



Transcrestal sinus lift with simultaneous implant placement using osseodensification in posterior maxilla with residual bone height of 4-6 mm

Elevação de seio maxilar via crista do rebordo com instalação simultânea de implante utilizando osseodensificador em região posterior de maxila com altura do remanescente ósseo de 4 a 6 mm

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ABSTRACT

Objective: The aim of this study was to evaluate the transcrestal sinus lift using Osseodensification technique with simultaneous implant placement. **Material and Methods:** In this case series 7 patients who needed implant placement in the atrophic posterior maxilla were enrolled. In all the cases the residual bone height between the sinus floor and the alveolar crest was 4-6 mm. Transcrestal sinus lift was performed using Osseodensification with simultaneous implant placement. Cone-beam computed tomography (CBCT) were obtained immediately postoperative and 6 months after operation. Implant stability using Osstell[®] were assessed at the time of implant placement and implant exposure (6 months). **Results:** The results showed that the mean bone height gain was 5.33 ± 0.83 mm at 6 months postoperatively. Mean bone density value was 818.43 ± 109.63 HU. Mean ISQ value was 80.00 ± 3.11 at 6 months postoperatively. The duration of surgical procedure (minutes) ranged between 25-38 minutes with an average of 30.86 ± 4.10 minutes. **Conclusion:** The crestal maxillary sinus floor elevation using Osseodensification technique with simultaneous implant placement provide superior results regarding bone density and implant stability and less duration of surgical procedure.

KEYWORDS

Sinus floor augmentation; Bone substitutes; Alveolar bone loss; Osteotomy; Dental implantation; Cone-beam computed tomography.

RESUMO

Objetivo: O objetivo deste estudo foi avaliar a elevação de seio maxilar via crista do rebordo com a técnica de Osseodensificação com instalação simultânea de implante. **Material e Métodos:** Nesta série de casos, participaram 7 pacientes que necessitavam de implantes em região posterior de maxila atrófica. Em todos os casos a altura de remanescente ósseo entre o soalho do seio e a crista alveolar estava entre 4 a 6 mm. A elevação de seio maxilar via crista do rebordo foi realizada com osseodensificação com instalação simultânea de implante. As Tomografias Computadorizadas Cone Beam (TCCB) foram obtidas imediatamente após a cirurgia e 6 meses depois. A estabilidade dos implantes utilizando Osstell[®] foi avaliada no momento da instalação do implante e no momento da reabertura (6 meses). **Resultados:** Os resultados mostraram que a média de ganho de altura óssea foi de 5.33 ± 0.83 mm após 6 meses da cirurgia. A média da densidade óssea foi de 818.43 ± 109.63 HU. A média de ISQ foi de 80.00 ± 3.11 após 6 meses da cirurgia. A duração do procedimento cirúrgico (minutos) foi entre 25 a 38 minutos com uma média de 30.86 ± 4.10 minutos. **Conclusão:** A elevação do soalho de seio maxilar

via crista do rebordo com instalação simultânea de implante utilizando osseodensificador promove resultados superiores em relação à densidade óssea, estabilidade do implante e menor duração do tempo cirúrgico.

PALAVRAS-CHAVE

Levantamento do Assoalho do Seio Maxilar; Substitutos ósseos; Perda do osso alveolar; Osteotomia; Implantação dentária; Tomografia computadorizada de feixe cônico.

INTRODUCTION

Dental implant is considered the “gold standard” for the rehabilitation of edentulous arches [1]. Crestal bone resorption of the posterior maxilla together with pneumatization of the maxillary sinus in addition to the poor bone quality are factors that affect the implant placement in the posterior maxilla. Several techniques have been introduced to overcome these problems including the use of short implants, pterygoid implants, zygomatic implants and vertical augmentation using sinus floor elevation. Sinus floor augmentation has been considered a predictable procedure to provide vertical dimension to allow for implant placement in the posterior maxilla with high survival rate [2].

Boyne and James [3] in 1980 proposed the lateral sinus lifting procedure which involves the direct visualization and manipulation of the Schneiderian membrane, through the lateral window osteotomy. In addition to being an invasive surgical procedure, it also presents with postoperative morbidities such as bleeding, swelling, and membrane perforation. Later, in 1994, Summers introduced a technique for elevation of the sinus floor using osteotomes. In this technique, the Schneiderian membrane is lifted through the alveolar crest by applying an osteotome. Application of graft materials decreases the risk of membrane perforation [4]. In addition, crestal approaches were demonstrated to be safe with highly predictable outcome when the residual bone height was ≥ 5 mm [5]. CBCT is currently considered the imaging modality of choice for dental implant procedures and evaluation. Recently, The use of ultrasound in dentistry can represent a valid radiation-free alternative, in certain cases to the CBCT [6].

Osseodensification is a novel, biomechanical osteotomy preparation technique that preserves bone through a hyphen drilling process utilizing specially designed burs with a tapered geometry and specially designed flutes to progressively expand the osteotomy while compacting bone

into its walls and apex. In this manner bone densification method enhances implant primary stability due to an elastic “spring-back” effect created in the prepared osteotomy by the compaction autografting [7]. The capacity of the osseous densification drilling process to elevate the sinus floor without sinus membrane perforation is based on the fact that the densifying burs are capable of bone instrumentation in a counterclockwise motion. Hence, irrigation is optimized throughout the osteotomy site, and irrigation solution is constantly present at the apical end of the osteotomy. Therefore, once the sinus floor is penetrated by the hyphen bone compaction drilling process, irrigation solution and autogenous bone chips perform a hydraulic detachment of the sinus membrane and subsequent elevation [1]. The pumping motion (in and out movement) creates a rate dependent stress to produce a rate dependent strain and allows saline solution pumping to gently pressurize the bone walls. This combination facilitates an increased bone plasticity and expansion [8].

Up till now there is limited research to evaluate the transcrestal sinus lift and simultaneous implant placement using Osseodensification. It was the aim of this study to evaluate the transcrestal sinus lift and simultaneous implant placement using Osseodensification in posterior maxilla with residual bone height of 4-6 mm.

MATERIALS AND METHODS

The present study is a prospective case series study and was carried out on human adult patients from both sexes. Seven patients included in this study were selected from the outpatient clinics of Oral and Maxillofacial Surgery at Faculty of Dental Medicine Al-Azhar University - Assuit. This study design complied with and was approved by the Ethics Committee of Faculty of Dental Medicine, Al-Azhar University.

- The following inclusion criteria were applied: (1) Need for implant placement in the maxillary premolar or molar area (2) A residual bone height of 4-6 mm (3) Patients with no sinus pathology. The following exclusion criteria were applied: (1) active infection or disease affecting bone and wound healing (2) Heavy smokers (considered when the patient smoking more than 10 cigarettes per day which it can be considered a risk factor for implant failure) (3) Sinus pathology that precludes routine sinus augmentation which ruled out based on the history, clinical examination and x-ray findings like; Acute active sinus infection, Neoplasm or large cyst of the sinus, Previous sinus surgery like the Caldwell–Luc operation, and Presence of Underwood’s septa/severe sinus floor convolutions 1` All patients were informed about the scope of the study and signed an informed written consent form. CBCT was done to evaluate the bone of the maxilla and to measure the residual ridge height and width at the area that planned to put the implant. These measurements were recorded.

Operative procedures

All Patients were prepared in general routine manner for operation under local anesthesia and scrupulous disinfection of oral cavity. A full thickness para-crestal incision with a conservative flap elevation was made on the alveolar crest. A pilot osteotomy prepared using a pilot drill to the depth determined within approximately 1 to 2 mm from the sinus floor. Following radiograph confirmation, the narrowest densifying bur¹ (2.5mm) used in counterclockwise rotation with irrigation in a modulating “bouncing” application into the osteotomy until the dense sinus floor reached. Thereafter, a wider densifying bur (3.0 mm) was utilized in the same modulating movement to gently interrupt the sinus floor and advanced up to 3 mm beyond the sinus floor. Bur depth was periodically verified by periapical radiograph. Sequentially wider densifying burs were used in a similar manner, to continue the process, elevating the sinus membrane, and augmenting additional autogenous bone shaving into the sinus, never extending the burs further than 3 mm into the sinus.

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Figure 1 - X-ray photo showing dome-shaped augmentation of bone surround the dental bur.

After achieving the desired osteotomy width, the established osteotomy was filled with Nanobone²™; then, the final densifying bur previously used to prepare the osteotomy was used in counterclockwise rotation at 100 to 200 rpm without irrigation to advance the graft apically in one gentle apical motion toward the sinus facilitating additional vertical and lateral membrane elevation. This was repeated until the desired vertical augmentation was achieved, and the implant³ was placed according to the manufacturer’s protocol. The cover screw was placed over the implant and the flap was repositioned and sutured using 4/0 absorbable suture.

A clearly defined, dome-shaped augmentation of bone is seen on the radiographs, confirming the intact Schneiderian membrane with no perforation and full containment of the graft volume under the membrane Figure 1.

The implant stability was measured using Osstell® device after tightening of the SmartPeg (Type 57) to the implant. Bone gain was measured on both buccal and palatal sides of the implant using cross-sectional cuts, parallel to the long axis of the implant followed by measurement of bone

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density in the same plane Figure 2. In order to minimize the measurement errors the bone density was measured at the crest, 3 mm from crest, 6 mm from crest and at the apex, both on the buccal and palatal aspect for all the designated implant sites.

RESULTS

The measurements of ridge height (mm) showed a highly significant increase ($p < 0.001^{***}$) between preoperative and postoperative measures. The ridge height (mm) recorded a level of 5.57 ± 0.32 preoperatively, however, it increased significantly to an average (\pm SD) of 10.54 ± 1.08 , 11.20 ± 0.82 , 10.56 ± 0.90 and 10.91 ± 0.81 mm in Immediate Post-operative Buccal, Immediate Post-operative Palatal, 6 months Post-operative Buccal, 6 months Post-operative Palatal; respectively Table I.

The Bone gain (mm) showed a non-significant increase ($p > 0.05$) between immediate

and 6 months postoperative measures. The Bone gain (mm) recorded a level of an average (\pm SD) of 4.25 ± 2.14 , 5.62 ± 0.83 , 4.99 ± 0.84 and 5.33 ± 0.83 mm in Immediate Post-operative Buccal, Immediate Post-operative Palatal, 6 months Post-operative Buccal, 6 months Post-operative Palatal; respectively Table II.

The results showed a highly significant increase in Implant stability quotient (ISQ) in between intra-operative and 6-months postoperative. Implant stability quotient (ISQ) recorded a level of an average (\pm SD) of 61.43 ± 2.07 and 80.00 ± 3.11 in intraoperative and 6-months post-operative; respectively Table III. Also, the results showed a highly significant increase in bone density ($t = -6.81$; $p < 0.001^{***}$) between intra-operative and 6-months postoperative. Bone density in Hounsfield units (HU) recorded a level of an average (\pm SD) of 757.29 ± 69.89 HU and 818.43 ± 109.63 HU in intraoperative and 6-months post-operative; respectively Table IV.

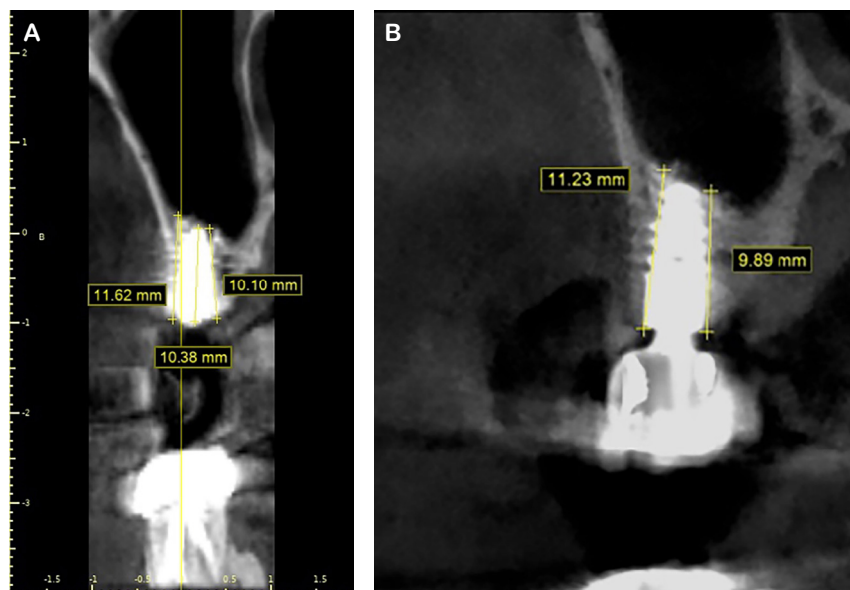


Figure 2 - Photo showing cross sectional cut of Preoperative CBCT Immediate Postoperative CBCT (A) and 6 Months Postoperative CBCT (B).

Table I - Ridge height (mm) in Crestal Maxillary Sinus Floor Elevation using Osseodensification. Difference assessed by ANOVA repeated measure. Means followed by different letters are significantly different according to DMRTs

Time of investigation	Ridge Height (mm)		DMRTs
	Mean	SD	
Preoperative	5.57	0.32	b
Immediate Post-operative Buccal	10.54	1.08	a
Immediate Post-operative Palatal	11.20	0.82	a
6 months Post-operative Buccal	10.56	0.90	a
6 months Post-operative Palatal	10.91	0.81	a
ANOVA			
F-ratio		72.88	
p-value		<0.001***	

***It refers to the results were significant at $p < 0.001$. SD: standard deviation.

Table II - Bone gain (mm) in Crestal Maxillary Sinus Floor Elevation using Osseodensification. Difference assessed by ANOVA repeated measure. Means followed by different letters are significantly different according to DMRTs

Time of investigation	Bone gain		
	Mean	SD	% change from preoperative
Immediate Post-operative Buccal	4.25	2.14	76.3
Immediate Post-operative Palatal	5.62	0.83	101.0
6 months Post-operative Buccal	4.99	0.84	89.5
6 months Post-operative Palatal	5.33	0.83	95.7
ANOVA p-value	>0.05 ns		

Ns: non significant; SD: standard deviation.

Table III - Implant Stability Quotient (ISQ) in Crestal Maxillary Sinus Floor Elevation using Osseodensification. Difference assessed by ANOVA repeated measure. Means followed by different letters are significantly different according to DMRTs

Time of investigation	ISQ	
	Mean	SD
Intra-operative	61.43	2.07
6 months Post-operative	80.00	3.11
Change	18.57	
Change %	30.23%	
Paired t-test		
F-ratio	57.146	
p-value	<0.001***	

***It refers to the results were significant at $p < 0.001$. SD: standard deviation.

Table IV - Bone density (HU) in Crestal Maxillary Sinus Floor Elevation using Osseodensification. Difference assessed by Paired samples t-test

Time of investigation	Bone density	
	Mean	SD
Immediate postoperative	457.29	69.89
6 months Post-operative	818.43	109.63
Change, %	361.14 (75.97%)	
Paired t-test		
F-ratio	-6.81	
p-value	<0.001***	

***It refers to the results were significant at $p < 0.001$. SD: standard deviation.

The duration of surgical procedure (minutes) ranged between 25-38 minutes with an average of 30.86 ± 4.10 minutes.

DISCUSSION

Bone resorption and atrophy of the posterior maxilla together with pneumatization of the maxillary sinus as well as the poor bone quality are factors that impede implant placement in the posterior maxilla. Several techniques have been introduced to overcome these problems including the use of short implants and vertical augmentation using sinus floor elevation. Sinus floor augmentation has been considered a predictable procedure to provide vertical dimension to allow for implant placement in the posterior maxilla with high survival rate [2].

The present study showed that the transcrestal sinus lift and simultaneous implant placement using Osseodensification is a reliable procedure and can be used for implant placement in the atrophic posterior maxilla with residual bone height of 4-6 mm to restore the function.

The main objective of this study was to evaluate the transcrestal sinus lift using Osseodensification technique with simultaneous implant placement. The evaluation was made of this technique regarding the bone gain, bone density, implant stability and the duration of surgical procedure. Considering the results of this study, the sinus floor elevation procedures showed 100% implant survival rate for 6 months after implant placement.

The indirect technique has been recommended for sinus augmentation when the residual bone is

at least 5 mm to stabilize the implant during the healing period. The Schneiderian membrane can withstand 4 to 8 mm of elevation without rupture [9]. In the present study, the average of the ridge height was 5.57 ± 0.32 mm. The implant length of 10 mm was selected to minimize the risk of sinus membrane perforation and to provide space for endo- sinus bone formation. A recent study performed using osseodensification crestal sinus lift for patients have residual bone height of ≤ 1.5 mm as well as vertical height of augmentation (> 10 mm) [10].

In this clinical study, a simplified, minimally invasive transcrestal sinus augmentation approach utilizing the osseous densification method was performed to simultaneously augment the sinus and prepare the osteotomy, by compacting autogenous bone tissue along its wall and apex. This was achieved exclusively by the unique novel design of the densifying burs. This method enhances bone plasticity by introducing the densifying bur into the osteotomy in a modulating “bouncing” motion, in and out of the osteotomy. Therefore, when coupled with copious irrigation, it induces a hydrodynamic compression wave ahead of the point of contact. The irrigating fluid that is forced into the osteotomy facilitates the autografting of bone particles, which are derived from the osteotomy walls to be regrafted back as compacted autograft into both the lateral and apical directions [1].

Various graft materials have been used for sinus augmentation. In this study, a deproteinized bovine bone mineral, known as Nanobone®, was applied. Nanobone is a recently developed and approved granular material consisting of nanocrystalline HA embedded in a silica gel matrix, which offers several of the advantages of nanostructural biomaterials. Because of the open silicone hydroxide (SiOH) or silicone oxide (SiO) groups of polysilicic acid, the internal surface of this material is extremely large (about 84 m²/g). The interconnecting pores in the silica gel have sizes ranging from 10 to 20 nm, leading to material porosity of about 60%. The surface of the granules is very rough, thus creating an inter-connecting porous structure ranging from micrometer to millimeter dimensions. However, Nanobone has a high breaking strength of about 40 Mpa [11].

In the current study, the results showed significantly higher ISQ values at the 2 study intervals representing 1ry and 2ry stability. This could be explained by the drilling technique of osseodensification, which drives bone compaction in the osteotomy site wall, and the presence of residual bone chips which form an autograft wall around the osteotomy perimeter. Furthermore,

due to the spring back effect created by the elastic strain recovery of the compacted bone, a reverse compression of bone tissue against the implant body is created and consequently enhances the implant primary stability [1].

CBCT is currently considered the imaging modality of choice for dental implant procedures and evaluation because it provides 3-dimensional measurements of the bone height in both buccal-palatal and mesial-distal views. However, the data obtained by CBCT for comparative analysis may not reach scientific standard acceptance if the comparative images are not in the same 3-dimensional position and section level. To increase the reliability of the measurement, 3-dimensional registration program was used. Therefore, in this study, the 6-month CBCT data could be accurately compared with the base line data which taken from the immediate postoperative CBCT at the same cross- sectional cut which is coinciding with the long axis of each implant.

In the present study the 6 months postoperative CBCT was performed to evaluate any further changes in the bone gain or bone density in comparison with the immediate postoperative results. The bone gain in the current study was 5.33 ± 0.83 mm which is consistent with data reported by Huwais et al. in 2018 [1].

In the present study, average density was determined around implant in CBCT radiograph using HU. The results of the present study showed that; the mean radiographic bone density scores were showed a highly significant difference all over the studied samples, and overall differences between time points were highly significant. A similar result obtained before [2,11].

The duration of surgical procedures in minutes were recorded and analyzed. The duration of surgical procedure (minutes) ranged between 25-38 with an average of 30.86 ± 4.10 minute. In addition to a significantly less sever limitation in swallowing, continuing daily activities, eating, speaking, opening the mouth, and continuing school/work activities was found. Moreover, it was generally observed that the procedure chairside time was reduced, as was treatment duration, trauma, and morbidity, with improved patient comfort.

Based on the above mentioned results the following conclusion could be drawn

- The crestal maxillary sinus floor elevation using Osseodensification technique with simultaneous implant placement provide superior results regarding bone density and implant stability values;

- The crestal maxillary sinus floor elevation using Osseodensification technique proved to be less time consuming, less invasive, more conservative, and reduces postoperative discomfort to the patient;
- The crestal maxillary sinus floor elevation using Osseodensification technique can be applied in cases having 4 mm or more of residual bone height;
- Further studies are required with larger sample size and longer follow-up periods to assess the definitive results of both interventions, and evaluate its performance and patient related outcome.

Author's Contributions

Conceptualization; E.M., AE.M., S.M.: Methodology; E.M., AE.M., S.M., A.M.; Software; E.S.: Validation; E.M., S.M., A.M.: Formal Analysis; AE.A, E.S.: Investigation; E.M., AE.A.: Resources; E.M., E.S.: Data Curation: E.M., S.M.: Writing Original Draft Preparation; Writing Review & Editing: E.M., E.S.: Visualization; S.M., A.M.: Supervision: AE.M.: Validation; E.M., E.S.: Project Administration; E.M.; Funding acquisition; E.M.

Conflict of interest statement

The authors declare no conflict of interest.

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Regulatory Statement

The datasets collected and/or analysed during the current study are available from the corresponding author on request. The corresponding author had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

All procedures performed were in accordance with the ethical standards of Al-Azhar university research committee and with full declaration and its later amendments. The study was approved by the local ethical committee.

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