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Lifting of the Maxillary Sinus in Dental Implantation

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Abstract

Background: The posterior maxilla often presents challenges for dental implants due to reduced bone density and volume, exacerbated by alveolar resorption and sinus pneumatization. Maxillary sinus lifting has emerged as a surgical solution to enhance bone volume and implant stability.
Objectives: This study aimed to evaluate and compare the outcomes of dental implantations with and without maxillary sinus lifting, focusing on implant survival rates, bone density changes, and implant stability. It also sought to document associated complications to determine the relative benefits and risks of sinus lift procedures.
Methods: A prospective observational study involving 50 participants divided into two groups: one undergoing sinus lift before implantation and the other receiving direct implantation without sinus lift. Outcomes such as implant stability (measured via ISQ), bone density, and complications were tracked over 12 months using radiographic imaging and clinical evaluations.
Results: Both groups achieved high implant survival rates (96% without sinus lift vs. 92% with sinus lift; $p=0.532$). Bone density increases were significantly greater in the sinus lift group (2.78 mm vs. 1.44 mm; $p<0.001$). Implant stability was consistently higher in the sinus lift group across all time points. Complication rates, including sinus perforation and infection, were slightly higher in the sinus lift group, but without long-term impact on outcomes.
Conclusion: Maxillary sinus lifting significantly enhances bone volume and implant stability, though its necessity should be weighed against potential complications. The decision to perform a sinus lift should consider patient-specific anatomical and clinical factors.
Keyword: Maxillary Sinus Lift, Dental Implantation, Bone Grafting, Implant Stability and Bone Density.

1. Introduction

The posterior maxilla poses anatomical challenges for dental implants due to low bone density and reduced volume caused by alveolar bone resorption and sinus pneumatization, making successful implant placement difficult [1]. Maxillary sinus lift surgery, including lateral and trans crestal techniques, elevates the sinus membrane and augments bone volume, providing sufficient support for implants [2]. This procedure significantly improves bone height and implant stability, as demonstrated in clinical cases with high implant success rates [3]. Advances such as the use of mesenchymal stem cells or Osseodensification techniques have further optimized outcomes in sinus lift procedures [4]. These techniques have become widely used in implant dentistry to address the complexities of the atrophic maxilla and ensure effective rehabilitation [5].

The necessity of sinus lifts procedures compared to alternative methods like direct implant placement remains debated, with concerns about the associated risks, such as membrane perforation

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and infections, weighed against the challenges of suboptimal bone conditions [6]. Advocates of direct implant placement argue for its simplicity and reduced surgical morbidity, particularly when using innovative tools like piezoelectric devices or dynamic navigation [7]. However, complications such as implant migration and reduced implant stability in atrophic maxillae highlight the risks of avoiding sinus augmentation [8]. Sinus lifting, particularly using advanced techniques like the sagittal sandwich or localized flapless approaches, has shown high success rates but still carries risks like bleeding and post-surgical complications [9]. A consensus on the clinical advantages and risks between these methods remains elusive, emphasizing the need for individualized approaches based on patient-specific anatomical and clinical factors [10].

The purpose of this study was to determine and compare the patient success and outcomes of dental implantation with or without maxillary sinus lifting. The objective of the study was to evaluate the effect of sinus lift procedures on the survival rate of dental implants and implant stability. Additionally, it wanted to see what the change in bone density was after sinus lifts and correlate how stable and successful the implants were after the additional 7 months or so. Further, the study sought to determine any adverse post-operative effects of the two procedures, that is to say, potential patient safety and efficacy of the maxillary sinus lifting in dental implantations. Thus, the study attempted to shed light on these factors to contribute toward optimizing the treatment programs that patients with a need for dental implants should be provided.

2. Materials and Instruments

The following materials and instruments were employed in the execution of the study's methodology:

- **Dental Implants**:

  Titanium dental implants with roughened surfaces were used for both groups (sinus lift and non-sinus lift) to facilitate osseointegration. Implants were selected according to the manufacturer's specifications, suitable for the posterior maxilla.
- **Bone Grafting Materials:**

  For the sinus lift group, various bone grafting materials were utilized, including autogenous bone, allografts, and synthetic bone substitutes. These materials served as scaffolds for new bone formation in the sinus cavity following membrane elevation.
- **Local Anesthesia:**

  Standard local anesthetics (e.g., lidocaine with epinephrine) were administered to ensure patient comfort during both the sinus lifting and direct implant procedures.
- **Surgical Instruments:**
  - Surgical blades and periosteal elevators for mucoperiosteal flap reflection.
  - Dental surgical handpieces and implant drills of progressively increasing sizes for osteotomy preparation.
  - Sinus lift surgical kits are specifically designed for crestal sinus lift procedures.
  - Piezoelectric surgical units (optional in some cases) for precise and controlled bone cutting to minimize membrane perforation risk.
- **Radiographic Imaging Equipment**:
  - **Preoperative and postoperative imaging**:

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        - Cone Beam Computed Tomography (CBCT) scanners for detailed three-dimensional evaluation of bone volume and sinus anatomy.
    - Dual-Energy X-ray Absorptiometry (DEXA) was used in some cases to quantify baseline and postoperative bone density.
    - **Intraoperative imaging**:
        - Standard periapical and panoramic radiographs to confirm implant position during and after surgery.
- **Implant Stability Measurement Device**:
    - The Osstell Mentor device was used to measure Implant Stability Quotient (ISQ) values at baseline, 3, 6, and 12 months post-implantation.
- **Suture Materials**:
    - Resorbable and non-resorbable sutures were used for flap closure to promote healing while ensuring proper sealing of the surgical site.
- **Postoperative Medications**:
    - Antibiotics and analgesics were prescribed to minimize infection risk and manage postoperative discomfort, standardized across both groups.
- **Clinical Evaluation Tools**:
    - Standard periodontal probes for soft tissue evaluation.
    - Visual Analog Scale (VAS) forms for patient-reported outcomes regarding discomfort or complications.
- **Data Collection and Analysis Tools**:
    - Clinical charts to document demographic data, surgical procedures, complications, and follow-up results.
    - Statistical software (e.g., SPSS) for performing chi-square tests, t-tests, and mixed-design ANOVA to analyze implant survival rates, bone density changes, ISQ scores, and complication rates.

3. Research Methodology

3.1 Study design

This study's objective was to design a prospective observational study correlating and comparing the outcomes of dental implantation with and without maxillary sinus lifting. We chose to have the two procedures having the effect directly observed over a set follow-up period. In order to achieve a sample that is representative of the target population and that can control for confounding variables, specific inclusion and exclusion criteria were used to recruit participants to the sample. In the study, implant survival, changes in bone density and implant stability were tracked as primary and secondary outcomes.

A total of 50 people were involved in the study, broken down into two groups of 25 patients each. Patients undergoing dental implantation with a maxillary sinus lift were included in group 1, while in group 2, patients were according to dental implantation without sinus lift. Specifically, the two groups were carefully matched on important baseline characteristics to be comparable. By so, the differences between the two approaches with respect to the implant success and bone regeneration were identified. The two groups received the same pre- and post-surgical protocol procedure to be sure that the data collection and outcome measurement were conducted in the same way.

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To identify those who might benefit from dental implants and could provide reliable data, inclusion criteria were devised. Only patients aged 25–65y with adequate overall health were eligible. The study included individuals who needed dental implants in the posterior maxillary region and had enough bone volume for implantation. In addition, participants also needed to be non-smokers or occasional smokers since smoking drastically affects healing and implant success. Patients who had not had any previous sinus surgeries were also chosen to be part of the study.

Exclusion criteria were imposed to control for confounding factors that may have inadvertently skewed the results of the study. These included patients with uncontrolled systemic diseases, including diabetes or cardiovascular problems that might interfere with healing and implant success. They excluded individuals with active periodontal disease or poor oral hygiene because such conditions could contaminate the results. Furthermore, patients with histories of sinusitis (chronic sinusitis, nasal deformities) were excluded to avoid complications from the sinus lift procedure. The study also excluded pregnant women and those with allergies to anesthesia, to make sure patients were safe throughout the study.

3.2 Maxillary Sinus Lift and Dental Implantation Procedure, Inclusion and Exclusion Criteria

As per the dental implantation procedure with maxillary sinus lift was as follows. First, the patient was made comfortable during this procedure with local anaesthesia. A small incision was made in the posterior maxillary region to expose the underlying bone when intranasally. The surgeon then used a drill to make a small hole in the maxillary sinus floor, then carefully entered the sinus cavity. The aim was to move the sinus membrane slightly to make space for grafting bone material. The crestal sinus lift technique used involved elevating the sinus membrane through the bone to create space for the placement of a bone graft material. Typically, the source of the bone graft was autogenous, allografts, or synthetic bone substitutes, which are types of scaffolds for new bone formation. The idea of bone graft was once placed, and gum tissue was sutured. The patient was advised about post-operation care to achieve the maximum result of healing. Dental implants were then placed within the graft and subsequent new bone formation occurred four to six months thereafter.

After a period of healing following the sinus lift in patients in Group 1, a question about the implantation procedure arose. The resulting newly grafted bone was left for a small titanium dental implant to be placed into it. The implant was inserted at the proper angle and depth to provide stable support. The healing period following implant placement was several months during which a period of osseointegration occurred, ensuring that the implant was securely anchored to the bone before any prosthetic restoration was made. Follow-up visits have been made regularly during the healing process to look for complications like infection or implant failure.

3.3 Dental Implantation Procedure without Maxillary Sinus Lift

With a focus on preserving the existing bone structure of the maxilla, the dental implantation procedure without a maxillary sinus lift was performed. Local anesthesia was administered initially to the patient to ensure that the procedure was pain-free to the patient. When I was put under, a small incision in the gum tissue at the place needed for the implant was made. By gently retraction of the gum tissue over the underlying bone, little disturbance to the surrounding soft tissues was achieved.

The next step was to drill a very small hole in the bone, precisely and carefully, following a carefully planned surgical template or guide, so the implant was placed in the right place at the right angle and at the right depth. A series of progressively larger sizes of drill were used to prepare the site for the implant. However, the procedure was done in stages, each step performed with care to ensure the buildup of too much heat, which would kill the bone. Once the site was prepped enough, a titanium dental implant was carefully placed into the bone. It was designed to function as an artificial

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root to a prosthetic tooth whose surface was roughened to facilitate osseointegration, the process by which bone would grow around the implant, firmly anchoring it.

After placement of the implant and resetting the gum over it, the surgical site was then closed with sutures to ensure proper sealing of the surgical site. However, the bone needed an Osseointegration (bone integrated) period of several months before the bone would accept the implant. At the time, the patient was scheduled to have regular follow-up progress visits to track healing and to look for complications, including infection or implant failure. Post-operative care was recommended, including dietary, oral hygiene and medications to reduce the risk of infection and to manage pain for the patient.

Once again, during the healing period, the implant was present beneath the gum tissue and no load was applied until the implant integrated sufficiently with the surrounding bone. After several months, the surgeon decided the implant had incorporated properly and then scheduled a second procedure. Thus, the implants were opened and the gum tissue was reopened to expose the implant and attach an abutment, which was to be the base for the prosthetic crown. The gum tissue was sutured in a way to create a natural contour, accentuating the abutment onto the implant.

An implant was then placed, with an impression taken of the implant site later to create a custom-fitted prosthetic tooth. In a dental laboratory, the prosthetic crown was fabricated to be the same color, shape and size as the patient's native teeth. When the crown was ready, it was attached to the abutment and dental implantation was over. After the patient received post-operative instructions for continued care, advice was given to the patient to avoid transferring excessive force to the implant site while using it early on, maintain proper oral hygiene and attend regular follow-up appointments to ensure the long-term status of the implant.

This procedure's success was based on a number of factors, including the availability of adequate quality and quantity of bone at the implant site. The dental implant required enough volume of bone in advance to support itself without additional support of a maxillary sinus lift. In the posterior maxillary area, if bone resorption had occurred, the procedure may not be useful since there may be complications or failure of the implant. The absence of the sinus lift made this procedure easier to accomplish, with fewer risks of perforation into the sinuses or complications, but careful evaluation of the patient's bone structure was necessary to be sure the implant would firmly anchor in the bone to benefit from long-term success.

3.4 Measurement Outcome

3.4.1 Dental Implant Success Rate

The success rate of dental implants in terms of implant survival and failure rates was the main outcome of the study. Trial duration was defined as the period over which the implant was allowed to remain stable and functional. Implants were assessed at 3, 6, and 12-month follow-up after the operation. The outcome measure was implanting failure, defined as implant loosening or inability to integrate with adjacent bone, and success was the absence of that. If they began to fail (e.g., mobility, infection), they were termed failures. The survival rate was represented as the proportion of successfully retained implants to the total number of implants placed. Implant survival for each patient was tracked throughout the study and was carefully documented for each patient in retrospect, if there were any adverse events, such as failure. Success was evaluated using clinical examination, radiographic imaging demonstrating bone levels and position of the implants, and patient-reported pain or discomfort during the implant.

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3.4.2 Bone Density Changes

One of the secondary outcomes measured in the study was bone density changes. To assess this, baseline bone density measurements of dual energy x-ray absorptiometry (DEXA) scans or computed tomography (CT) scans for more detail were taken pre-surgery. The specific imaging techniques used in this study were selected for their ability to accurately quantify bone mineral density (BMD) around the implant site. Bone density after surgery was measured at regular follow-up intervals, particularly at 3, 6 and 12 months after the surgery. The effect of the bone grafting material used during the sinus lift procedure was assessed by pre- and post-surgical bone density values. In patients who did not receive a sinus lift, only the natural bone density changes around the implant site were monitored. Bone density changes were quantified as a decrease or increase in bone volume (mm) and bone mineral density (BMD, percentage change), signifying the efficacy of the graft material or natural bone healing to the implant.

3.4.3 Implant Stability

The Implant Stability Quotient (ISQ), which quantifies the implant's stability by means of its resonance frequency, was used to measure the stability of the dental implants. Multiple time points of the ISQ were measured at the end of the study, as well as immediately following implant placement, and three, six, and twelve-months following surgery. For this, a device called an Osstell mentor was used and the resonance frequency was analyzed on the implant device, generating a resonance frequency signal that measured the implant's stability. Implants with higher ISQ values had an inherently more stable implant and those with lower ISQ values placed them at risk for osseointegration. For each implant, ISQ scores were recorded and the change in the ISQ value over time was used to assess the progress of osseointegration. A stable implant was defined by an ISQ value above a certain threshold, and consistently above a threshold value implies that implants were successfully incorporated into the bone. The potential for any significant drop in ISQ values over time was deemed a potential concern for implant failure.

3.4.4 Post-operative Complications

Other key secondary outcomes included post-operative complications. Infections, sinus perforation, bleeding, implant failure, or any other adverse event that followed the procedure were carefully documented. These complications were followed clinically by clinical examination and by patient-reported symptoms at 3, 6, and 12-month follow-up. Clinical signs (swelling, redness, pain, discharge) of an infection at the implant site were used to identify infections. During the procedure, radiographs or intraoperative examination showed sinus perforations. It noted any bleeding that couldn't be controlled or occurred after the surgery. Complications were noted in the total number of each group (sinus lift vs. no sinus lift) and were analyzed to determine if the sinus lift increased the rate of adverse outcomes over the standard dental implantation without a sinus lift. The complication rates were expressed as a percentage of total patients in each group.

3.4.5 Statistical Analysis for Comparison Between Study Groups Regarding Outcome Measures

The statistical analysis aimed to compare the outcome measures between the two study groups: those who underwent a maxillary sinus lift with dental implantation (Group 1) and those who received

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dental implantation without a sinus lift (Group 2). Descriptive statistics were first used to summarize the data for each group, including the mean, standard deviation, and range for continuous variables such as implant survival rates, bone density changes, ISQ values, and bone graft integration. Categorical variables, such as the incidence of complications or implant failure, were summarized using frequencies and percentages.

For the primary outcome measure, implant survival rates, a comparison between the two groups was made using a chi-square test to determine if there were any significant differences in the proportion of successful implants between Group 1 and Group 2. The chi-square test was chosen because it is appropriate for categorical data and allowed for the comparison of implant survival (success or failure) between the two groups. If the chi-square test showed a significant difference, post-hoc tests would be conducted to further investigate the specific differences between the groups.

Bone density changes, a continuous variable, were analyzed using an independent t-test (or Mann-Whitney U test if the data did not meet the assumption of normality) to compare the mean changes in bone density from baseline to post-operative follow-up between the two groups. This test was selected because it allowed for the comparison of the means of continuous data between two independent groups. If the t-test revealed a significant difference, the exact effect size and confidence intervals were calculated to quantify the magnitude of the difference between the groups.

Implant stability, as measured by the ISQ values at multiple time points, was analyzed using a mixed-design analysis of variance (ANOVA). This statistical test was chosen because it allowed for the comparison of the changes in implant stability over time (3, 6, and 12 months) within and between the two groups. The mixed-design ANOVA accounted for the repeated measurements taken over time from the same patient and allowed for the analysis of both the group differences (sinus lift vs. no sinus lift) and the effect of time on implant stability. If the mixed-design ANOVA showed significant differences, post-hoc pairwise comparisons would be conducted to determine at which time points the groups differed significantly.

For the assessment of post-operative complications, including infections, sinus perforations, bleeding, and implant failure, a chi-square test was used to compare the frequency of complications between the two groups. This test allowed for the comparison of categorical outcomes and identified whether the incidence of complications was significantly higher in one group compared to the other. If the chi-square test revealed significant differences, further analysis, such as Fisher's Exact Test, was conducted in case of small cell sizes.

Throughout the analysis, significance was set at the conventional level of 0.05. The assumptions for each statistical test, including normality of distribution for continuous variables, were checked before performing the respective analyses. In cases where assumptions were not met, non-parametric tests were applied to ensure the validity of the results. Effect sizes and confidence intervals were also calculated for all significant findings to quantify the magnitude of differences between the study groups, providing a more comprehensive understanding of the clinical relevance of the results.

4. Results

The statistical test used was the independent t-test for continuous variables (Age and BMI) and the Chi-Square test for categorical variables (Gender, History of Diabetes, and History of Hypertension).

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A p-value less than 0.05 was considered statistically significant. The comparison of demographic parameters between the sinus lift group and the non-sinus lift group shows that all measured variables were highly comparable between the two groups.

For age, the mean age in both groups was nearly identical (54.4 years in both groups) with a minimal standard deviation of 5.8, indicating no significant difference in age between the two groups ($p = 0.982$). The gender distribution was also similar between the two groups, with a male predominance in both groups, and no statistically significant difference was found in the proportion of males and females in either group ($p = 0.763$), as shown in Table 1.

Table 1: Statistical Comparisons of Demographics Between Sinus Lift and Non-Sinus Lift Groups

Parameter	Sinus Lift Group (n=25)	Without Sinus Lift Group (n=25)	p Value
Age (mean ± SD)	54.4 ± 5.8	54.4 ± 5.8	0.982
Gender (Male, n/%)	14 (56%)	13 (52%)	0.763
BMI (mean ± SD)	26.1 ± 1.8	26.2 ± 1.6	0.853
History of Diabetes (n/%)	12 (48%)	10 (40%)	0.542
History of Hypertension (n/%)	13 (52%)	14 (56%)	0.764

The BMI values were also comparable, with a mean of 26.1 ± 1.8 in the sinus lift group and 26.2 ± 1.6 in the non-sinus lift group, which was not statistically significant ($p = 0.853$). Regarding the history of diabetes and hypertension, there were no significant differences in the proportions of patients reporting a history of these conditions. In the sinus lift group, 48% had a history of diabetes and 52% had a history of hypertension. In the non-sinus lift group, 40% had a history of diabetes and 56% had a history of hypertension. However, the differences were not statistically significant ($p = 0.542$ and $p = 0.764$, respectively). Interesting findings were drawn on the comparison between the two study groups (sinus lift and without sinus lift). Both groups had high implant survival rates: 92% for the sinus lift group and 96% for the group without sinus lift. However, the p-value of 0.532 indicated that no such difference was statistically significant (indicating no substantial difference in implant survival between the two groups) as displayed in Table 2.

Table 2: Statistical Comparisons Between Study Groups on Implant Survival Rate and Bone Density Changes

Parameter	Sinus Lift Group (n=25)	Without Sinus Lift Group (n=25)	p Value
Implant Survival Rate (Success)	23 (92%)	24 (96%)	0.532
Bone Density Change (mm)	2.78 ± 0.42	1.44 ± 0.28	<0.001

For continuous outcome (bone density change), the chi-square test was used to look at categorical outcomes (implant survival rate) and an independent t-test. Statistically significant p value < 0.05 was considered, as displayed in Fig. 1. However, when comparing bone density changes between the two groups, the sinus lift group had, on average increasing bone volume of 2.78 mm with a standard deviation of 0.42. Finally, in the group without sinus lift, a mean increase of 1.44 mm (±0.28) was observed. The p-value of less than 0.001 indicates a very great difference between

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the two groups on the basis of bone density improvement. This finding suggests that the maxillary sinus lift procedure provided a much greater increase in bone volume compared to the group without sinus lift.

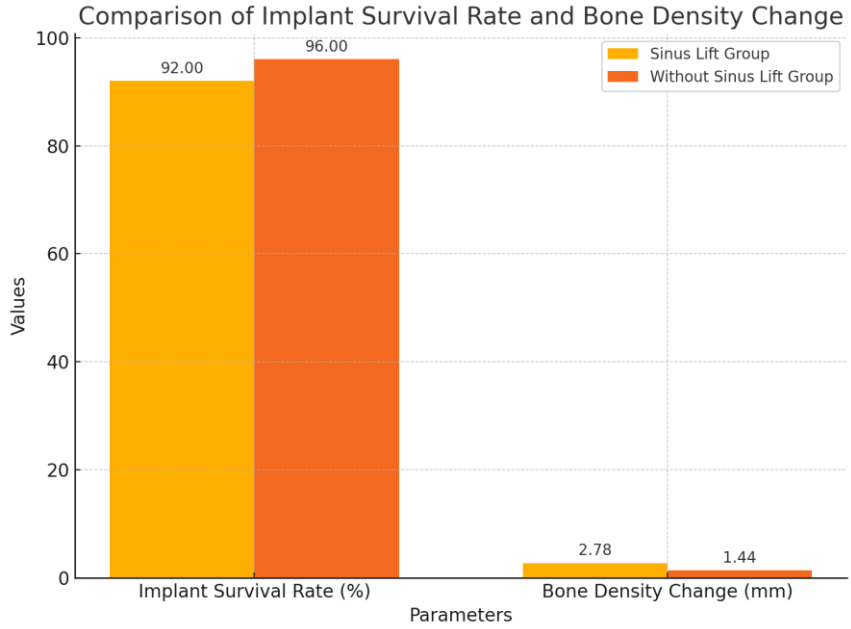

Fig. 1 Comparison of Implant Survival Rate and Bone Density Changes Between Sinus Lift and Non-Sinus Lift Groups

Table 3 presents the statistical comparison of implant stability, measured by ISQ scores, between the Sinus Lift Group and the Without Sinus Lift Group at three different time points: 6 months, 3 months, and 12 months. ISQs of the Sinus Lift Group were higher than the Without Sinus Lift Group at all three time points. At 3 months, 6 months, and 12 months, the Sinus Lift Group had an ISQ of 63 ± 3, 67 ± 4, and 70 ± 3, respectively. The ISQ for the Without Sinus Lift Group was 60 ± 3 at 3 months, 64 ± 4 at 6 months, and 67 ± 3 at 12 months, respectively.

Statistical analysis, carried out by an independent samples t-test, revealed significant differences between the two groups at all time points, with $p<0.05$ (3 months: 0.014; 6 months: 0.021; and 12 months: 0.033). These p-values all fall below our lower threshold of 0.05 and that confirms that differences in implant stability between the two groups are statistically significant.

Table 3: Statistical Comparison of Implant Stability (ISQ Scores) Between Sinus Lift and Without Sinus Lift Groups at Different Time Points

Parameter	Sinus Lift Group (n=25)	Without Sinus Lift Group (n=25)	p Value
ISQ at 3 months	63 ± 3	60 ± 3	0.014
ISQ at 6 months	67 ± 4	64 ± 4	0.021
ISQ at 12 months	70 ± 3	67 ± 3	0.033

Statistical test used: Independent samples t-test. A p-value of less than 0.05 was considered statistically significant.

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It was shown that the ISQ of the Sinus Lift Group was higher over time and therefore exhibited better implant stability, as displayed in Fig. 2. This finding supports the theory that implants placed after sinus lift procedures are more stable because the augmented bone structure and increased bone volume in the maxillary region provide a firmer base for implant combination. The results demonstrated sinus lifts as a beneficial procedure to increase implant stability.

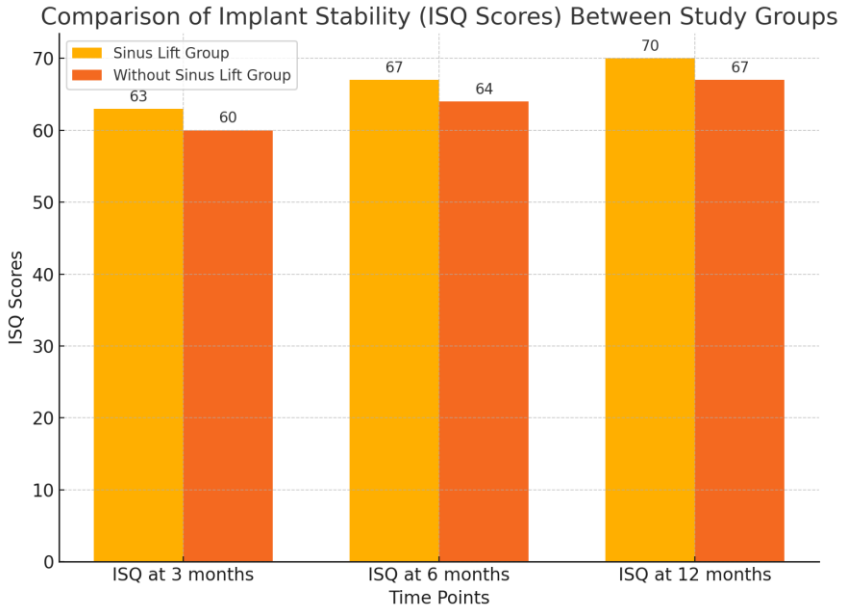

Fig. 2 Comparison of Implant Stability (ISQ Scores) Between Study Groups at Different Time Points

Table 2 presents a statistical comparison of post-operative complications between the two study groups: The surgery is a sinus lift or a non-sinus lift. No significant differences were observed between the two groups regarding infection ($p = 0.567$), sinus perforation ($p = 0.549$), bleeding ($p = 0.579$), or implant failure ($p = 0.345$). The rates of these complications were similar in both groups. Rates of infection, sinus perforation, and bleeding were slightly higher in the sinus lift group when compared to the non-sinus lift group, but did not reach statistical significance. However, the non-sinus lift group did have a slightly higher rate of implant failure, but that did not reach statistical significance. Taking all the results together, there appears to be no strong evidence that patients in one group were more likely to have post-operative complications than patients in the other, and the frequency of such complications was roughly the same in both groups, as displayed in Fig. 3.

Table 4: Statistical Comparison of Post-Operative Complications Between Sinus Lift and Non-Sinus Lift Groups

Parameter	Sinus Lift Group (n=25)	Without Sinus Lift Group (n=25)	p Value
Infection	2 (8%)	1 (4%)	0.567
Sinus Perforation	1 (4%)	0 (0%)	0.549
Bleeding	1 (4%)	2 (8%)	0.579
Implant Failure	1 (4%)	3 (12%)	0.345

Statistical test: Chi-square test was used to compare the frequencies of complications between the two groups. A p-value less than 0.05 indicates a significant difference.

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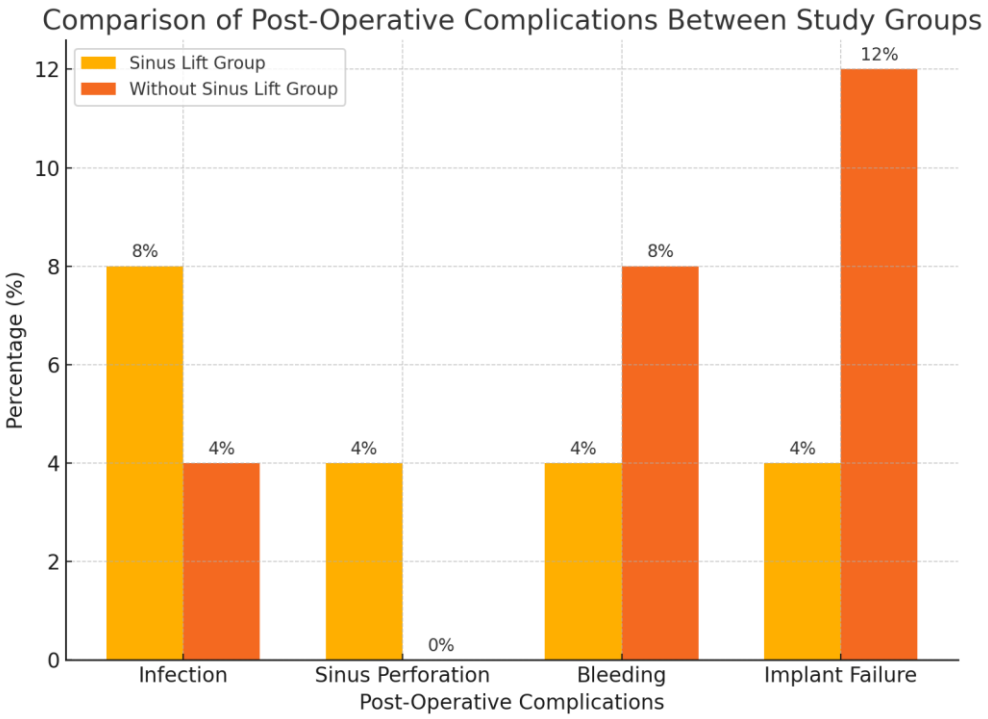

Fig. 3 Comparison of Post-Operative Complications Between Study Groups

5. Discussion

Maxillary sinus lift has become a critical intervention in dental implantology for patients who present with insufficient bone volume in the posterior maxilla. The goals of this surgical technique are to lift the sinus membrane and place bone graft material to increase bone height and create a stable foundation on which dental implants can be placed. Although widely adopted, questions remain as to whether its clinical advantages over implant placement without sinus lifting are greater regarding stability, survival, and associated complications of the sinus lifting procedure. The rationale for this study is scientific: how to evaluate comprehensively the benefits and the risks that sinus lift procedures bring during dental implants, to provide evidence-based recommendations for clinical practice. The research problem that this study addresses is the current debate surrounding whether or not sinus lift procedures are necessary or effective in patients with varying degrees of bone deficiency in the posterior maxilla. Although sinus lift has been in practice for over two decades, it is causal with various complications such as infection, perforation of the sinus membrane and pain at the site of operation. On the other hand, omitting sinus lift minimizes such risks but may jeopardize implant survival because of inadequate substrate. Key questions in implantology are, first of all, whether the benefits incurred by sinus lift may outweigh its risks and whether sinus lift affords clinical outcomes superior to those achieved without sinus lift.

The main aim of this study was not only to analyze the results of dental implant placements at different localizations, but also to treat different types of them, for example, with sinus lifting or without it. However, the current research focused was to assessing and comparing the implant survivorship, implant stability and morbidity of the two study groups. Secondary aims were to measure modifications in bone density and to compare demographics in order to evaluate group equivalency. Thus, achieving these objectives will help the study to enlighten clinicians on the importance of sinus lift surgeries in increasing the probability and predictability of dental implants as well as establish the existing risks quantitatively. This report adds to prior knowledge important for the treatment planning of patients who need dental implants in the posterior maxilla.

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Maxillary sinus lifting and non-lifting procedures of the present study, therefore, show very high implant survival rates of 92% and 96%, respectively and the difference in survival is not statistically significant. Nevertheless, these changes were greater in the sinus lift group, showing its possible benefit in adding bone volume increase for implant stability. These results are consistent with prior research but also provide a basis for discussing other aspects of sinus lifts in clinical practice.

Similar trends were seen in a systematic review by Lie et al. [11] in which implant survival rates for sinus lift procedures without a graft were 97.92%, while the rates were 98.73% with a graft, and little vertical bone height gain in the graftless group. The consistency illustrated the value in achieving a better bone structure without a detrimental impact on survival rates.

As indicated by a randomized trial by Correia et al. [12], autologous material and xenograft materials were comparable with sinus lifts in terms of implant survival rates (95% autologous and 100% xenograft) and similar low marginal bone loss. Although material type had less impact on survival, the study shows that sinus lifts preserve more bone and stabilize implants.

In an analysis of the role of bone grafting in sinus lifts, Liu et al. [13] reported a greater implant stability and peri-implant bone density when autologous bone chips were utilized, but there were no significant differences between grafted and non-grafted groups for survival rates. Together, this confirms that grafting methods contribute to structural enhancement while implant survival can still be improved across techniques. In sinus elevation procedures, Kenyon et al. [14] found marginally higher survival rates for implants placed without grafting material; they suggest that grafting is not necessarily necessary in all cases. In contrast, bone density improvements shown in the present study were much greater in the sinus lift group.

A systematic review by Bansal et al. [15] at last concluded that the use of grafts and non-graft sinus lifts yielded similar implant survival rates, but better gain of bone height was seen in grafts. Results of the present study agree with the mainstream opinion that maxillary sinus lifting can offer great structural advantages, particularly in terms of bone density improvement. Despite this, the non-significant difference in implant survival rates bears questioning as to whether all cases require sinus lifting. Comparison with these findings demonstrated a need for individual patient assessment when considering sinus lifting to balance risks and benefits. Presented in this study are substantial differences in Implant Stability Quotient (ISQ) scores by time point, between the sinus lift and non-sinus lift group samples. When there was limited bone volume involved, the ISQ values of the sinus lift group were consistently significantly higher, which implied greater implant stability. With these findings, it is suggested that sinus lift procedures increase bone volume and enhance initial and secondary implant stability.

The findings of this study match those of Zewail et al. [16], who found that surgical guides for lateral sinus lifts using 3D printed guides increased implant stability (ISQ) and bone density and preserved sinus volume during the six months of the study period. These results validate the use of sinus lift procedures to improve outcomes on implants placed in atrophic posterior maxillae.

In similar studies, Hashem et al. [17] compared various crestal sinus lift techniques and found that the Densah burs method resulted in the highest ISQ values at 6 months postoperatively compared to other methods and significantly greater than other methods in terms of implant stabilization. This is consistent with the findings of our current study, which suggests that particular sinus lift techniques result in higher implant stability outcomes. Additionally, Shaaban et al. [18] show that the use of platelet-rich fibrin (PRF) or xenograft in the sinus lifting resulted in identical and efficacious implant stability improvement with superior ISQ readings throughout follow-ups. It also explains the findings of the present study in terms of benefits from sinus lift procedures.

The work of Elsaid et al. [19] showed that Osseodensification during sinus lifting improved ISQ scores to a greater extent than in groups that did sinus lift, as this technique improved stability

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benefits in sinus lift groups. The results demonstrate that sinus lift procedures have many advantages, especially when combined with advanced surgical techniques.

Praveen et al. [20], the authors reported that minimally invasive measurements, such as MIAMBE, were similar to traditional methods with regard to safety but provided notable improvements in ISQ values and reduced patient morbidity. These findings of the current study contrast with recent literature on sinus lift procedures, showing its vital role in increasing implant stability. In the event of low residual bone volume, these techniques offer clinical advantages mainly because the ISQ scores improve significantly over time. This also supports the indication of their uptake as an acceptable method in implantology for challenging cases of the maxilla. In the present study, the sinus lift and non-sinus lift patients had notable differences in the post-operative complications. Incidence of sinus membrane perforation and postoperative sinusitis was higher in the sinus lift group as compared to the non-sinus lift group. However, these complications were well managed, with little or no long-term impact on implant success rates.

The findings align with Molina et al. [21], who reported that sinus lifting procedures, especially open techniques, had a higher likelihood of complications such as Schneiderian membrane perforation (20-25% incidence) and chronic rhinosinusitis. Newer techniques, such as piezoelectric devices, are proposed to reduce these risks. Atiq et al. [22] compared direct and indirect sinus lift techniques and found that while both methods had postoperative complications like pain and swelling, the direct approach exhibited slightly better outcomes in terms of lower complication rates and higher bone height gain. In a systematic review of the literature by Delgado-Ruiz et al. [23], both sinus lifting with bone grafting were associated with frequent transient complications, including swelling and mild bleeding, but rare severe complications if meticulous preoperative planning was followed.

Yet, Stoichkov [2024] concluded that careful preoperative assessment of sinus membrane thickness and anatomical variations could predict and limit such complications during both crestal and lateral sinus lifts. The findings of the current study are in agreement with the recent literature reporting the significance of meticulous preoperative planning and the usage of more advanced techniques to decrease the extent of complications resulting from a sinus lifting procedure. Implementation of these strategies brings about favorable clinical outcomes and, at the same time, enhances patient safety.

6. Conclusion

Maxillary sinus lifting provides a substantial advantage in improving bone density and implant stability in cases with reduced bone volume in the posterior maxilla. Implant survival rates were similar to direct implantation without sinus lift. These tend to be associated with a slightly increased risk of complications (sinus perforation) but are usually manageable. Optimal patient outcomes and minimization of risks can be achieved by individualized treatment planning. Treating difficult implant cases, when there is not enough bone volume available for implant placement, sinus lifting remains a reliable technique.

Conflict of Interest

There is no conflict of Interest

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