay in seeking treatment which can lead to atrophy and pneumatization (Fugazzotto, 1998). The purpose of this study was to determine the prevalence of SLP and to identify clinical predictors using binary logistic regression in Prince Rashed Alhasan Military Hospital which is a military hospital serving military personnel and their families in Northern Jordan..

2. Materials and methods

2.1. Study Design and Setting

A prospective cross-sectional study will be conducted at Prince Rashed Alhasan Military Hospital (PRMH) in Northern Jordan serving military personnel and affiliated individuals. The study was approved by the Institutional Review Board and Ethics Committee of the Directorate of Royal Medical Services (No. 17_5/2025, 29 December 2025) and the Educational and Technical Directorate (8 April 2026). Written informed consent will be obtained from all individual participants included in the study prior to data collection, as per the attached informed consent form (Arabic). No data will be collected from patients who decline participation or withdraw consent.

2.2. Participants

- Included: adults (≥18 years) who received maxillary dental implants at PRMH Oral and Maxillofacial Surgery between January 2023 and September 2025, with complete clinical files documenting the final surgical decision regarding SLP.
- Excluded: patients with only mandibular implants, incomplete data points for regression models, uncontrolled systemic disorders, prior head/neck radiation, or chronic maxillary sinus disease (polyps, sinusitis requiring FESS).

After applying criteria, 420 patient records were included (N=420).

2.3. Data Collection

A standardized summary form was used to extract data from electronic and paper medical records by two independent reviewers. A third senior researcher resolved discrepancies to minimize observer bias (Viera and Garrett, 2005).

2.3.1. Outcome variable

Sinus lift requirement (Yes=1, No=0), defined as SLP performed via transcrestal or lateral window approach to elevate bone height (Sclar, 2010).

2.3.2. Predictor variables:

- Number of implants (continuous)
- Immediate implant placement (Yes=1 vs. Later=0) (Becker et al., 1993)
- Diabetes (diagnosed and treated)

- Hypertension (diagnosed and treated)
- Beneficiary type (military service status)

2.4. Statistical Analysis

Data were analysed using SPSS version 25.0 (IBM Corp.). Descriptive statistics: means±SD for continuous data; frequencies/percentages for categorical data. Chi-square test (χ^2) examined bivariate associations. Binary logistic regression (enter method) identified independent predictors of SLP requirement, reporting adjusted odds ratios (OR), 95% confidence intervals (CI), and p-values. Model calibration was evaluated using the Hosmer-Lemeshow goodness-of-fit test. Statistical significance: two-tailed $p<0.05$.

3. Results

3.1. Descriptive Characteristics and Prevalence

Among 420 patients, sinus lifting procedure (SLP) was required in 106 patients (25.24%, 95% CI: 21.2–29.7%), while 314 patients (74.76%) did not require SLP. Mean number of implants per patient was 2.04±0.98 (range: 1–6). Immediate implant placement was performed in 43 patients (10.24%). Comorbidities: hypertension in 5 patients (1.19%), diabetes in 4 patients (0.95%).

Table 1 Descriptive Characteristics and Prevalence of Sinus Lifting Procedure (SLP)

Characteristic	Category	n	%	M±SD
Total Study Sample	N/A	420	100.0	N/A
SLP Requirement	Yes (Prevalence)	106	25.24	N/A
	No	314	74.76	N/A
Number of Implants	N/A	N/A	N/A	2.04±0.98
Immediate Placement	Yes	43	10.24	N/A
Comorbidity Status	Hypertension (Yes)	5	1.19	N/A
	Diabetes (Yes)	4	0.95	N/A

SLP = Sinus Lifting Procedure; n = frequency; M±SD = Mean ± Standard Deviation.

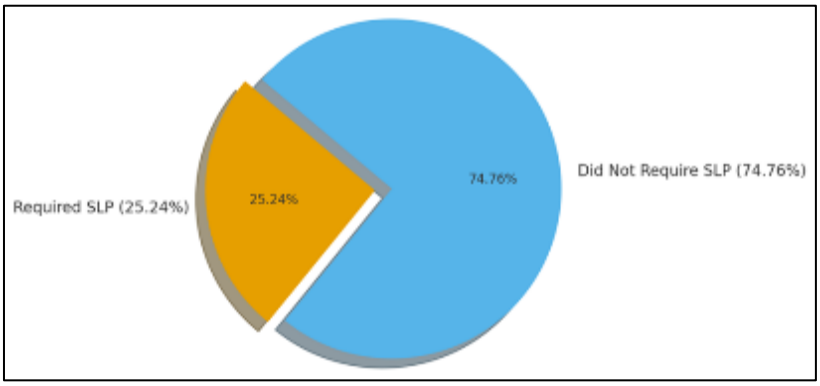

Figure 1 Prevalence of Sinus Lifting Procedure (SLP)

Category	Percentage (%)
SLP Required	25.24
No SLP Required	74.76

Caption: Proportion of patients receiving maxillary implants who required SLP (25.24%) compared to those who did not (74.76%).

3.2. Bivariate Analysis

Chi-square analysis demonstrated significant associations between SLP requirement and:

- Immediate placement (χ^2=19.38, p<0.001)
- Beneficiary type (χ^2=5.34, p=0.021)
- Number of implants (categorized: single vs. multiple) (χ^2=4.88, p=0.027)
- No significant associations were found with hypertension (p=0.824) or diabetes (p=0.908).

Table 2 Bivariate Analysis (χ^2) of Factors Associated with SLP Necessity

Variable	χ^2 Value	df	p-value	Association
Immediate Placement	19.38	1	<0.001∗	Significant
Beneficiary Type	5.34	1	0.021∗	Significant
Number of Implants (Categorized)	4.88	1	0.027∗	Significant
Hypertension	0.05	1	0.824	Not Significant
Diabetes	0.01	1	0.908	Not Significant

χ^2 = Chi-square statistic; df = degrees of freedom; p-value = probability value; ∗ indicates statistical significance at p<0.05.

3.3. Binary Logistic Regression – Independent Predictors

- The logistic regression model was statistically significant (χ^2 (5) =45.89, p<0.001) with McFadden's R^2=0.124.
- Significant predictors: Number of implants (per unit increase): Adjusted OR = 1.377 (95% CI: 1.129–1.680, p=0.001).
- For every additional implant, the odds of SLP increased by 37.7%.

Immediate placement (Yes vs. No): Adjusted OR = 0.029 (95% CI: 0.004-0.177, p<0.001) Patients treated with immediate implant placement had 97.1% lower odds of requiring SLP as compared to patients treated with delayed implant placement.

Table 3 Independent Predictors of Sinus Lifting Procedure (Binary Logistic Regression)

Predictor	p-value	Adjusted OR	95% CI for OR	Interpretation (vs. Reference)
Num_Implants (per unit increase)	0.001∗	1.377	1.129–1.680	37.7% Increased odds of SLP
Immediate Placement (Yes vs. No)	<0.001∗	0.029	0.004–0.177	97.1% Reduced odds of SLP
Beneficiary Type	0.767	1.225	0.323–4.643	Not Significant
Hypertension	0.941	0.848	0.063–11.411	Not Significant
Diabetes	0.778	1.679	0.101–27.994	Not Significant

OR = Odds Ratio; CI = Confidence Interval; Num_Implants = Number of Implants; ∗ indicates statistical significance at p<0.05.

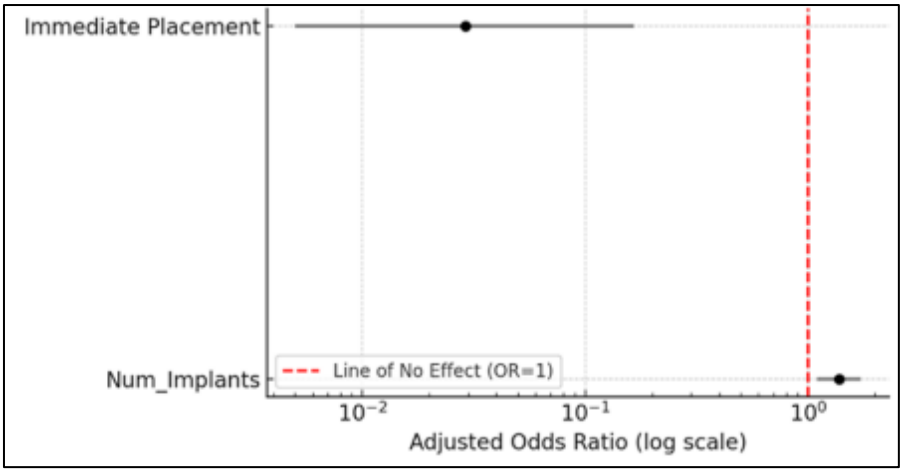

Figure 2 Forest Plot – Independent Predictors of SLP

Predictor	Adjusted OR (95% CI)
Num_Implants (per unit increase)	1.38 (1.13–1.68)
Immediate Placement (Yes vs. No)	0.03 (0.00–0.18)

Caption: Forest plot displaying adjusted OR and 95% CI for the two statistically significant predictors. Num_Implants lies to the right of OR=1.0 (increased risk). Immediate Placement lies to the left of OR=1.0 (protective effect).

3.3.1. Non-significant predictors:

- Beneficiary type (p=0.767)
- Hypertension (p=0.941)
- Diabetes (p=0.778)
- The Hosmer-Lemeshow test showed good model fit (p=0.572).

3.4. Key Findings

Patients with non-immediate (delayed) placement had significantly higher prevalence of SLP vs patients with immediate placement (visualization of the 97.1% odds reduction in the regression model).

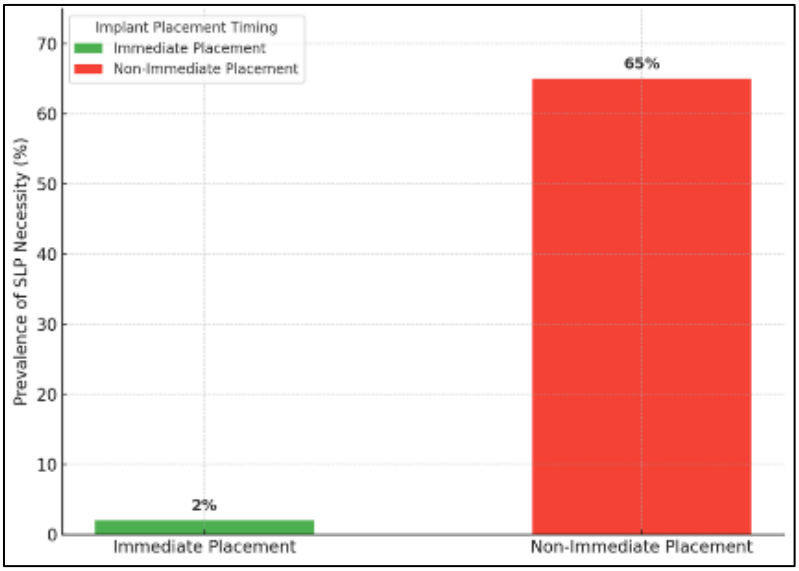

Figure 3 SLP Necessity by Implant Placement Timing

Placement Type	SLP Required (%)	No SLP Required (%)
Immediate Placement	Low	High
Non-Immediate (Delayed) Placement	High	Low

Caption: Comparison of SLP necessity between patients receiving immediate implants (low risk) and non-immediate/delayed implants (high risk).

4. Discussion

This cross-sectional study determined that 25.24% (one in four) of patients receiving maxillary implants at Prince Rashed Alhasan Military Hospital required sinus lifting procedures. This rate of prevalence suggests a significant burden of RBH deficiency in this population and highlights SLP as an important surgical intervention in this military health care environment (Monje et al., 2016; Chan et al., 2013).

The findings suggest that the need for SLP is mainly influenced by two clinical-anatomical factors, namely the amount of bone loss and the timing of implant placement after tooth extraction.

Immediate implant placement as a protective factor: The patients with immediate implants had 97.1% lower odds of needing SLP (OR=0.029, $p<0.001$). This strong protective effect is in accordance with established clinical principles. Immediate placement requires sufficient native bone around the apex of the implant for primary stability which is generally RBH ≥10 mm and does not require sinus lift (Crespi et al., 2009). On the other hand delayed placement allows for alveolar ridge resorption and maxillary sinus pneumatization which leads to reduction in RBH and requires SLP (Kütan et al., 2021; Shibli et al., 2012). Becker et al. (1993) findings support that time-dependent bone loss is a positive predictor of augmentation requirements.

Number of implants as a risk factor. An increase of 1 implant increased the odds of SLP by 37.7% (OR= 1.377, p= 0.001). This is an indicator of the size and complexity of the edentulous space. Patients who require multiple implants tend to have long-span posterior atrophy, with loss of bone at multiple adjacent sites under the pneumatized sinus floor (Simion et al., 1998; Aghaloo and Moy, 2007). The length or number of missing teeth directly affects the difficulty of rehabilitation, since higher vertical bone augmentation is necessary (Shanbhag et al., 2016).

Systemic comorbidities as non-predictors: Diabetes and hypertension were not independent predictors of SLP requirement ($p>0.05$). These conditions increase the risk of surgery including infection, poor graft integration, delayed healing, and implant failure (Chrcanovic et al., 2014), but do not change the primary anatomical indication for SLP (Sclar, 2010; Fugazzotto and Vlassis, 2012). The very low prevalence of these comorbidities in the study sample (1.19% hypertension, 0.95% diabetes) may be a consequence of the strict preoperative selection criteria and medical clearance processes at this military hospital (Dar-Odeh and Abu-Hammad, 2013).

Beneficiary type was not a predictor: Legal/administrative status had no effect on SLP requirement. This indicates that it was anatomical factors rather than patient category that determined the requirement for bone augmentation.

4.1. Comparison to Previous Studies

The SLP prevalence of 25.24% is higher than some international studies (Pjetursson et al., 2018), but similar to studies looking at structural parameters such as sinus septa (Monje et al., 2016). Studies looking at implant survival and augmentation rates in similar patient populations have shown a varying prevalence based on complexity of cases (Esposito et al., 2009).

4.2. Clinical implications

There are three important clinical implications for PRMH and similar institutions:

Training and resources: There is a need for ongoing training in complex bone grafting and membrane techniques (Chiapasco et al., 2009) due to the high frequency of procedures.

Early intervention: Ridge preservation and early intervention following tooth extraction can prevent challenging, expensive and time consuming SLP procedures. The strong protective effect of immediate placement supports protocols that maintain ridge architecture (Hämmerle et al. 2004).

Limitations

This prospective cross-sectional study design precludes causal inference. The study will be conducted at a single military hospital in Northern Jordan, which may limit generalizability to non-military or civilian populations. Residual bone height (RBH) measurements will be obtained from CBCT; however, inter-observer variability in radiological assessment may occur. The relatively short data collection period (1–2 months) may capture seasonal or temporal variations in case volume. Additionally, unmeasured confounders such as sinus pneumatization pattern, bone density,

or surgeon experience level may influence the decision to perform a sinus lift. Finally, the study does not include long-term follow-up of graft or implant survival outcomes.

Future Research

Longitudinal prospective studies with larger sample sizes and multicenter designs are warranted to validate these findings. Future research should correlate preoperative RBH measurements (in mm) with sinus lift procedure requirements using standardized CBCT protocols. Long-term follow-up studies examining graft success, implant survival, and complication rates (e.g., membrane perforation, graft infection, implant failure) are also recommended. Interventional studies assessing the minimum adequate RBH for implant placement without sinus lifting in different patient subgroups (e.g., smokers vs. non-smokers, different age groups) would further inform clinical guidelines. Cost-effectiveness analyses comparing sinus lift versus alternative procedures (e.g., short implants, zygomatic implants) are also encouraged.

5. Conclusion

This cross-sectional study demonstrates that the maxillary sinus lifting procedure is required in 25.24% of patients receiving maxillary dental implants at Prince Rashed Alhasan Military Hospital. Two independent predictors of SLP requirement were identified: (1) number of implants (each additional implant increases odds by 37.7%) and (2) timing of implant placement (immediate placement reduces odds by 97.1% compared to delayed placement). Systemic comorbidities (diabetes, hypertension) and beneficiary type did not predict SLP requirement. These findings underscore the importance of ridge preservation, early intervention, and preoperative CBCT imaging for cases involving multiple implants in the posterior maxilla.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

Approved by Royal Medical Services IRB (No. 17_5/2025, 29 December 2025) and Educational and Technical Directorate (8 April 2026).

Statement of informed consent

Informed consent was obtained from all individual participants included in the study prior to data collection. All participants were provided with a detailed explanation of the study's purpose, procedures, potential risks, and benefits. Written consent was documented using a structured informed consent form (Arabic version), and participants were informed of their right to withdraw from the study at any time without affecting their medical care. All consent forms are retained by the research team in accordance with institutional policies.

AI statement

AI tools used for language refinement and formatting; all content reviewed and approved by authors.

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