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CLINICAL AND RADIOGRAPHIC EVALUATION OF TRANSCRESTAL VERSUS LATERAL SINUS FLOOR ELEVATION (RANDOMIZED CONTROLLED CLINICAL STUDY)

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ABSTRACT

Objectives: Sinus augmentation with a lateral window approach is the traditional treatment when the atrophic posterior maxilla's residual bone height (RBH) is ≤6mm. The goal of the current research is to compare the clinical and radiographic results of the transcrestal approach in sites with RBH ≤6mm compared to the lateral window approach. **Subjects and Methods:** Twenty-two patients with one or more extracted teeth in the sinus zone of the posterior maxilla and a subantral RBH of ≤6mm were selected for the study. Their ages varied from 34 to 59. At random, two equal groups of patients originated: group (I) received dental implants following a sinus lift utilizing the lateral window approach, while group (II) included patients who underwent dental implantation after a sinus lift through a transcrestal approach. All patients were clinically evaluated at the following intervals: preoperative, immediate, one, three, and six months postoperatively. Sinus membrane perforation, pain, edema, and implant stability were clinically evaluated. Radiographic assessment using CBCT was used to measure the ridge height and bone density. **Results:** The incidence of intraoperative sinus membrane perforation, postoperative pain, and swelling in the transcrestal approach group was lower than that in the lateral approach group. All implants had primary stability with significant improvement in secondary stability measured 6 months postoperatively in both groups. **Conclusions:** The transcrestal approach can be considered an effective and safe alternative to the lateral window approach in the atrophic posterior maxilla.

KEYWORDS: Maxillary sinus Augmentation; lateral window sinus lift; transcrestal sinus lift

INTRODUCTION

Dental implant rehabilitation for patients who are partially or completely edentulous is regarded a predictable therapeutic modality with favorable long-term functional results. However, the posterior maxillary region is frequently difficult for dental implant placement due to decreased alveolar bone height and density caused by post-extraction ridge atrophy and maxillary sinus pneumatization[1,2].

To enhance the amount of bone in the posterior maxilla, the sinus lift procedure was developed and described by Tatum[3] at the Alabama Implant Conference in 1976 and subsequently published by Boyne[4] in 1980. This procedure involves detaching

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the Schneiderian membrane from the floor of the maxillary sinus to create a space that is filled with bone grafts, with the aim of increasing vertical ridge height in the posterior maxilla to facilitate dental implant insertion[5].

Two main approaches to maxillary sinus floor elevation procedures are widely practiced. The first is the classic lateral window approach, and the second is the conservative transcrestal approach utilizing osteotome, which gained widespread acceptance due to its simplified, less traumatic procedure with a lower incidence of complications compared to the lateral approach[6,7].

Several authors have classified the maxillary sinus augmentation technique. At the 1996 Academy of Osseointegration Consensus Conference on Sinus Grafts in Boston (Massachusetts), the members provided recommendations that were dependent on the residual bone height (RBH) of the patient. These recommendations were as follows: for patients with an RBH of 10mm or more, the classic implant procedure can be performed. For patients with an RBH of 7-9mm, a transcrestal sinus lift with simultaneous implant placement is preferred. When the RBH is 4-6mm, a one-stage open sinus lift is recommended. Finally, for patients with an RBH of 3mm or less, a two-stage open sinus lift with implant installation after 6-9 months is recommended[8].

Subsequently, a series of studies suggested going beyond the recommendation and extending the utilization of the transcrestal approach at the site with RBH ≤6mm instead of the lateral approach. Both approaches have the effectiveness of significantly increasing vertical bone height but with different degrees of perioperative and postoperative complications. However, there is an insufficient number of randomized clinical trials evaluating the safety and efficacy of the transcrestal approach compared to the lateral approach when RBH is ≤6mm with simultaneous implant placement[9–12].

Therefore, this research relied on the hypothesis that the transcrestal osteotome approach decreases postoperative morbidity and enhances vertical bone gain. This research aimed to compare the outcomes of the sinus floor elevation surgery using transcrestal osteotome technique with the lateral window approach with simultaneous implant insertion in terms of patient-reported outcomes and radiographic results at a place with a residual bone height of ≤6mm. To test this hypothesis, a randomized controlled trial was conducted.

SUBJECTS AND METHODS

I . Ethical consideration:

The study was approved by the ethical committee at the Faculty of Dental Medicine (Boys - Cairo) Al-Azhar University with ethical code 664/223. All patients were informed about the aim and protocol of the study and signed the Al-Azhar University informed consent form, which contained all information about the surgical procedure and post-operative follow-up.

I. Study design: a randomized controlled clinical study.

II. Study setting and population:

The study included 22 patients (9 males and 13 females) aged between 34 and 59 years. Patients were chosen from the Outpatient Clinic of the Oral and Maxillofacial Surgery Department, Faculty of Dental Medicine, Boys, Cairo, Al-Azhar University. All patients satisfied the eligibility criteria.

III. Eligibility criteria:

- ***Inclusion criteria:***

The inclusion criteria for this study included patients aged 25 years or older with good physical and oral health who required implant treatment in the posterior maxilla and had a residual bone height of ≤6 mm as measured on preoperative CBCT scans. Additionally, patients were required to have undergone a minimum 3-month healing period following extraction.

- ***Exclusion criteria:***

The exclusion criteria for this study included patients with sinus diseases that contraindicated sinus floor elevation, untreated periodontal disease, bad oral hygiene, uncontrolled diabetes, metabolic bone disease, or other systemic disorders that contraindicated implant surgery, smoked cigarettes, women who were pregnant or breastfeeding, and patients who required horizontal or vertical bone augmentation other than sinus floor elevation.

Preoperative evaluation:

- Clinical evaluation of the patient including medical and dental history and a complete intra-oral and extra-oral examination were carried out for each patient.
- Radiographic evaluation including pre-operative residual alveolar ridge height and bone density, and any pathologies that may involve the alveolar bone or the maxillary sinus.

Intervention

All patients received an oral hygiene protocol and were instructed to start with antibiotic therapy with Augmentin 1g (Amoxicillin/clavulanate) one day before the planned intervention. All surgical procedures were performed under local anesthesia. After disinfection and draped the surgical site, the planned surgical field was anesthetized with Articaine (4%) with Epinephrine (1:100,000), commencing one tooth before and after the site of tissue flap. In the lateral window approach (group I): a midcrestal as well as mesial and distal releasing incisions were made to expose the lateral wall of the maxillary sinus. After a full-thickness mucoperiosteum flap was reflected, a lateral window was created utilizing Neobiotic SLA kit. The SLE elevators from the SLA kit were used to properly detach and elevate the sinus membrane. Elevation should only be preceded when the membrane detaches. The Valsalva maneuver was used to examine the membrane's integrity. Next, the preparation of implant osteotomy was completed, and the created space was compactly filled with cortico-cancellous bone graft (Lyoplast allogenic bone graft, liosell Co., Samara, Russia). The implants (Neobiotic Co., Seoul, South Korea) were inserted in the prepared osteotomy, and extra bone graft were placed through the lateral window and lightly tamped onto the external surfaces of the implants. Finally, tension-free suturing was done after a collagen membrane (BIOGUARD, Connectbiofarm LTD Co., Moscow, Russia) was placed over the lateral window. Figure (1)

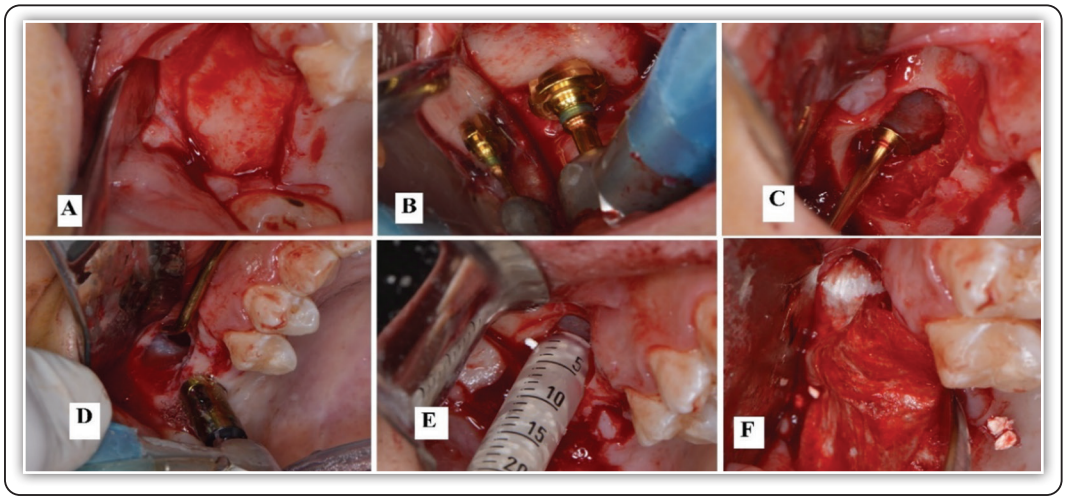

FIG (1) **(A)** Flap elevation to exposure of the maxillary sinus' lateral wall **(B)** Antrostomy using LS-reamer of Neobiotic SLA kit **(C)** Membrane detachment using SLE elevator **(D)** Implant bed preparation **(E)** Placement of bone graft **(F)** Collagen membrane placement.

While in the transcrestal approach (group II): a midcrestal incision and full-thickness mucoperiosteal flap was elevated to expose the ridge crest. A pilot drill of 2.2 mm diameter with a stopper was used in order to prepare an osteotomy within 1 mm short of the sinus floor according to preoperative CBCT measurements. After complete osteotomy preparation, an osteotome of lesser diameter than the implant body was inserted into the prepared implant site and tapped gently to create a green-stick fracture and elevate the floor of the sinus to the level of the desired implant length. Then, the sinus membrane integrity was assessed by performing the Valsalva maneuver. If the integrity had not been compromised, a plastic syringe was used to deliver the bone graft (previously hydrated with saline) into the osteotomy. The osteotome was reinserted again in the osteotomy site to spread the graft particles and apply pressure to the sinus membrane, elevating it to achieve the desired level of sinus membrane elevation. The implant was finally screwed in with clockwise rotations at a very slow speed (30–40 rpm) using a rotary handpiece or hand ratchet, and tension-free suturing was performed. Figure (2)

Postoperative care and medication:

Patients were given regular postoperative instructions and prescribed medication. They were instructed to return for a follow-up appointment 7-10 days after the surgery to remove sutures.

Post-operative assessment:

- ***Clinical evaluation:***

All patients were clinically evaluated at the following intervals; immediate, one, three and six months postoperatively for evaluation of membrane perforation and sinus function. Postoperative complications were also assessed, such as pain using a Visual Analog scale (VAS)[13] and facial edema using a measuring tape from the tragus of the ear to the ala of the nose[14]. Implant stability was measured immediately after implant installation before flap closure and six months postoperatively using Osstell ISQ.

- ***Radiographic evaluation:***

All patients were evaluated radiographically immediately and six months after implant placement by CBCT for assessing post-operative bone height and height gain after surgery, and bone density around the implant using Blue Sky Plan 4 software. Figure (3)

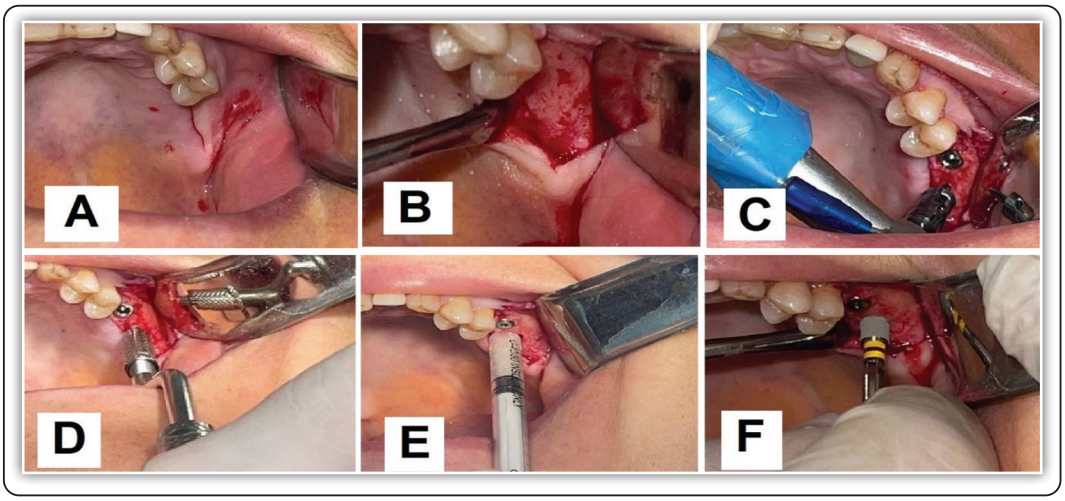

FIG (2) **(A)** Midcrestal incision **(B)** Bone crest after flap elevation **(C)** Preparation of the implant osteotomy (D) Sinus floor fracture using osteotome **(E)** Bone graft added to fill the space under the elevated membrane **(F)** Implant placement.

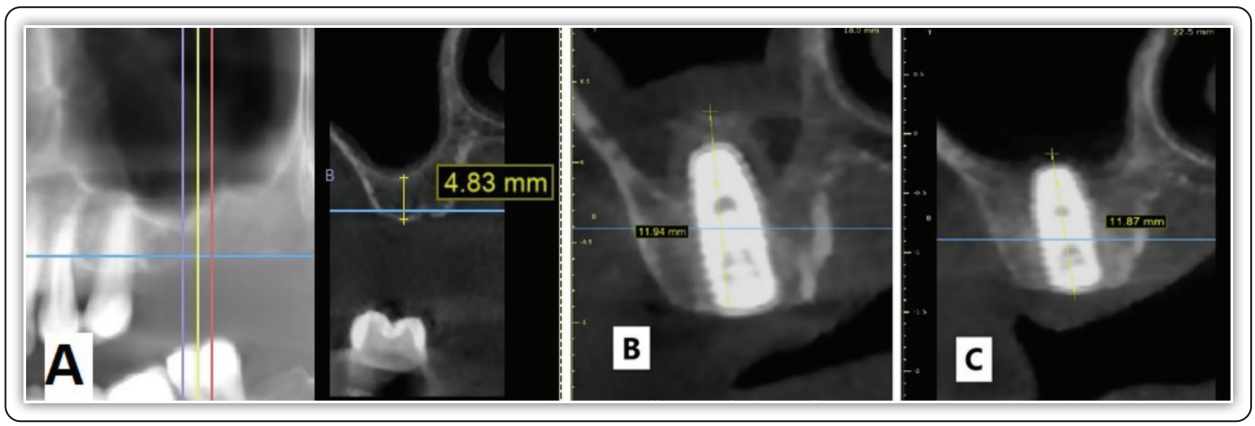

FIG (3) Radiographic CBCT scans for the studied group II at different time intervals (A) Preoperative (B) Immediate postoperative (C) 6 months Postoperative.

Statistical analysis

The Statistical Package for Social Sciences program (SPSS Chicago, IL, USA) was used to analyze the collected data. Qualitative data were expressed as number and percentage. Numerical data were described in terms of range (minimum and maximum), mean ± SD and median or as appropriate according to the normality of the data. Data were checked for normality using Kolmogorov–Smirnov test. Data were compared using student's t-test or Mann Whitney U test according to the data normality. The level of significance were set at $P \leq 0.05$. All tests were two tailed

RESULT

A. The patient and implant-related characteristics:

There were no statistically significant differences between the two groups in terms of age and gender distributions. Both approaches were compared under similar local conditions regarding RBH and pre-operative bone density, with no significant differences observed. The mean implant dimensions also did not show any significant differences between the two groups. Table (1)

TABLE (1) Summary of the patient and implant characteristics of the two groups.

	Group I (n=11)	Group II (n-11)	P-value
Age (years)	47.14 ± 9.47	45.29 ± 9.51	0.721
Gender (No. of males/females)	4/7	5/6	0.665
RBH (mm)	4.47 ± 0.76	4.81 ± 1.03	0.54
Bone density (HU)	427.6 ± 52.19	473.1 ± 122.5	0.39
Implant length (8.5mm/10mm)	0/11	2/9	0.65
Implant diameter (4mm/4.5mm)	4/7	3/8	0.14

Data was expressed using Mean ± SD p: p value for comparing between the studied groups

B. Postoperative complications:

1. **Sinus membrane perforation and sinus function:** one sinus membrane perforation was observed during the lateral window approach (group I), without a statistically significant difference between the two groups (P= 0.31).

2. **Postoperative Pain:** the mean value of pain VAS Scores ranged from mild to moderate, with a lower score recorded in group II than in group I. All patients reported pain and discomfort on the same day of the surgery, with the peak pain intensity recorded on the second postoperative day with a mean score of (5.87 ± 0.50) for group I and (4.64 ± 0.41) for group II (P= 0.0003*). Pain decreased significantly on the 3rd day and mostly disappeared within 1 week.

3. **Postoperative facial edema:** the mean value of the edema was ranged from mild to moderate, with group I recording a greater degree of edema than group II. The facial edema grade reached its peak on the second postoperative day and was significantly decreased after the 4th day. Edema resolved completely 7-10 days postoperatively in both groups. Figure (4)

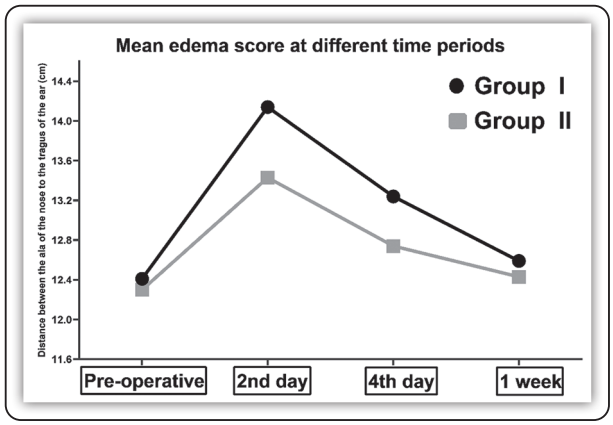

FIG (4) Comparison between the different time periods in each group according to edema.

C. Surgical and cost-related characteristics :-

When comparing the two groups, it was found that group I was associated with a longer surgical duration, a greater dose of anesthetic, a greater amount of bone graft and a higher frequency of using releasing incisions than group II. Table (2)

TABLE (2) Descriptive statistics of surgical and cost related characteristics.

	Group I (n=11)	Group II (n=11)	P-value
1- Duration of the surgical procedures	63.57 ±15.74	35.86 ±6.49	0.001*
2- Dose of anesthetic (No. of vials)	2.5 ±0.41	1.71 ±0.27	0.0011*
3- Amount of bone graft	1.58 ±0.17	0.46 ±0.07	<0.0001*

Data was expressed using Mean ± SD

***:** *Statistically significant at p ≤ 0.05*

D. Implant stability:

The study's findings demonstrated that all implants in both groups achieved primary stability and showed significant improvement in secondary stability, measured 6 months after implant placement. There was no significant difference between the two groups regarding implant stability. Figure (5)

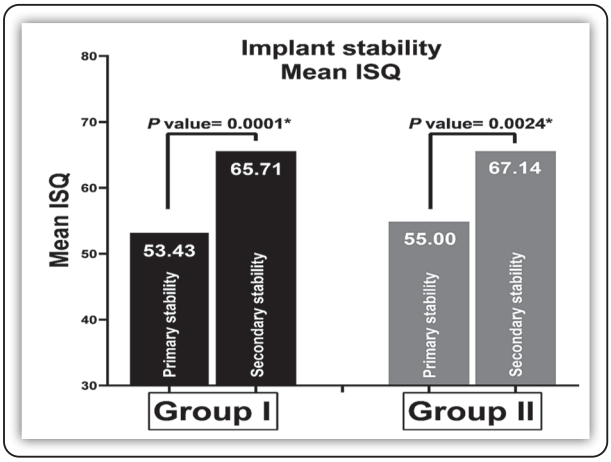

FIG (5) Comparison between the primary and secondary stability in each group.

E. Postoperative bone height (Post-BH) and height gain:

There was a significant difference in Post- BH between the two groups (P= 0.0009*), with a significant increase in the amount of height gain observed in group I (9.15 ± 1.53) compared to group II (5.5 ± 0.54) on the immediate postoperative CBCT (P< 0.0001*). Table (3)

TABLE (3) Descriptive statistics of Post-BH and height gain in each studied groups.

	Group I (n=11)	Group II (n=11)	P-value
Pre-BH (mm)	4.47 ± 0.76	4.81 ± 1.03	0.49
Post-BH (mm)	13.61 ± 1.72	10.31 ± 1.02	0.0009*
Height gain (mm)	9.15 ± 1.53	5.5 ± 0.54	<0.0001*

Data was expressed using Mean ± SD
p: p value for comparing between the studied groups
***:** *Statistically significant at p ≤ 0.05*

F. Bone density:

Regarding the immediate post-operative CBCT, the mean value of bone density of native bone was (428 ± 83.13) group I and (486.4 ± 116.8) for group II. The grafting materials had relatively high bone density values compared to the native bone of the maxilla in each group, with no significant difference between the two groups (704.1 ± 71.17) and (658.9 ± 63.58), respectively (p= 0.0015* for group I and p= 0.0113* for group II). On the 6 month post-operative CBCT, the mean value of bone density of the grafting materials and native bone of the maxilla were comparable, without significant differences in both groups.

DISCUSSION

This study compared two distinct surgical approaches in order to identify a treatment option that would offer superior clinical and radiographic outcomes. Patients generally favor surgical techniques that cause less trauma and are less time-consuming without altering the success rate. The outcome analysis of this study assessed the clinical outcomes, including patient post-surgery responses, complications, and implant stability, as well as the radiographic outcomes, including height gain and bone density after sinus augmentation and simultaneous implant placement via transcrestal and lateral window approaches when RBH ≤6mm.

It is well known that the most common intra-operative complication during sinus augmentation procedures in edentulous maxillary regions is Schneiderian membrane (SM) perforation[15–17]. In the present study, accidental perforation occurred in one case in group I. The perforation was managed by leaving the membrane folded over itself, and a slow-reabsorbing collagen membrane was used to cover the perforation, preventing bone graft from escaping into the sinus.

The occurrence of SM perforation had no impact on implant survival or continuing complications over time if the perforation could be covered during surgery. Many studies have found no differences in the success rates of implants placed in a grafted sinus with a unsound membrane and those placed in a sinus with an sound membrane[18,19].

This finding was supported by the study performed by Farina et al. in 2018[10], which showed that the transcrestal approach had a lower incidence of membrane perforation compared to the lateral approach. The incidence of membrane perforation in the transcrestal group was 6.9%, while the lateral approach group had a rate of 17.9%. However, the difference in the incidence of membrane perforation between the two groups was not statistically significant.

In the present study, group II was associated with lower pain VAS scores than group I, with the peak pain intensity recorded during the 2nd postoperative day with a mean score of (5.87±0.50) and (4.64±0.41) for group I and II, respectively. The intensity of pain significantly decreased by

the third day and had mostly disappeared within the first week. These findings were consistent with the findings of research conducted by Al-Almaie in 2019[6], which reported that the pain intensity score for the lateral approach was higher (4.8) than that for the transcrestal approach (3.1).

In this study, facial edema reached its peak value on the 2nd day, with a significant increase in measurements compared to preoperative measurements in group I (P<0.0001*) and an increase without statistically significant difference in group II (P= 0.0731). Facial edema resolved completely 7-10 days postoperatively in both groups.

These results were consistent studies by Hamdoon et al. in 2021[14] and Farina et al. in 2018[10]. Both studies showed that the intracrestal approach resulted in less facial swelling compared to the lateral approach in maxillary sinus surgery. Additionally, the transcrestal approach required less frequent use of releasing incisions, less bone volume removal, less surgical trauma, and had a shorter surgical duration compared to the lateral approach.

The study found the average amount of bone grafts utilized in both groups was significantly different. The average amount of bone graft used for group I was (1.58±0.17)g, while it was (0.46±0.07)g for group II. These findings are consistent with a study by Farina et al in 20222[20], which demonstrated that the lateral approach demanded more bone graft than the transcrestal approach (1.975 vs. 0.42, respectively), to compensate for the bone loss of the lateral wall of sinus during antrostomy.

The mean value of the primary stability was (53.43±7.5) ISQ for group I and (55.00±8.5) ISQ for group II, without significant differences (P-value =0.72). Additionally, the secondary stability assessed six months following sinus augmentation showed a considerable improvement, with no discernible difference between the two groups (65.71±5.1) ISQ for group I and (67.14±5.2) for group II; (P-value =0.61). Nedir et al.[21], reported that implants with an ISQ ≥47 should be regarded as stable, and an ISQ of ≥49 immediately after implant placement results in osseointegration of all implants at 3 months postoperatively. Therefore, the stability of each implant included in this study was favorable.

The study also found a significant increase in membrane elevation and height gain in the lateral window approach group (9.15±1.53) compared to the transcrestal approach group (5.5±0.54) on the postoperative CBCT (P < 0.0001*). These findings are consistent with previous research by Daniel and Rao in 2012[22], who concluded that the lateral approach resulted in a greater average increase in bone height (9.5 mm) compared to the transcrestal approach (5.5 mm).

The bone density values on the preoperative CBCT were (427.6±52.19) for group I and (473.1±122.5) for group II. These results are similar to the findings of Sreerama et al. in 2021[23], which reported a mean bone density in the posterior maxilla was 438.1±110.2 HU.

On the immediate postoperative CBCT, the mean density value of native bone was (428±83.13) for group I and (486.4±116.8) for group II. The grafting materials had relatively high bone density values in both groups (704.1±71.17) and (658.9±63.58), respectively. CBCT scans taken six months postoperatively showed that the mean value of bone density of the grafting materials and native bone of the maxilla were comparable without significant differences in both groups due to a significantly higher proportion of bone graft maturation. The results of a study published by Kim et al. in 2020[24] are consistent with these findings, which suggest that a cortico-cancellous allograft mix is a radiographically acceptable option for maxillary sinus augmentation

CONCLUSION

Based on the results of relatively short-term clinical observation, the transcrestal approach has demonstrated high implant success rates, as well as cost-savings and shorter surgical durations, compared to the lateral window approach. Furthermore, it can achieve favorable implant stability and has been associated with fewer complications. As a result, the transcrestal approach may be considered an effective alternative to the lateral window approach when the RBH of the posterior maxilla is insufficient, such as in cases where access to window preparation is limited.

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