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Case Report

The Versatility of Maxillary Sinus Augmentation by Direct Implant Valve Approach

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Abstract

Objective: This study was designed to evaluate the efficacy of the Direct Implant Valve Approach (DIVA) for the rehabilitation of posterior atrophic posterior maxilla with implant-supported fixed prostheses.

Patients and methods: This prospective clinical study included 7 patients (3 males and 4 females). They ranged from 27 to 68 years with the posterior atrophic edentulous maxilla. All patients underwent clinical and radiographic examinations, including full-mouth intra-oral photographic series and cone-beam computed tomography (CBCT), which were performed to assess the maxillary sinus floor. The predictor variables were intraoperative primary stability and level of sinus membrane lifting. The outcome variables were secondary implant stability (Osseointegration) and the level of bone height gained.

Results: The mean bone height before surgery was 5.814 ± 0.669 mm, which became 12.78 ± 0.526 after 6 months. ISQ was 39.00 ± 2.160 , which became 71.71 ± 1.604 , after 6 months. The mean value of bone density at immediate was 472.7 ± 54.14 that increased to 667.7 ± 63.262 after 6 months of implant placement and the difference within the group appeared highly statistical significant at 3, and 6 months when compared with immediate.

Conclusion: The DIVA was an effective approach to augment alveolar bone height without causing maxillary sinus membrane perforation. However, required meticulous surgical procedures.

Keywords

Direct Implant Valve Approach, Balloon technique, Sinus membrane.

Declaration of Conflicting Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Introduction

Sufficient bone width and height are some essential requirements in the field of implant dentistry. The maxillary posterior area is a difficult location for implant placement in comparison with the other areas of the mouth⁽¹⁻⁴⁾. The process of maxillary sinus enlargement due to bone loss after maxillary posterior tooth extraction is known as pneumatization of the maxillary sinus. Moreover, this area of maxilla tuberosity has the lowest bone density.

Maxillary sinus augmentation is a surgical procedure to increase the vertical height of the alveolar bone followed by immediate or second stage dental implant placement^(5,6). There are many approaches and bio-materials used for this procedure.

Tatum first developed the procedure in 1977, and Boyne and James were the first to publish research regarding this technique in 1980^[7].

The osteotome-mediated transcrestal sinus augmentation was first proposed by Tatum in 1986. The technique was then modified in 1994 by Summers² using a set of tapered osteotomes with increasing diameters intended to increase the density of the soft bone and create an up-fracture of the maxillary sinus floor. The Direct Implant Valve Approach was designed from inside with an internal screw that may be used for bone augmentation delivery and possible direct observation by an endoscope. The DIVA was used in cases when the dental implant insertion may be combined with the maxillary sinus membrane elevation and bone augmentation.^[11,14] The new dynamic implant valve approach simplified dental implant procedures and reduced treatment time.^[10]

Hence, the aim of reporting this series of cases was to describe the effect of DIVA in the augmentation of the posterior atrophic maxillary alveolar ridge.

Patients And Methods

Study design and population: This is a report of a series of cases in which subjects who needed sinus augmentation, with remaining bone height of 4 to 9 mm, for implant-supported prostheses were treated and agreed to take part in reporting the results of their treatment. The study continued from September 2018 to August 2020 in the Faculty of Dental Medicine, Department of Oral and Maxillofacial Surgery / Al- Azhar University. The sample included 7 patients, 3 males, and 4 females with age (28-68 years) with single or multiple missing teeth in the sinus zone of the posterior maxilla in which the sub antral bone height ranged from 4mm to 9 mm for the one-stage sinus floor elevation surgery.

The patient inclusion criteria were: patients between 28 and 68 years old, nonsmokers, without presence of systemic diseases at the time of implant insertion and any serious medical diseases known to alter bone formation.

The patient exclusion criteria were, patients who presented, sinus pathology, ongoing periodontitis, skeletal disorder or taking medications that would influence bone metabolism.

Clinical evaluation: all patients underwent clinical and radiographic examinations, including full-mouth intra-oral photographic series and cone- beam computed tomography (CBCT), which were performed to assess the maxillary sinus. Medical consultation was undertaken when necessary (ENT Department in faculty of medicine in Assuit branch – Al -Azhar University).

Surgical procedure

Anesthesia: All surgical procedures were performed using maxillary nerve block technique local anesthesia, with strict aseptic conditions. The procedure was performed under local anesthesia (2% Lignocaine with 1:100,000 adrenaline) (1.8 ml cartridge) was administered to the patient. middle and Posterior superior alveolar nerve block along with greater palatine nerve block was given to ensure optimal anesthesia of the surgical site.

Surgical exposure: An alveolar mid-crestal horizontal incision was performed in the edentulous site and connected with the sulcular incision of adjacent teeth. Muco-periosteal envelope flap was elevated exposing alveolar bone. A surgical guide template was used to guide the pilot drill.

After using a pilot drill, a 2mm drill was used to move up to 1-2 mm from the sinus floor (according to the CBCT image). Following the drilling, a 2.8 mm curved osteotome was used to reach a 1-2 mm level from the sinus floor. The implant was inserted in the bone till the primary stability was reached, **Figure (1A)**. After that, the internal screw was removed and saline irrigation via the internal port was used. This procedure was performed until the vertical level needed for the length of the implant was obtained, **Figure(1B)**. The integrity of the maxillary sinus membrane was assisted by the movement of the saline level via the implant coronal space. Injection of gel form bone graft via the DIVA injection adaptor kit. Wound closure was performed utilizing a non-absorbable suture gauge (4/0). The post-operative vertical bone height was evaluated in the axial view of CBCT, **Figure (1C)**.

CBCT measurement

All radiographic images were obtained by CBCT. Coronal and cross sectional images were integrated to measure the vertically elevated heights.

Maximum VH was measured from the implant bed of the crestal bone to the highest point of the bone level below the sinus membrane.

Data analysis All the parameters were presented as mean \pm SD (mm). ANOVA test using statistical software identify the difference of new bone height, ISQ and bone density in different follow up periods.

Result

A total of 7 adult patients aged 28-68 (mean 47.5 years), 3 males and 4 females participated in

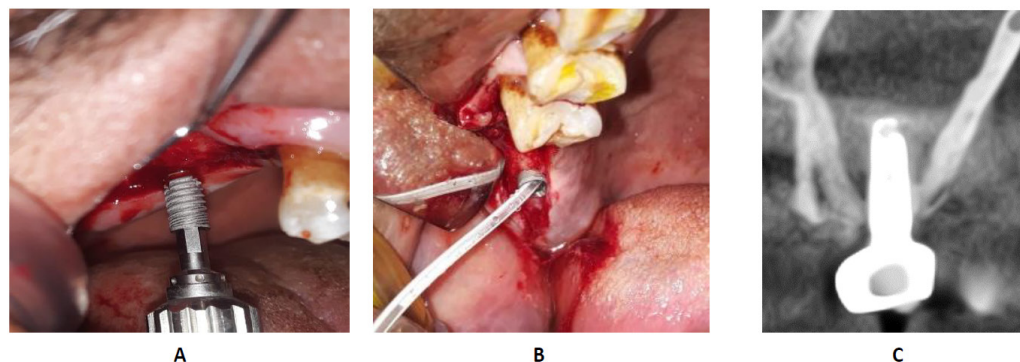


Figure-1 (A)Showing primary implant stability (B)Saline irrigation through interval valve (C)New vertical bone height after bone graft injection.

this study. The total performed sinus floor elevation sites were 11 with a total of 11 dental implants. **Changes in vertical bone height:** vertical bone height means, standard deviations, t-values, and p-values within the group illustrated in the **Table (1)** and **Figure (2)**. It showed a highly statistically significant difference in comparing pre-operative versus post-operative vertical bone height. The mean value of vertical bone height in the. The mean value of vertical bone height in DIVA was 5.81 mm \pm 0.66 at immediate that increased to 12.78 mm \pm 0.66 after 6 months.

Implant Stability Quotient (ISQ): Implant stability was checked for all implants using osstell (Osstell Co. Sweden) intraoperatively, 3, 6, and 9 months postoperatively. The mean ISQ measured values increased during the observation period. RFA measurements demonstrated that the mean ISQ value at the time of implant placement in the DIVA group was 39.00 \pm 2.16, the mean ISQ value of DIVA group was 71.71 \pm 1.60. Patients were seen at 3rd, 6th, and 9th months for the clinical follow-up sessions, and all patients completed the 9 months' clinical observation period. **Table (2)** presents the mean and standard

Interval	Range	Min	Max	Mean	SD
Preoperative	1.94	4.82	6.76	5.814	0.669
3Months	1.45	12.76	14.21	13.28	0.500
6Months	1.47	12.23	13.7	12.78	0.526

Table-1 Illustrating range,min.,max.,mean and SD of vertical bone height at different follow up periods.

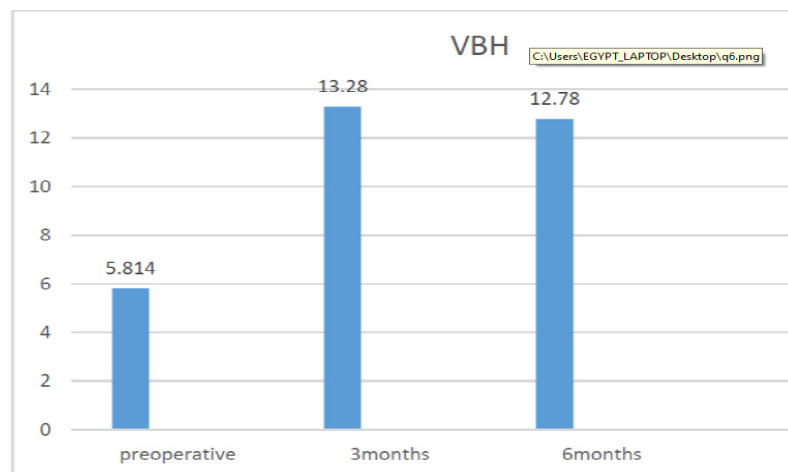


Figure-2 Showing vertical bone height at different follow up periods

deviations of ISQ values during follow up period.

Figure (3) showed a high statistically significant difference at 9 months of observation interval when compared to the immediate observation period.

Bone density:The mean value of bone density at immediate was 472.7 ± 54.14 that increased to 667.7 ± 63.262 after 6 months of implant placement and the difference within the group appeared highly statistical significant at 3, and 6 months when compared with immediate.

Interval	Range	Min	Max	Mean	SD
Preoperative	6.0	36.0	42.0	39.00	2.160
3Months	4.5	66.5	71.0	69.07	1.694
6Months	7.0	66.0	73.0	70.43	2.370
9Months	5.0	69.0	74.0	71.71	1.604

Table-2 Illustrating range,min.,max.,mean and SD of ISQ dentisty at different folloe up periods.

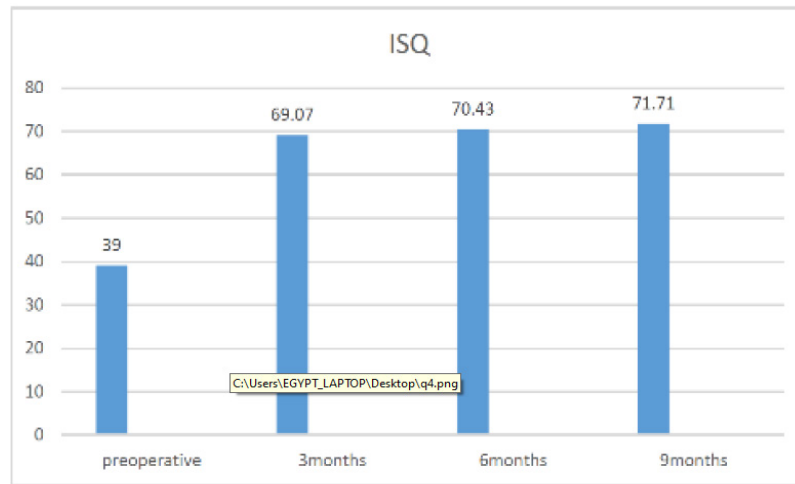


Figure-3 Showing ISQ at different follow up periods

Interval	Range	Min	Max	Mean	SD
Preoperative	140	402	542	472.7	54.14
3Months	78	528	606	574.6	31.77
6Months	176	605	781	667.7	63.26

Table-3 Illustrating range,min.,max.,mean and SD of bone dentisty at different follow up periods.

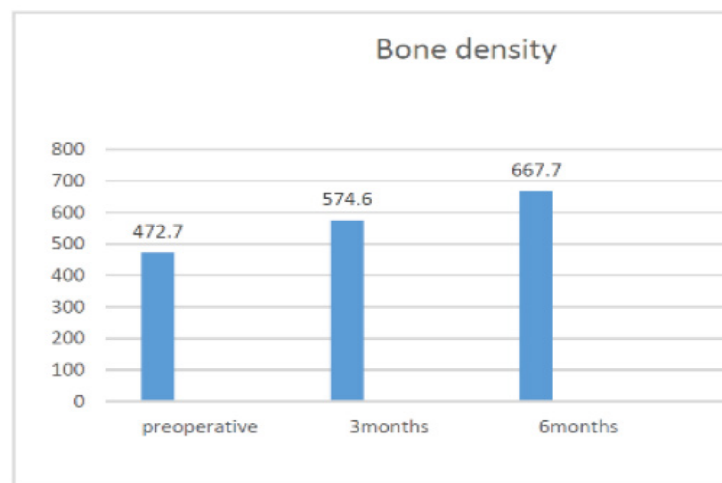


Figure-4 Showing bone dentisty at different follow up periods.

Discussion

Bone resorption and maxillary sinus pneumatization add some level of complexity to implant planning and placement. The lateral approach for maxillary sinus augmentation has become a routine and predictable technique; however, perforation of the sinus membrane is still a frequent occurrence.

So, it is important to innovate various methods for maxillary sinus floor elevations in order to achieve better clinical results.

Moreover, it is vital to compensate any vertical alveolar bone loss to support proper implant placement and to ensure its viability (1). Our case report illustrates a DIVA for the patients in need of a maxillary sinus augmentation.

In order to restore vertical alveolar bone loss, various surgical modalities have been proposed for the insertion of dental implants in the maxillary posterior part, showing a high implant survival rate with a low failure incidence.

The residual alveolar bone height and the ability to establish implant stability are fundamental in deciding which augmentation modality should be used to obtain a sufficient bone height for dental implant installation.

Traditionally, lateral window techniques were used to augment the maxillary sinus in cases with an alveolar height < 5 mm. However, this approach often results in postoperative complications such as discomfort, swelling, bleeding, infection, exposure of the covering membrane, and occasionally nasal bleeding. As a result, minimally invasive surgical procedures were devised to shorten the treatment period and to optimize the maxillary posterior edentulous area for implantation. In this paper, the DIVA is reported for maxillary sinus floor elevation, achieving a maximum height of 12 mm.

The calculated ISQ values represented a significant increase of implant-bone osseointegration. In this study, Osstell™ was used to measure (primary) dental implant stability at the day of surgical placement, after 3, 6, and 9 months to evaluate the degree of osseointegration (secondary implant stability). RFA measurements demonstrated that the stability of implants increased during the healing period, and the mean ISQ values became 71.71 ± 1.60 after 9 months' implant placement. This finding was in line with several studies that reported an increase in stability of implants placed simultaneously with SFE procedures during the healing period. This increase in the implant stability during the healing period represents the changes in the bone-implant interface during the process of osseointegration. (11-13) In this study, the mean initial implant stability quotient (ISQ) values at the surgery were 39.00. The implant stability quotient (ISQ) values at the time of the surgery can be viewed as a low number in comparison with values after 6 months 70.43, this was expected since the implants placed immediately after the sinus lifting procedure may have lower primary stability due to main bone contact originated from the apical aspect of the osteotomy site (in regular implant osteotomy bed), which in the study group was absent, only lateral friction was present. This compatible with Turkyilmaz & McGlumphy (12) histomorphometric study showed that resonance frequency analysis (RFA) values correlated well with the amount of bone-to-implant contact. At 3 months, this observation showed a higher implant stability quotient (ISQ). These results might be explained by a correlation between the amount and distribution of bone grafts around the dental implant as gel form bone graft resorbed and replaced by natural bone; giving semicircular and symmetric distribution around the DIVA implant which was seen in periapical x-ray investigation during the study.

The mean vertical bone height after sinus lifting in the DIVA was $13.28\text{mm} \pm 0.50$ after 3 months from implant insertion, which was a clinically significant, due to sequential insertion and gradual membrane dissecting by injection of saline through the implant, and injection of gel form bone graft at the same time of implant installation that made the need for vertical bone height was done. These results were in the same line with Yassin (4) where the vertical bone height 7mm after membrane elevation but this results from an animal study.

The results of the present study showed that; the mean radiographic bone density scores were increasing in all follow up periods when compared with base line with a statistically significant increase in bone density. A similar result obtained by Attia (14)

In the present study, average density was determined around implant in C.B.C.T radiograph using HU. This clinical findings reported that bone density during all observation periods increased. These results in accordance to findings of Hassan et al (11) which demonstrated that increased bone density around implant with augmented bone graft was 101.49 at 3 months increased to 129.56 at 12 months.

The present study suggested that bone density of grafted bone was increasing with time but we can't compare those densities with adjacent existing bone because of the influence of sinus lifting technique on the whole area surrounding the implants.

Smieszek-Wilczewska et al (13) found a significant increase of the optical density of regenerated bony defect augmented with Bio-Gen and Bio-Oss (biomaterials derived from animals), when compared to lesions healed without biomaterial augmentation. However, they also concluded that it is difficult to draw clear-cut conclusions relating to the speed of their resorption and bone modeling.

Conclusion

Although, the small sample size of this study, the results suggest that:

1. The DIVA implant simplified the sinus lifting procedure and reduced surgical time.
2. The DIVA implant was an effective, safe procedure for maxillary sinus lifting
3. This newly designed implant can be used in a standard fashion and also intraoperative delivery for gel form bone grafts.

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