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Assessments of lateral window over crestal sinus lift techniques for implant placement in the maxillary posterior region

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Abstract:
The maxillary sinus pneumatization reduces bone height and density. Therefore, it is of interest to assess the outcomes of direct (lateral window) versus indirect (crestal/osteotome) maxillary sinus lift techniques for implant placement. Sixty patients with insufficient posterior maxillary bone height were assessed with lateral window over crestal sinus lift method. At 12-month follow-up, vertical bone gain, implant stability; post-operative were evaluated. In severely resorbed posterior maxillae, the lateral window sinus lift approach improves secondary implant stability and increases vertical bone growth.

Keywords: Crestal osteotome technique, dental implants, sinus augmentation, sinus lift, vertical bone gain

Background:
Alveolar bone resorption and maxillary sinus pneumatization, lowers residual bone height and may jeopardize implant durability, frequently impede implant placement in the posterior maxilla **[1].** Due to differences in residual bone morphology, occlusal load distribution and prosthetic planning from fully edentulous or mixed instances, partially edentulous individuals constitute a unique clinical cohort that affects implant prognosis **[2].** It is also influenced by sinus augmentation procedure **[3].** In order to restore sufficient bone volume and facilitate predictable implant-supported rehabilitation, maxillary sinus augmentation is frequently carried out **[1].** The direct lateral window approach and the indirect crestal (osteotome) approaches are the two main methods used for sinus floor elevation **[4].** Although the lateral window technique is preferred in cases of severe posterior maxillary bone loss and permits greater vertical bone gain **[5],** it is linked to higher morbidity, including longer surgical times, a higher risk of Schneiderian membrane perforation and temporary post-operative discomfort **[6].** The crestal method, on the other hand, is less intrusive, appropriate for mild augmentation and typically leads to less pain for the patient, a quicker recovery and fewer surgical problems **[7].** Clinicians must balance bone growth, implant stability, morbidity and patient comfort while choosing the best sinus augmentation approach. In order to enhance evidence-based decision-making and maximize treatment outcomes, this emphasizes the necessity of direct comparisons between lateral window and crestal methods in partially edentulous posterior maxillae **[7].** Therefore it is of interest to compare the results of direct (lateral window) and indirect (crestal/osteotome) maxillary sinus lift methods for implant insertion.

Materials and Methods:
This study randomized controlled trial was done in the Periodontics department after obtaining the approval from the institutional ethics committee. Informed consent was obtained from the participants. Using G*Power (version 3.1.9.7) with an effect size of 0.3, α error of 0.05 (standard convention) and 90% power, the sample size was determined. Pilot data and earlier research assessing vertical bone gain following sinus augmentation served as the basis for the impact size. Sixty patients in all were needed. Adults between the ages of 20 and 60 who had adequate dental hygiene and an edentulous posterior maxilla with residual bone height of 4 to 10 mm met the inclusion criteria. ASA I or II and who are willing to give informed permission and undergo implant-supported rehabilitation. Uncontrolled systemic disease, smoking, a history of previous maxillary sinus surgery and pregnancy or lactation were the exclusion criteria. Total 60 participants were equally divided into groups using a computer-generated random sequence. Group A (Direct Sinus Lift – Lateral Window Technique) or Group B (Indirect Sinus Lift -Osteotome / Crestal Approach). In group A, a full-thickness facial flap was mirrored to reveal the lateral maxillary wall and a crestal incision was performed on the palatal face of the posterior maxillary edentulous ridge. Additionally, vertical relief incisions were made anteriorly and distally to improve access. With the inferior border 1-2 mm above the sinus floor, the superior border 2-3 mm above the intended implant length, the anterior line 1-2 mm from the sinus anterior wall and the posterior line roughly 5 mm posterior to the planned implant site, a rectangular lateral access window was created using a rotary handpiece under sterile saline irrigation. The Schneiderian membrane was carefully removed from the lateral walls and sinus floor. Allograft material was then packed into the sinus after collagen and antibiotic were put against the raised membrane using a layered grafting approach. After repositioning the flap, 4-0 silk was used to stitch it. In Group B, a full-thickness crestal flap was reflected to reach the bony ridge and a pilot drill was used to prepare the first osteotomy 1-2 mm below the sinus floor. IOPA, RVG and OPG imaging were used to validate the bone height. Using progressively larger drills, the osteotomy was progressively expanded until it was one size below the eventual implant diameter. After gently mall eating a small-diameter osteotome to fracture the sinus floor, incremental osteotomes were utilized to achieve vertical bone extension. Periapical radiographs were performed to validate the position. A bone graft carrier and osteotome were used to pack more bone graft material into the

sinus after PRF and collagen were gradually added to raise the membrane. The implant was inserted and the incision was sealed with 4-0 silk sutures after sufficient elevation was attained. Every participant was advised to eat a soft, nourishing diet and to practice good oral hygiene by using antiseptic mouthwash. Following surgery, post-operative evaluations were conducted at 3, 6 and 12 months. Clinical (swelling, discomfort, Visual Analogue Scale/VAS) and radiographic alterations for residual alveolar bone height, bone increase at the implant site and peri-implant bone level changes were assessed after surgery. Both resonance frequency analysis and the Glickman method were used to evaluate implant stability. Schneiderian membrane perforation during surgery was evaluated. Vertical bone gain, primary and secondary implant stability and 12-month implant survival were the main results. Post-operative morbidity, which included discomfort, edema, membrane perforation and other issues, was a secondary outcome. At one week, three months, six months and twelve months after surgery, follow-up evaluations were carried out. Statistical evaluation was done using SPSS software version 25.0 of IBM USA and Student's t-test, analysis of variance (ANOVA) and Chi-square test.

Result:

In this study, 30 individuals with missing anterior teeth received treatment. Every lost tooth was treated as a separate sample. The study included 13 females and 17 males. The average age was 35.4 years, with a range of 18 to 50 years. After surgery, the recordings were recorded at six and twelve months. Group A and Group B each received an equal number of 60 implants. With very slight differences across groups, 10 mm implants were most commonly utilized followed by 11 mm and 13 mm. longer implants were distributed equally, although shorter implants were typically favored. Schneiderian membrane perforation happened during surgery in 3 out of 30 cases (10%) in Group A and 1 out of 30 cases (3.33%) in Group B, for a total of 4 perforations (13.3%) in both groups. Re-suturing or collagen patches were used to successfully handle all perforations during surgery, guaranteeing that the problem was resolved (**Table 1**). At the time of insertion and six months later, implant stability (ISQ) was evaluated. Group A's mean ISQ at insertion was 67.5 ± 4.2, whereas Group B's was 63.4 ± 5.7. There was no statistically significant variation (p = 0.15), suggesting similar main stability. After six months, both groups' ISQ values rose to 72.3 ± 3.1in Group A and 71.2 ± 4.2 in Group B. This difference was statistically considerable (p = 0.02), indicating that Group A had somewhat higher secondary stability (**Table 2**). Over time, changes in radiographic bone height were assessed. Prior to surgery, Group A's residual bone height was 6.11 ± 1.31 mm, while Group B's was 6.12 ± 0.64 mm. Bone height rose to 11.5 ± 1.3mm in Group A and 10.1 ± 1.4mm in Group B at 6 months, with Group A showing a larger rise. A little remodeling was suggested by the slight decrease at 12 months (11.2 ± 1.4 mm in Group A and 10.1 ± 1.2 mm in Group B). Over the course of the follow-up, Group A continuously increased its bone height (**Table 3).** The Visual Analog Scale (VAS) was used to measure postoperative pain on Day 2 and after one week. Group A and Group B had mean pain levels of 3.6 ± 1.3 and 3.2 ± 1.1 on Day 2, respectively, with no statistically significant difference (p = 0.11). Scores dropped to 1.3 ± 0.6 and 1.1 ± 0.4 at one week, respectively, with no discernible difference (p = 0.24). Overall, discomfort decreased with time for both groups, suggesting similar postoperative results (**Table 4**). In Group A, 16 out of 30 patients (53.3%) had postoperative edema on Day 2, whereas 14 patients (46.7%) had no swelling. Of the 30 patients in Group B, 13 (or 43.3%) had edema, while the remaining 17 (56.7%) did not. These results show that early postoperative edema was somewhat more common in Group A than in Group B (**Table 5**). Implant survival was high in both groups at the 12-month follow-up. Of the 28 implants in Group A, 28 (93.3%) were functionally stable, while 2 (6.7%) failed and needed to be removed. All 30 implants (100%) in Group B were successful. A positive short-term prognosis and a high overall success rate were demonstrated by the fact that 58 out of 60 implants (96.7%) were stable at 12 months, with only 1 failure (3.3%) (**Table 6**).

Table 1: Intraoperative Schneiderian membrane perforation

Outcome	Group A	Group B	Total
Perforation (yes)	3 (10%)	1 (3.33%)	4 (13.3%)
Managed intraoperative (re-suturing / collagen patch)	3 (10%)	1(3.33%)	4(13.3%)

Table 2: SQ (implant stability) at insertion and 6 months

Time point	Group A mean ± SD	Group B mean ± SD	p-value
ISQ at insertion	67.5 ± 4.2	63.4 ± 5.7	0.15
ISQ at 6 months	72.3 ± 3.1	71.2 ± 4.2	**0.02**

Table 3: Radiographic bone height (pre-op, 6 months, 12 months)

Timepoint	Group A (mm) mean ± SD	Group B (mm) mean ± SD
Pre-op residual height	6.11 ± 1.31	6.12 ± 0.64
Radiographic height at 6 months	11.5 ± 1.3	10.1 ± 1.4
Radiographic height at 12 months	11.2 ± 1.4	10.1 ± 1.2

Table 4: Pain (VAS 0–10): Day 2 & 1 week

Timepoint	Group A mean ± SD	Group B mean ± SD	p-value
VAS Day 2	3.6 ± 1.3	3.2 ± 1.1	0.12
VAS 1 week	1.3 ± 0.6	1.1 ± 0.4	0.24

Table 5: Swelling (clinical) on Day 2

Outcome	Group A (n=28)	Group B (n=28)
Swelling present (clinical)	16 (53.3%)	13 (43.3%)
Swelling absent	14 (46.7%)	17 (56.7%)

Table 6: Implant survival at 12 months

Outcome	Group A	Group B	Total
Survived / functionally stable	28 (93.3%)	30 (100%)	58 (96.7%)
Failed / removed	2 (6.7%)	0 (0%)	2 (3.3%)

Discussion:

Sixty patients receiving maxillary sinus augmentation participated in this prospective, randomized comparative trial. Early post-operative morbidity was significantly higher and implant survival was equal in both groups. The observed vertical bone gain for the crestal group (4.3 ± 1.1 mm) and lateral window group (6.4 ± 1.2 mm) is consistent with previous randomized trials. Our cohort exhibited slightly higher gains, which may be due to the use of grafting materials, standardized surgical procedures. Although absolute results were impacted by residual bone height and site-specific factors, ISQ disparities between groups were in line with other research. When remaining bone height is less than 5 mm, the lateral window technique is still the recommended method since significant vertical augmentation is needed **[8].** On the other hand, the crestal/osteotome technique offered sufficient elevation with less invasiveness, shorter operating periods and faster early recovery for bone heights of 5–10 mm **[9]**. Despite being statistically greater in the lateral window group, early post-operative morbidity was clinically minimal and resolved within a week, indicating that it is safe to employ in properly chosen patients. Internal validity is strengthened and selection bias is reduced by the randomized design with nearly full follow-up (98.2%) **[10].** Robust evaluation of augmentation success was made possible by objective clinical and radiographic measurements, including as insertion torque, ISQ values and vertical bone increase **[11].** Clinical relevance is improved by thorough reporting of complications and patient-reported results. The results of simultaneous implant insertion and the lateral maxillary sinus lift surgery did not significantly differ, according to Hussein *et al.* **[12].** Because of its special benefits, the lateral window method is still relevant: makes it easier to overcome **[5].** Al-Almaie and Kavarodi discovered no discernible variations in VAS pain scores or between lateral and crestal approaches **[13].** Hashem *et al.* revealed superior implant stability, faster operation time and fewer problems with Densah group but, the vertical bone growth was larger with the osteotome technique **[14].** Hussein *et al.* came to the conclusion that there was no discernible difference between the results of simultaneous implant implantation and the lateral maxillary sinus lift operation **[12]**. Clinicians can handle the challenges of implant implantation in a weak posterior maxilla with the use of both osteotome and lateral window procedures **[15]**.

Advancement to knowledge:

In order to increase implant stability and lower patient morbidity, recent developments in maxillary sinus augmentation place a high priority on minimally invasive methods. In order to provide safer and more reliable results, modern procedures often combine a lateral window approach with crestal approaches, utilizing sophisticated instrumentation.

Conclusion:

The safety and efficacy of both lateral window and crestal/osteotome sinus augmentation procedures for implant insertion in the posterior maxilla are confirmed by this randomized comparative trial. The crestal method offers less invasiveness, a shorter operating time and better initial patient comfort for modest augmentation (residual bone 5–10 mm). In order to provide evidence-based guidance for clinical decision-making in the partially edentulous posterior maxilla, this focuses on customizing the technique to unique anatomical factors, such as residual bone height, sinus morphology and site-specific bone quality.

Limitations:

The long-term implant survival, marginal bone loss, prosthetic success and functional outcomes are limited by the 12-month follow-up. In radiography and ISQ evaluations, inter-operator variability and possible measurement bias were not taken into consideration. Cost-effectiveness, patient satisfaction and quality-of-life metrics were not included and variations in grafting materials were not thoroughly examined. Lastly, the small, single-center sample size limits the identification of uncommon problems and diminishes external validity.

Future directions:

Future studies should concentrate on standardized patient-reported outcome measures to measure quality of life and functional recovery, stratified trials based on residual bone height to optimize technique selection and long-term studies assessing marginal bone changes, prosthetic outcomes and cost-effectiveness. Instead than being a definitive conclusion, this would present current data as a basis for patient-centered, evidence-based sinus augmentation.

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