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Evaluation of Maxillary Sinus Lift by Osseodensification versus Closed Sinus Lift

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ORIGINAL STUDY

Evaluation of Maxillary Sinus Lift by Osseodensification versus Closed Sinus Lift

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Abstract

Purpose: The objective of this study was to assess the clinical and radiographical outcomes of implant placement in the posterior maxilla with insufficient residual vertical height by sinus lifting, either by osseodensification (OD) or conventional osteotome (OS) technique. **Patients and methods:** Ten patients underwent 16 crestal sinus floor elevations with a residual vertical height of 5−7 mm. Patients were divided randomly into two groups: group I (OD): six patients with eight implants were inserted simultaneously with an OD sinus lift. Group II (OS): four patients with eight implants were inserted simultaneously with a conventional OS sinus lift. Cone-beam computed tomography (CBCT) was done preoperatively, immediately, and after 6 months. Implant Stability Quotient (ISQ) was measured in both groups immediately and after 6 months. The collected results were tabulated and statistically analyzed. **Results:** There was a significant increase in torque in the OD group than in the OS group (P value = 0.001). There was also a significant decrease in pain immediately (P value = 0.002) and after 1 week (P value = 0.001) in the OD group. Regarding apical bone gain, there was insignificant increase in bone gained both immediately in the OD group (P value = 0.86) and after 6 months in bone gain in the OS group (P value = 0.926). In the OS group, marginal bone loss increased insignificantly immediately (P value = 0.522) but increased significantly after 6 months (P value = 0.026). Bone density insignificantly increased in the OS group immediately (P value = 0.606), but insignificantly decreased after 6 months (P value = 0.443). **Conclusion:** Both OD and OS techniques showed good clinical outcomes in 6 months' follow-up.

Keywords: Osseodensification, Osteotome, Sinus lift

1. Introduction

Insertion of dental implants in the posterior maxilla is complicated by various factors. Periodontal disease causes bone and tissue loss, low bone density, and extremely high occlusal stresses [1]. Also, significant ridge atrophy and pneumatization of the maxillary sinus may occur following tooth extraction in the maxillary posterior area. So, augmentation of the sinus is necessary to provide enough vertical volume of bone for adequate implant insertion [2].

A variety of procedures have been recommended as treatments for a defective edentulous ridge of the posterior maxillary region with poor bone quality. Two approaches are traditionally used, the direct sinus elevation with a lateral window approach and the indirect sinus elevation with a crestal approach [3]. In comparison to the direct lateral window technique, the indirect approach has advantages compared with the open sinus approach. Advantages include being more conservative, having a lower frequency of rupture of the sinus membrane, enabling simultaneous implant placement, having effective bone healing, and having a high implant survival rate [4].

The osteotome (OS) closed sinus lift approach was the first technique reported for the crestal sinus lift, which is now frequently used to increase the quantity of bone available for implant placement in the posterior region of the maxilla. It depends on compressing the bone at the implant location and pushing it in lateral and upward directions, raising the floor of the sinus using OSs of sequential

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diameters. This approach showed a number of surgical drawbacks, such as delayed implant secondary stability, and certain patient-related issues such as vertigo, headache, and nasal bleeding, besides patient discomfort during the procedure [5].

Osseodensification (OD) is a novel technique for preparing bone for dental implant insertion. It has recently been suggested to reposition existing bone to the maxillary sinus floor and reduce the risk of membrane perforation [6]. Minimal plastic bone deformation is achieved by rolling and sliding contact with a fluted Densah bur, which densifies the bone. It is a bone non-extraction method that typically uses burs with specific designs (Densah burs) to assist bone densification while preparing an osteotomy [7]. During osteotomy preparation, Densah burs help preserve bone and condense it by compaction autografting, resulting in increased density of the bone around the implant and improved stability of the implant. OD, unlike typical osteotomies, does not remove bone; instead, bone fragments are compressed and autografted outwardly, conserving vital bone tissue [8].

Therefore, the aim of the current study was to assess the use of these two methods simultaneously with implant insertion by evaluating patient satisfaction, implant stability, apical bone height, marginal bone loss around the implant, and density of bone.

2. Patients and methods

2.1. Study design

Patients in this randomized study were selected from the Department of Oral and Maxillofacial Surgery outpatient clinics at the Faculty of Dental Medicine for Girls, Al-Azhar University, and Al-Zahraa University Hospital. Patients were informed of the nature of the study, benefits, risks, and possible alternative treatments and signed an informed consent. This research was approved by the Research Ethics Committee (REC) at Al-Azhar University's Faculty of Dental Medicine for Girls (code: REC-SU-22-02).

2.2. Inclusion and exclusion criteria

Patients with subsinus residual vertical bone height of 5−7 mm with a bone density of D3-D4 and preferred fixed implant-supported restoration were included in this study. Exclusion criteria included patients with maxillary sinusitis or any pathosis, any systemic diseases that may interfere with bone or soft tissue healing, poor oral hygiene, and heavy smokers. Patients with bruxism or who had radiation treatment for the head or neck in the previous 5 years were also excluded [9].

2.3. Patient grouping

According to the eligibility criteria, patients were randomly divided into two groups. Group I: patients in this group received 1−2 implants simultaneously with sinus lift and OD. Group II: patients in this group received 1−2 implants simultaneously with an OS sinus lift.

2.4. Preoperative evaluation

A medical and dental history was taken for each patient in this study. All patients underwent intraoral and extraoral examinations and study models. A preoperative panoramic radiograph was done for each patient as a preliminary survey to estimate the maxillary sinus condition, septa, existence of residual roots or any localized pathosis, and residual bone height in the posterior maxillary area. Cone-beam computed tomography (CBCT) is used to evaluate the buccolingual width, residual bone height, and planning and constructing surgical guides [1].

2.5. Preoperative preparation

All patients had full mouth scaling performed before surgery and were instructed to use chlorohexidine mouthwash. They all received a prophylactic dose of antibiotics [10], Amoxicillin 875+clavulanic acid 125 (Augmentin 1 g, Glaxo-Smith Kline S.A.E., Egypt), one day before surgery [11].

2.6. Surgical procedure

All procedures were performed under local anesthesia (Articaine 4% 1 : 100 000 epinephrine) in both groups. The surgical guide was checked before surgery in the mouth of the patient to see how well it fit before the day of surgery. A sharp clean cut crestal incision was made through the mucoperiosteum using blade No.15. A periosteal elevator was used to carefully reflect buccally and slightly palataly ensuring a full-thickness mucoperiosteal flap to provide good accessibility. A pilot drill of 1.8 mm width was first used in clockwise mode with 800−1500 rpm speed and 40 Ncm torque, guided by the surgical guide to a depth 1 mm below the floor of the sinus to avoid perforation of the sinus floor [5].

OD group: After using the pilot drill guided by the surgical guide, the motor was switched to reverse-densifying mode drill speed of 800–1200 rpm with profuse irrigation using a Densah bur (2.0 mm), 1 mm shorter than the sinus floor as shown in Fig. 1 using pressure and in a pumping motion. The next (3.0) Densah Bur advanced into the previously created osteotomy in the same manner. Pressure was controlled using a mild pumping movement to advance by 1 mm increments through the thick sinus floor after experiencing the tactile sensation of the bur, when the drill reached the thick floor of the sinus. Densah bur (4.0) was used in patients with a sufficient width of the residual alveolar ridge which would receive implants of 5 mm in width or more. The implant was inserted into the prepared site, which increased the vertical depth and sinus membrane lift. The final drill pressed bone in the apical direction and gradually raised the membrane and autografted bone to reach the final desired length [12].

OS group: A pilot drill was first used guided by the surgical guide to a depth of 1 mm below the floor of the sinus to avoid perforation of the sinus floor. A group of concave graduated OSs of varying sizes was used successively to expand the osteotomy according to implant width by surgical mallet as shown in Fig. 2. Concave OSs were applied to gather and compress bone into the apical part of the osteotomy. OSs were selected to enlarge the osteotomy both horizontally and vertically. To prevent the tip from locking in the bone, the OS was rotated after each stroke of the mallet. The sinus floor was fractured using the larger OS by tapping gently. Then an implant of adequate size was inserted to the desired length at the end of the surgical procedures [5].

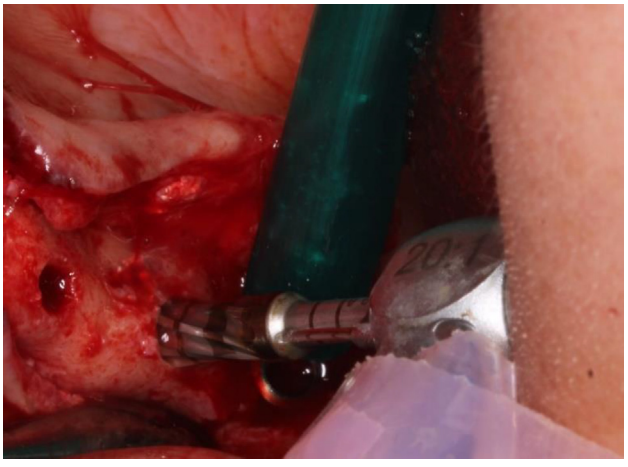

Fig. 1. Photograph showing Densah bur (2.0) during drilling.

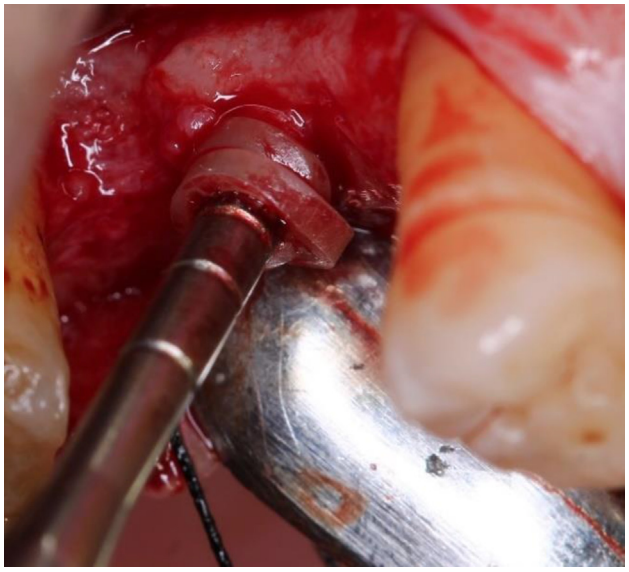

Fig. 2. Photograph showing the smallest osteotome.

After implant insertion in both groups, the transducer (SmartPeg; Integration Diagnostics AB, Göteborg, Sweden) corresponding to the implant system was connected to the implant, and Osstell was used to record the implant stability quotient (ISQ) value using resonance frequency analysis (RFA). The implant was finally covered with a cover screw. The flap was approximated and sutured around the implant with 3-0 non-resorbable sutures [1].

Postoperatively, patients received Amoxicillin 875+clavulanic acid 125 (Augmentin 1 g, GlaxoSmithKline S.A.E, Egypt) twice daily for 5 days and local decongestant Xylometazoline (Otrivin, GlaxoSmithKline, UK) nasal drops every 8 h for 1 week. Patients were instructed to use Diclofenac potassium 50 mg (Cataflam Novartis-Switzerland) postoperatively only if they had pain. In addition, patients were advised to have proper oral hygiene, avoid eating solid food, and avoid blowing their noses or sneezing without opening their mouths to avoid any negative pressure in the sinus. Sutures were removed after 1 week [13].

2.7. Second surgical phase (prosthetic phase)

All patients were recalled 6 months after implant insertion for the second stage of surgery procedures. The implant was uncovered by a tissue punch. After removing the cover screw, the secondary stability was measured by Osstell. To ensure proper gingival contouring around the implant collar, a healing abutment was placed for 2 weeks. The abutment was then prepared and connected to the implant.

The impression was taken using the closed tray technique. The impression was sent to the dental laboratory. At the end, the cement-retained final restoration was delivered.

2.8. Follow-up and data collection

2.8.1. Patient's satisfaction questionnaire

Each patient's perception of headache, nasal bleeding, and vertigo was assessed postoperatively using the patient's satisfaction chart. The patients were offered the questionnaire at the end of the surgical operation and were asked to complete it each postoperative day for 5 successive days. This questionnaire was created to evaluate the patient's impression of their recovery in four key categories: headache, general activity, nasal bleeding, and vertigo. On a five-point scale each parameter was evaluated as 0 representing not at all 5 representing very much.

2.9. Clinical parameters

(1) Pain: Using the 0-to-10 visual analog scale (VAS), pain was evaluated both immediately following surgery and 1 week later.
(2) ISQ: ISQ was measured at the time of implant placement and at 6 months postoperatively by Osstell. The ISQ scale ranges from 0 to 100.
(3) Torque gauge scale: Once the implant was surgically placed, the manual calibrated torque ratchet gauge was used to seat the implant to its final position. The maximum applied torque was recorded from the torque gauge scale.

2.10. Radiographic parameters [14]

Postoperative CBCT was taken immediately (within 1 week after surgery) and 6 months for each patient. The superimposition was performed in three planes (axial, coronal, and sagittal).

2.11. Apical bone height gain

Apical bone height gained after sinus lift was measured all around the surfaces surrounding the apical part of the implant including mesial, distal, palatal, buccal, and apical ends below the sinus floor. It was measured immediately and 6 months after surgery from CBCT cuts. It was measured from the first implant thread to the sinus lining level.

2.12. Marginal bone height loss

Marginal bone height level at the implant's palatal, buccal, distal, and mesial sides were all measured in relation to the crestal implant level. Marginal bone height loss was measured by comparing between immediate and 6 months postoperative CBCT.

2.13. Bone density

It was measured using the profile of bone density. Bone density was measured from preoperative, immediate, and 6 months postoperative CBCT.

2.14. Statistical analysis

All collected numerical data were analyzed and represented as means, standard deviations, and ranges using IBM MINITAB Advanced Statistics, version 20. In this study, pain, implant stability, apical bone gain, marginal bone loss, and bone density were analyzed. The Shapiro–Wilk test was used for normality, while differences and associations between groups were investigated by the t-test in the case of normally distributed data. P value was established to determine the statistically significant difference between the groups if a P value less than or equal to 0.05 was considered statistically significant. In comparing more than two groups, one-way analysis of variance (ANOVA) was used.

3. Results

Ten patients (three males and seven females) participated in this research with 16 implants that were inserted in the maxillary molar area. All patients had a deficiency in residual vertical height in the maxillary posterior area. The mean age of the patients in the OD group was 51.5 ± 7.7 years, while in the OS group the mean age of the patients was 57.5 ± 9.9 years. All patients completed their follow-up periods and their implants were osseointegrated (Table 1). There was no evidence of inflammation or sinusitis through all follow-up periods.

Pain was measured on the day of surgery and after 1 week postoperatively. In the OD group, the mean of pain at the day of surgery was 2.75 ± 1.0 and was 0.38 ± 0.5 after 1 week. In the OS group, the mean of pain at the day of surgery was 4.75 ± 1.0 and 1.75 ± 0.5 after a week. There was a significant decrease in pain after a week in both groups (P value = 0.01 in both groups). It was observed that there was a highly significant decrease in pain in the OD group than in the OS group at both intervals,

Table 1. Demographic data of patients.

	OD group	OS group	*P* value
Number of patients	6	4	
Sex			
Females	3 (50.0%)	4 (100.0%)	0.005**
Males	3 (50.0%)	0	
Age (y)			
Mean ± SD	51.5 ± 7.7	57.5 ± 9.9	0.309
Affected side			
Right	4 (50.0%)	3 (37.5%)	
Left	4 (50.0%)	5 (62.5%)	1.0

**Statistically highly significant difference *P* less than or equal to 0.01.

where the *P* value was 0.002 immediately and was 0.001 after 1 week in the OD group.

ISQ was measured by the Osstell device immediately and at 6 months postoperatively. There was a highly significant increase in ISQ in the OD group when measured immediately (*P* value = 0.002), where the mean in the OD group was 88.25 ± 5.9 while it was 78.0 ± 4.4 in the OS group immediately. Also, ISQ significantly increased in the OD group when measured after 6 months postoperatively (*P* value = 0.01). In the OD group, the mean was 93.75 ± 6.2 while it was 86.25 ± 3.4 in the OS group. There was a highly statistically significant increase in ISQ in both groups when measured after 6 months postoperatively (*P* value = 0.001) (Table 2).

Regarding apical bone gain, in the OD group it was 7.19 ± 0.7 mm immediately and 7.19 ± 0.8 mm at 6 months postoperatively with no significant difference between the two intervals (*P* value = 0.933). In the OS group, it was 7.04 ± 2.0 mm immediately and at 6 months postoperatively it was 7.26 ± 1.8 mm with no significant difference between the two intervals (*P*-value = 0.137). There was a statistically insignificant increase in bone gain in the OD group immediately (*P* value = 0.86), whereas there was slight increase in bone gain in the OS group with no statistical significance (*P* value = 0.926) (Table 3).

There was a slight increase in marginal bone loss in the OS group immediately as the mean was 1.26 ± 0.1 mm in the OD group and 1.31 ± 0.2 mm in the OS group with insignificant difference (*P* value = 0.522). After 6 months, there was a significant increase in marginal bone loss in the OS group as the mean was 1.11 ± 0.1 mm in the OD group and 1.31 ± 0.2 mm in the OS group (*P* value = 0.026) (Table 4).

As shown in Table 5, the values of bone density were recorded for both groups at three intervals: preoperatively, immediately, and 6 months postoperatively. In the OD group, preoperatively the mean was 335.5 ± 123.5 HU, 672.0 ± 143.3 HU immediately, and 452.64 ± 150.7 HU postoperatively whereas in the OS group, the mean bone density preoperatively was

Table 2. Mean and standard deviation values of implant stability at immediate and 6-month follow-up periods for both groups.

	OD group Mean ± SD	OS group Mean ± SD	*P* value
Immediate ISQ	88.25 ± 5.9	78.0 ± 4.4	0.002**
6 months postoperative ISQ	93.75 ± 6.2	86.25 ± 3.4	0.01*
P value	0.001**	0.001**	
ISQ percentage change	6.23 ± 2.6	11.41 ± 5.3	0.046*

*Statistically significant difference *P* less than 0.05.
**Statistically highly significant difference *P* less than 0.01.

Table 3. Mean and standard deviation values of apical bone gain at immediate and 6 months follow-up periods for both groups.

	OD group Mean ± SD	OS group Mean ± SD	*P* value
Apical bone height gain			
Immediate	7.19 ± 0.7	7.04 ± 2.0	0.86
6 months postoperative	7.19 ± 0.8	7.26 ± 1.8	0.926
P value	0.933	0.137	

NS: Statistically nonsignificantly different at *P* greater than 0.05.

Table 4. Comparison of marginal bone loss between both groups in the immediate and 6 months postoperative intervals.

	OD group mean ± SD	OS group mean ± SD	*P*-value
Marginal bone loss			
Immediate	1.26 ± 0.1	1.31 ± 0.2	0.522
6 months postoperative	1.11 ± 0.1	1.31 ± 0.2	0.026*
P value	0.015*	0.972	

*Statistically significant difference *P* less than or equal to 0.05.
NS: Statistically nonsignificantly different at *P* greater than 0.05.

Table 5. Mean and standard deviation values of bone density of osseodensification and osteotome groups at preoperative, immediate, and 6 months postoperatively.

	OD group mean ± SD	OS group mean ± SD	*P* value
Bone density			
Preoperative	335.5 ± 123.5	344.49 ± 137.4	0.893
Immediate	672.0 ± 143.3	633.64 ± 147.8	0.606
6 months postoperative	452.64 ± 150.7	402.22 ± 99.4	0.443

NS: Statistically nonsignificantly different at *P* greater than 0.05.

344.49 ± 137.4 HU, 633.64 ± 147.8 HU immediately, and 402.22 ± 99.4 HU after 6 months. When comparing both groups, there was insignificant increase in bone density preoperatively in the OS group (*P* value = 0.893), but there was insignificant decrease in bone density immediately (*P* value = 0.606) and after 6 months (*P* value = 0.443).

4. Discussion

Procedures for sinus membrane elevation and augmentation have been frequently documented in the literature with great results. Elevation of the maxillary sinus floor by crestal approach is a widely used treatment for rehabilitation of implants in the posterior maxillary region, with predictable grafting results and a high rate of implant survival [15].

The indirect crestal method is used frequently because of its low morbidity and noninvasiveness, as well as simultaneous implant insertion [16]. In this technique, a number of sequential concave OSs were used to compress bone and push it laterally and apically. However, there were several disadvantages in this technique. It was supposed that the OSs compacted the bone apically and laterally. A histologic analysis found that only the periapical area showed an increase in bone density, with no significant change in the lateral walls. A mallet is used repeatedly, which is a painful method that can be difficult to manage and results in unintentional dislocation and vertigo [17].

It was reported that OD improves bone mineral density at the boundaries of the osteotomy and results in compaction autografted bone over the full length of the osteotomy, especially at the apical part. Bone tissue is reversely compressed against the implant body due to the compressed bone's elastic recovery of strain, which causes a springback effect, that improves the implant's main stability [7]. As a result of the presence of an autografted layer of bone in the osteotomy, this allows a faster rate of osseointegration. The success rate was 100% in both groups.

All implants were osseointegrated. According to the findings of this study, all implants in both groups showed increased ISQ values of more than 70 at both measurements, showing that both OS and OD methods produced good primary stability, which is a critical component of implant success. The OD group had higher torque values at the time of insertion, in which it was 40.0 ± 2.7 N cm in the OD group and 33.13 ± 2.6 N cm in OS group. Also, secondary stability increased significantly in the OD group immediately as it was 88.25 ± 5.9 in the OD group and 78.0 ± 4.4 in the OS group and after 6 months as it was 93.75 ± 6.2 in the OD group and 86.25 ± 3.4 in the OS group. This could be the result of creating a crust of increased bone mineral density around the osteotomy site. The OD approach improves primary stability and the amount of bone at the surface of the implant [8].

These results support those of many authors [7], who found that Densah bur had the potential to increase the proportion of bone volume and implant contact for dental implants placed in bone with low density compared with standard osteotomies, which may aid in increasing osseointegration. Also, research reported the same results in a sheep model [18].

Immediately following the procedure and 1 week later, the patient's pain was assessed by VAS. There was a statistically significant difference in pain between both groups in both intervals. The mean of pain in the OD group was 2.75 ± 1.0 immediately and 0.38 ± 0.5 after 1 week. In the OS group, the mean was 4.75 ± 1.0 immediately and after 1 week was 1.75 ± 0.5. Patients in the OS group had poor experience, which may be due to using the OS with increased force during malleting. These results were consistent with those of researcher [13], who found the same findings.

Apical bone gain was insignificantly higher in the OD group than in the OS group immediately (*P* value = 0.86), but it was insignificantly higher in the OS group after 6 months postoperatively (*P* value = 0.926). These results were in contradiction with the results of Arafat and Elbaz [1], who found that after 6 months postoperatively, bone gain in the OD group was significantly higher than bone gain in the OS group. Regarding bone density, there was an insignificant difference between both groups at all intervals. As in the OD group, the mean bone density was 335.5 ± 123.5 HU preoperatively 633.64 ± 147.8 HU immediately and 452.64 ± 150.7

HU postoperatively. In the OS group, the mean of bone density was 344.49 ± 137.4 HU preoperatively, 672.0 ± 143.3 HU immediately, and 402.22 ± 99.4 HU postoperatively. These results were contradictory to results of Yeh et al. [19], who showed that bone density around the implants significantly increased.

4.1. Conclusion

OD and the Summers techniques were reliable and promoted implant success. OD was superior to the OS technique in that it promoted higher primary stability, less pain, and more apical bone height gain immediately. There was no significant difference between both groups regarding marginal bone loss or bone density.

4.2. Recommendations

Further studies should be conducted to confirm the superiority of OD to the OS technique in closed sinus lift procedures.

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Conflicts of interest

The authors declare that there is no conflict of interest.

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