

Absorbable Gelatin Sponge versus Alloplastic Graft Material as Adjuvants in Direct Sinus Lift Procedures - A Comparative Study

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Abstract

The purpose of this study was to evaluate and compare the quantity of new bone formed in the maxillary sinus using Abgel versus β -TCP as adjuvants in maxillary sinus lift procedures using lateral window approach. This randomized clinical study was conducted on 14 patients with 16 sites in Misch's SA – 4 category, divided into Group A: Absorbable gelatin sponge was used as graft material and Group B: Alloplast (β tricalcium phosphate) was used as graft material. In the Abgel group, 4 sites were augmented with immediate implant placement, whereas 4 sites were augmented without implants, similar to the β -TCP group. CBCT scans were obtained pre operatively, immediate post operatively and 5 months post operatively to assess the quantity of bone formed and the maintenance of membrane elevation achieved post augmentation; both within the group and between the two groups. The 5 months post treatment bone height was significantly higher than pre-treatment bone height ($p < 0.05$) in both the groups: however the mean increase in bone height using β -TCP was not statistically significant when compared to Abgel group ($p > 0.05$). On comparing the post treatment height in membrane elevation measurements (irrespective of the material used), more height loss was seen in group without implants (3.52 ± 2.59) than group with implants (1.46 ± 1.12) which was statistically significant ($p < 0.05$). In conclusion, Abgel is effective as an adjuvant in both with and without immediate implant placement; however the bone height achieved is better in patients with immediate implant placement.

Keywords: Maxillary Sinus Lift, Absorbable Gelatin Sponge, Alloplastic Graft Material, β - Tricalcium Phosphate, Bone Augmentation, Immediate and Delayed Implants

1. INTRODUCTION

Long term edentulism leads to various deleterious sequelae like decrease in the alveolar bone height, width and density, dental migration, supra-eruption, accelerated degeneration of remaining teeth.¹ Along with the above hard tissue changes, posterior maxilla is additionally affected by the pneumatization process resulting in very minimal available bone height; the placement of implant in such a situation becomes contraindicated unless an additional adjuvant procedure is advocated. Sinus lift procedure with/ without graft material has become a standard procedure to overcome this problem.²

A wide array of bone-grafting materials have been studied for use in maxillary sinus augmentation to accelerate the bone healing process and prevent re-pneumatization of the maxillary sinus after grafting.³ The characteristics of the bone substitute material to be used comprise a crucial factor in the success of the reconstruction. These characteristics include biocompatibility, adequate mechanical strength, osteoconductive properties, minimal immune response, and controlled resorption. Autogenous bone grafts have been used for more than two decades and are considered as the "gold standard" even today. However they require a second surgical site to harvest the graft with associated



donor site complications. To overcome these complications, different substitutes of bone are experimented which included allografts and xenografts (bovine, swine etc). It was observed that they suffice the volume requirement, and simultaneously provide initial stability for dental implants, but carry the potential of foreign body immune reactions leading to high rates of rejection and failure. Hence Alloplasts (beta-tricalcium phosphate, hydroxyapatite, etc) have emerged as an alternative material to overcome the drawbacks of autogenous and allogeneous bone graft materials.

The use of beta-tricalcium phosphate (β -TCP) for sinus grafting procedures has received increased attention in implant dentistry, due to the similarity of its structural composition to human bone. It is biocompatible and shows osteoconductive properties, which allows the osteoprogenitor cells to proliferate throughout the bone surface and inside its pores that later differentiate into osteoblasts to produce bone. Clinical success with the use of β -TCP compared to autogenous bone in sinus grafts has been reported in several studies making it one of the most popular substitutes during bone augmentation.⁴ In recent times, researchers are exploring the prospects of applying guided bone regeneration strategy by maintaining the Schneiderian membrane in highest possible position with simultaneous implantation and by using whole blood⁵ as a sole filling material in the subsinus space. This allows regeneration of bone to take place naturally due to the innate osteogenic potential of the membrane. However, the main drawback of this approach is that filling the subsinus cavity with a stabilized blood clot is not that easy in everyday practice.

The ultimate bone substitute should eventually be resorbed and replaced by new bone formation, thus permanently replenishing the defect or loss of bone. Hence some researchers have used absorbable gelatin sponge⁶ as a space maintainer for new bone formation in the maxillary sinus as an alternative to bone graft materials. However search of literature fell short for the firm evidence on usage and success of this material for sinus augmentation in particular.

The aim of this study was to ascertain the efficiency of Absorbable gelatin sponge (Abgel) versus β -TCP as adjuvants in maxillary direct sinus augmentation procedures with/ without immediate implant placement, using CBCT (cone beam computed tomography) to assess the quantity of bone formed using millimetre scale (bone formed is measured between the alveolar crest to the sinus floor) and maintenance of bone height achieved post augmentation i.e., between immediate post-operative period and 5 months later; both within the group and between the two groups.

2. MATERIALS and METHODS

This prospective clinical study was conducted on patients reporting to the Departments of Oral and Maxillofacial Surgery, Prosthodontics and Oral Implantology, M. S. Ramaiah Dental College and Hospital between 01/10/2014 to 30/05/2016, seeking oral rehabilitation with implants. This study was approved by the ethics committee of our institution.

Patients with partial or completely edentulous posterior maxilla with clinical and radiological evidence of reduced alveolar bone height (<5 mm) and increased pneumatization of the sinus were included in the study. Patients with previously attempted sinus augmentation procedures, any sinus pathologies, who have undergone recent radiation therapy to the maxilla, any previous sinus surgeries, mentally challenged, heavy smokers, alcohol abusers and medically compromised patients were excluded. The patients were informed about the study, including the use of Abgel and β -TCP as adjuvant materials. A written consent was obtained from all participating patients.

A total of 14 patients with 16 sites in Misch's SA – 4 category (<5 mm residual bone height) were selected for this study. All patients underwent sinus lift procedure via lateral window approach. Patients were randomized into two groups using random numbers table. This was done by a clinical assistant who was not involved in the surgeries or in the data evaluation.

Group A: Patients who received Abgel as adjuvant material.



Group B: Patients who received β -TCP as adjuvant material.

Again within each group, patients were subdivided into two groups. This subdivision was based on the height of the residual bone. Sites with minimum residual bone height of 3 mm underwent immediate implant placement and sites with < 3 mm of bone underwent sinus lift procedure without immediate implant placement.

All the patients were in the age range of 24 years to 65 years, with the mean age of 43.06 years. Abgel group had no patient below the age of 25 years, however 6 patients were in the age group of 25 to 50 years and 2 patients were in the age group of 50 to 75 years. β -TCP group had 1 patient below the age of 25 years, 5 patients in the age group 25 to 50 years and 2 patients in the age group 50 to 75 years. Of the 14 patients, 12 patients underwent procedure on one quadrant whereas 2 patients underwent procedure on both right and left quadrants. In Abgel group, there was 1 patient who underwent the procedure on right side, 5 patients on left side and 1 patient on both sides. In the β -TCP group, there were 4 patients who underwent the procedure on right side, 2 patients on left side and 1 patient on both sides. Among the 16 sites augmented, 6 were in Premolar – molar region and 10 were in Molar region.

All the patients in both the groups were given prophylactic oral antibiotics (amoxicillin 500mg 3 times/day; if allergic to penicillin - erythromycin 500mg 3 times/ day) 1 day prior and karvol plus inhalation was started 2 days prior to the surgery. All surgical procedures were performed by the same surgeon, with a strict aseptic protocol, under local anesthesia (lidocaine 2% with epinephrine 1:2, 00,000). Incision, elevation and osteotomy were performed as per the standard protocol. An incision was made over the alveolar crest of the regions to be grafted. After sub-periosteal detachment, the maxillary sinuses were accessed through the lateral wall, as suggested by Tatum. After the elevation of the schneiderian membrane, the Group A patients underwent sinus augmentation with Abgel as adjuvant material; and the Group B patients underwent sinus augmentation with β -TCP as an

adjuvant material. Then the bony portion of lateral window was repositioned to prevent soft tissue ingrowth into the sinus cavity. Flap was sutured back using 3-0 vicryl sutures to achieve passive primary closure. In the Abgel group, 4 sites were augmented with immediate implant placement and 4 sites were augmented without implant placement. Similarly, in the β -TCP group, 4 sites were augmented with immediate implant placement and 4 sites were augmented without implant placement.

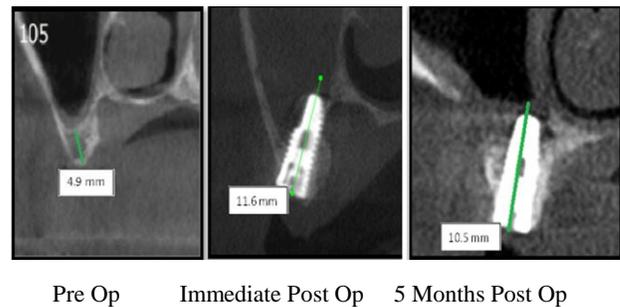


Fig. 1 Case 1: Abgel with simultaneous implant placement

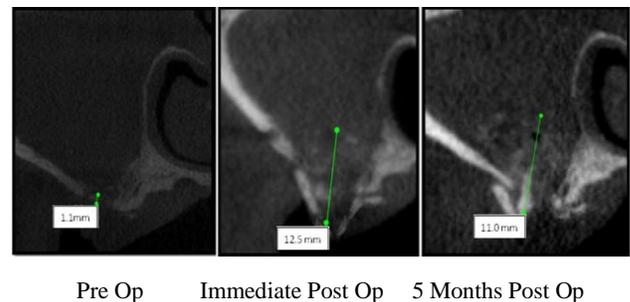


Fig. 2 Case 2: Abgel without simultaneous implant placement

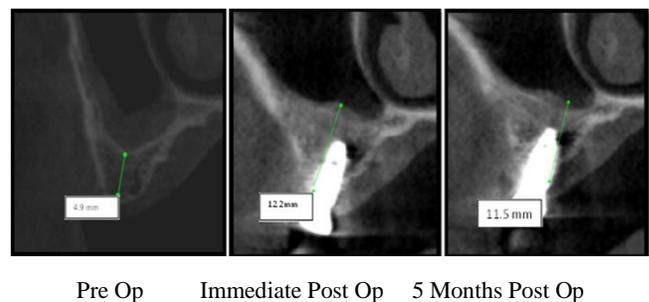


Fig. 3 Case 3: β -TCP with simultaneous implant placement

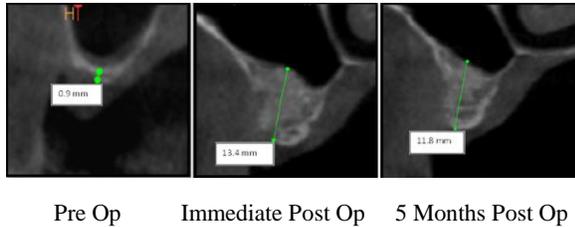


Fig. 4 Case 4: β -TCP without simultaneous implant placement

Apically tapered, commercially pure titanium implants (CMI implants, NeoBiotech, USA) were used in patients undergoing sinus augmentation with immediate implants. The lengths of implants used were 8.5, 10, 11, 11.5 mm and diameter was 3.5, 4.0, 4.2, 4.3 and 4.5 mm. Patients were instructed to be cautious during coughing or sneezing and not to blow their nose for 2 weeks after the surgery. All patients were advised to continue antibiotics, analgesics (Tolpa-D diclofenac 50mg and serratiopeptidase 10mg) and karvol plus inhalation for 1 week after surgery; sutures were removed after 14 days postoperatively.

Patients were assessed clinically as follows: immediate post-operative 1 week, 1 month and 5 months post-operative period. Radiographic assessment for bone height was done pre-operatively, immediate post-operatively and at 5 months post-operatively using CBCT. CBCT scans were assessed for pre-operative and post-operative bone height. The CBCT scans were obtained from care stream 9300 premium which is a hybrid machine using a CS3D imaging software and flap panel detector sensor with exposure parameters of 90 KV and 10 mA and resolution of 90 microns. The cross sections were made 1mm apart. The images acquired were in the Digital Imaging and Communications in Medicine (DICOM) data format.⁶⁷ CBCT scans were used for assessing pre-operative bone height as a measurement taken from the crest of the ridge till the sinus floor. In the immediate post-operative CBCT, the bone height was measured from the crest till the hyper density was evident apically. At post-operative 5 months, CBCT scans were obtained to assess whether the bone height achieved in the immediate post-operative period was maintained, increased or reduced in height. These measurements obtained were

standardized as a computer software drawing tool was used. All of these analyses and the data collection were performed by a single researcher trained in advance for this work.

3. RESULTS

Paired and unpaired *t* tests were used to compare the amount of bone formed both within the group and in between the two groups respectively; which was done at 3 different intervals i.e., pre-operative, immediate post-operative and 5 months post-operative period. In Abgel group, the preoperative bone height ranged from 1.1 mm to 4.9 mm, with a mean of 3.69 mm. The immediate post-operative bone height achieved ranged from 6.8 mm to 12.5 mm with a mean of 10.81 mm. The 5 months post-operative bone height ranged from 4.3 mm to 11 mm, with a mean of 7.92 mm. In β -TCP group, the preoperative bone height ranged from 0.9 mm to 4.9 mm, with a mean of 3.52 mm. The immediate post-operative bone height achieved ranged from 9.6 mm to 13.5 mm with a mean of 12.28 mm. The 5 months post-operative bone height ranged from 5.3 mm to 11.8 mm, with a mean of 10.18 mm.

The 5 months post treatment bone height in both the groups was higher than pre-treatment bone height ($p < 0.05$) which was statistically significant. The mean increase in bone height using β -TCP (6.66 ± 3.1 mm) was higher when compared to Abgel group (4.24 ± 3.12 mm) ($t = 1.55$, $p > 0.05$); however was statistically insignificant. The post treatment height loss was measured between the schneiderian membrane and alveolar ridge from immediate post-operative period to 5 months post-operative period. The post treatment height loss measurements in Abgel group with implants (1.52 ± 1.47 mm) was lesser than group without implants (4.52 ± 3.59 mm) ($t = 1.4$, $p > 0.05$), which was clinically significant but statistically insignificant. The post treatment height loss measurements in β -TCP group with implants (1.4 ± 0.87) was lesser than group without implants (2.8 ± 1.2) ($t = 1.8$, $p > 0.05$), which was both clinically and statistically insignificant.

The post treatment height loss measurements in group without implants (irrespective of graft



material used) ($3.52 \pm 2.59\text{mm}$) was higher than group with implants ($1.46 \pm 1.12\text{mm}$) ($t=2.05$, $p<0.05$), which was statistically significant. Among the intra-operative complications, sinus membrane perforations $< 2\text{mm}$ were noticed in 3 out of 16 sites; however there were no post-operative complications noted.

4. DISCUSSIONS

Bone remodelling following grafting procedures in the maxillary sinuses was first studied using conventional two-dimensional techniques. Fig.5

and Fig.6 Due to the various advantages of CBCT over conventional radiography, we intended to use CBCT scans for the height evaluation over the conventional two dimensional radiographs and computed tomography. It was an easy and effective way of measuring the bone height pre-operatively and post-operatively.⁷ The outcome of our study suggested that CBCT can be used as a tool in predicting the success of grafting in direct sinus augmentation and is highly recommended in all cases to improve the surgeon’s confidence and the accuracy of the sinus lift technique.

Fig. 5 Comparison of bone height between pre-operative, immediate post-operative and 5 months (delayed) post-operative period in Abgel group

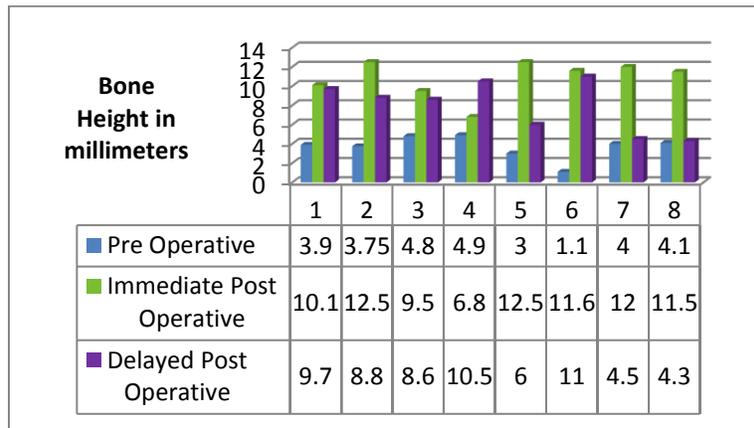


Fig. 6 Comparison of bone height between pre-operative, immediate post-operative and 5 months (delayed) post-operative period in β -TCP group

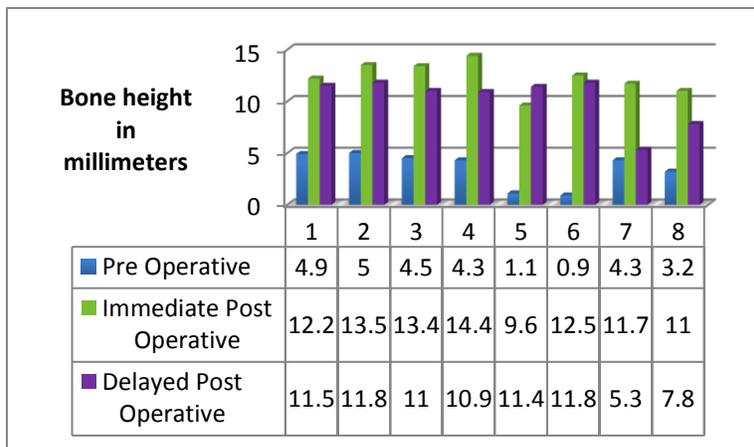


Table 1. Comparison - amount of height loss in Abgel group with and without implant

Abgel Group		Amount of Height Loss (mm)	Mean Difference	Unpaired t Test	
		(Mean \pm SD)		t	P Value
Implant	Present	1.52 \pm 1.47	2.72	1.4	0.21
	Absent	4.52 \pm 3.59			

p>0.05

Table 2. Comparison - amount of height loss in β -TCP group with and without implant

β -TCP Group		Amount of Height Loss (mm)	Mean Difference	Unpaired t TEST	
		(Mean \pm SD)		t	P Value
Implant	Present	1.4 \pm 0.87	1.4	1.8	0.1
	Absent	2.8 \pm 1.2			

p>0.05

Table 3. Comparison - amount of height loss with and without implant in both groups irrespective of material used

Irrespective of Material		Amount of Height Loss (mm)	Mean Difference	Unpaired t Test	
		(Mean \pm SD)		t	P Value
Implant	Present	1.46 \pm 1.12	2.06	2.05	0.05*
	Absent	3.52 \pm 2.59			

*p<0.05



In a landmark review study by Jensen et al.⁸ in 1988, which analyzed 349 implants for a mean follow up period of 3.2 years, showed that the majority of implants which were lost were placed in the residual bone height of <5mm; similar to the study by Geurs et al in 2001 inferring that the amount of residual bone height significantly influences the implant survival after sinus floor elevation. In our study, all 8 implants placed simultaneously with sinus augmentation in sinuses with minimum residual bone height of 3 mm, irrespective of the graft material used showed a 100% survival rate due to the primary stability achieved during the implant insertion. In our study, patients undergoing implants with simultaneous sinus augmentations were 8 in number. Among them, the post treatment bone height (11.27 ± 0.71 mm) was significantly higher than pretreatment bone height (2.44 ± 0.81 mm) ($t=32.17$, $p<0.005$). The results we obtained were in accordance with the study by Seung-MiJeong⁹. This could be due to the short follow up period as well as due to non-loading of the implants. Although our study achieved a greater increase in average bone height, it involved a comparatively smaller sample with less number of implants placed similar to Komarnyckys and London study.¹⁰

In a study conducted by Horch et al¹¹, sinus floor augmentation was performed without simultaneous insertion of dental implants. One year after surgery, approximately 85% of the β -TCP ceramic material in combination with autogenous bone had been resorbed when compared to only about 65% of the β -TCP when used alone. He stated that due to the initial progressive degradation phase of the ceramic material, the implants may not integrate with the bone and recommended that dental implants should not be inserted until ceramic degradation has shown considerable progress and accompanied by advanced bone regeneration, this implies a period of 5–6 months. However in our study, we found an overall bone loss of 22.80 % in β -TCP group without implants. Other authors however have presented promising results with simultaneous insertion of implants, but long-term results are not available. In a study by Gorla et al¹², he compared the changes in bone volume (CBV) after maxillary sinus lifting using

autogenous bone ($n = 12$), autogenous bone mixed with b-TCP 1:1 ($n = 9$), and β -TCP alone ($n = 11$) as grafting material, by means of CBCT. CBV (changes in bone volume) was evaluated by comparing CBCT scans obtained in the immediate postoperative period (5–7 days) and at 6 months postoperative in each group. He found that there was an average resorption of 45% for the autogenous bone group, 43% seen for autogenous bone associated with β -TCP 1:1 and an average of 38% for β -TCP alone. This may be an advantage of β -TCP over other bone substitutes, which often present a long duration of bone repair and a theoretically high risk of infection as the main negative points. Contrary to this, we found an overall bone loss of only 17.1% in β -TCP group with implants; which could be due to short term follow up.

According to Gorla et al¹², it was concluded that the implants inserted with the one-stage technique had a slightly higher survival rate than implants inserted with the two-stage technique. The utilization of grafts consisting of 100% autogenous bone or the inclusion of composite grafts to it did not affect implant survival. Hence alloplastic biocomposite material can be used alone and in preference to other materials available. In accordance to this, we found 100% survival rates of implants placed immediately in β -TCP group of our study. However long term follow up and loading of implants is recommended to claim high survival rate.

It has been noted that maintaining the blood clot in the maxillary sinus lift technique permits immediate bone formation under implant installation conditions without needing to fill it with any other type of material. According to Srouji et al¹³, sinus membrane has an innate potential to form new bone. Hatano et al¹⁴ stated that blood clots per se have been shown to contain endogenous growth factors and therefore have the potential to stimulate bone formation. Various studies by Simion and colleagues¹⁵, Ferrigno and colleagues¹⁶ and Ellegard et al¹⁷ have confirmed that the schneiderian membrane has inherent osteogenic potential. Sohn et al¹⁹ stated that absorbable gelatin sponge acts as a space maintainer and holds the sinus membrane in the elevated position making the subantral space a



closed cavity for blood clot to form below it which acts as a scaffold for new bone formation. Hence in our comparative study we used absorbable gelatin sponge as a space maintainer to stabilize the clot in the subsinus cavity. Due to the porosity of the sponge, blood platelets are caught and the coagulation cascade is activated transforming soluble fibrinogen into a net of insoluble fibrin. Thus, the sponge structure is believed to be essential for the mode of action of the sponge.¹⁸ This sponge along with the clot gets organized and stabilizes the membrane in the elevated position and acts as a scaffold for new bone formation.

To our knowledge, there are no studies conducted using Absorbable gelatin sponges as adjuvant material in sinus lift other than the study by Sohn et al¹⁹. In his study, he had 7 patients (9 sinus augmentations) who were consecutively treated with sinus augmentation with simultaneous implant placement; absorbable gelatin sponges were loosely inserted to support the sinus membrane over the implant apex. After 6 months, new bone consolidation in the maxillary sinus was observed on radiographs without bone graft. He suggested that maxillary sinus augmentation with a gelatin sponge can be a predictable procedure. In our study, we performed sinus augmentation using absorbable gelatin sponge with immediate implants in 4 patients and without implants in 4 patients. In the immediate post-operative CBCT scan there were blood clots and voids under the elevated schneiderian membrane. In the 5 month post-operative period, there was new bone formed under the membrane radiographically. No implant failure was noted due to the primary stability achieved during implant placement.

According to Lundgren et al²⁰, the mesenchymal cells probably migrate from the bone marrow of the alveolar bone to the blood-filled sinus, and use a fibrin mesh for anchorage. Periosteum elevation leads to resorption, bone marrow exposure, and stem cell entry into the sinus cavity. This mechanism along with the osteoprogenitor cells from the schneiderian membrane could probably explain the new bone formed in the Abgel group with or without implant placement. A prospective clinical study

conducted by A. P. F. Bassi et al²¹ of maxillary sinus lift procedures in the posterior region of the maxilla, using only blood clot as filling material had 17 patients with 20 maxillary sinus regions and a total of 25 implants. Computed tomography (CT) scans were obtained immediately postoperative ($T_{initial}$) and at 3 (T1) and 51 (T2) months postoperative for the measurement of linear bone height. Only one implant was lost in the first stage (96% success). After a follow up of 51 months, no implant was lost (100% success, second stage). The difference in mean bone height between $T_{initial}$ (5.94 mm) and T1 (13.14 mm), and between $T_{initial}$ and T2 (11.57 mm), was statistically significant (both $P < 0.001$); comparison between T1 and T2 also presented a statistical difference ($P < 0.001$). Thus he concluded that the maxillary sinus lift technique with immediate implant placement, filling with blood clot only, may be performed with a high success rate. However in our study, we had 8 patients undergoing sinus augmentation with Abgel as graft material with implants (4 sites) and without implants (4 sites). CBCT scans obtained at pre-operative, immediate and 5 month post-operative period showed bone heights of 3.69 mm, 10.81 mm and 7.92 mm. The 5 month post treatment bone height (7.92 ± 2.64) was significantly higher than pre-treatment bone height (3.69 ± 1.2) ($t=3.81$, $p<0.05$). The post treatment height loss of initial height achieved from immediate post-operative period to 5 month post-operative period was higher without implants (4.52 ± 3.59) than with implants (1.52 ± 1.47) ($t=1.4$, $p>0.05$). Although it was not statistically significant, this could be due to the lack of tenting effect, and also increased resorption rate in the Abgel, as the membrane was not maintained in an elevated position without implant placement.

A study by Felice et al²² suggested a two-stage procedure in patients with residual bone height between 1 and 3 mm below the maxillary sinus. They described a trend towards a lower risk of implant failure under these conditions when compared to a one-stage procedure similar to the study by Younes et al²³. In accordance to these studies, we had cases with residual bone height ≥ 3 mm grouped into implants group irrespective of the graft material used whereas cases with



residual bone height ≤ 3 mm grouped into without implants group. The post treatment bone loss measurements in group without implants (3.52 ± 2.59) was higher than group with implants (1.46 ± 1.12) ($t=2.05$, $p<0.05$), which was statistically significant. This could be due to lack of tenting effect of schneiderian membrane seen in the group without implants.

Whatever the place or period, complications have been an inevitable part of surgical practice. The most common intraoperative complication is reported to be the perforation of the sinus membrane ranging from 0–58.3%. However controversy still hovers whether this complication influences the survival rate of the implants. Some authors reported a correlation between membrane perforation and implant failure while other studies reported no correlation (Khoury 1999). Perforations are usually closed by using tissue fibrin glue, suturing or by covering them with a resorbable barrier membrane.²⁵ Although in our study, sinus membrane perforation was observed in 3 of the 16 augmented sites (18.75%), we did not encounter any complications associated with the perforation and healing occurred uneventfully. The membrane perforations were managed by covering them with a resorbable barrier membrane. Other complications like sinusitis, infection of grafted sinuses, excessive bleeding from the bony window or the sinus membrane, hematoma, wound dehiscence, injury of the infraorbital neurovascular bundle, implant migration into the sinus floor, implant failure are also noted occasionally²⁴. However in our study none of these complications were noted, this could be due to proper planning and strict adherence to surgical protocols. Penetration of the sinus by implants may increase the risk of infection and can be regarded as a contraindication. However Branemark et al. in 1984 reported that sinus penetration by implants caused no undesirable effects.²⁴ Similarly in our study, no apparent differences were observed on imaging of the augmentation sites with or without perforation. This was also in accordance with the study by Sohn et al.

Survival of an implant after perforation and repair of the Schneiderian membrane is controversial.

Although some authors have stated that perforation of the membrane compromises survival of the implant, several have shown that it does not affect the survival of the implant if the perforated area (Chanavaz et al ²⁵, 2000) is managed by means as mentioned earlier. This could probably explain the 100% success rate of implants in our study.

In conclusion, maxillary sinus augmentation with Abgel and β -TCP as adjuvant materials with/without simultaneous placement of implants, demonstrates new bone formation through radiographic evaluations. It has been already clinically proven that β -TCP is effective as a bone substitute in sinus augmentations. Similarly, in our study too, β -TCP was effective in bone formation both with and without immediate implant placement. Abgel was effective as an adjuvant in both with and without immediate implant placement; however the bone height achieved was better in patients with immediate implant placement.

There is great potential for new bone formation in the maxillary sinus without the use of additional bone grafts if sinus augmentation with Absorbable gelatin sponge is done with immediate implant placement. This new bone formation could be due to the innate osteogenic potential of the schneiderian membrane; however long-term follow-up is required for confirmation of the long term stability of this procedure.

Weighing the benefits and limitations of various bone substitutes, we would recommend use of Absorbable gelatin sponge as an adjuvant material in sinus augmentation procedures whenever immediate implant placement is planned; as it carries the advantages of being easy to place, is readily available and cost effective.

An insight into the impediments of our study –

- Histomorphometric analysis was not done to evaluate the quality of bone formed
- Small sample size and short term follow up
- Since long-term assessments are very important, especially after the installation of the prosthesis, further



research is warranted.

- Assessment of decrease in graft volume by radiographic means, through the analysis of mineralized tissue was not done.

Further studies with the same methodology, but with a longer-term evaluation period, are needed. Also studies with histomorphometric and immunohistochemical focus are necessary in

order to assess the efficacy of this material qualitatively.

Future research should concentrate on the following areas: volume of the sinus and its effect on the success of the grafting procedure and the implant; the use of mesenchymal stem cells for sinus augmentation; the effect of systemic diseases on the success of the augmentation procedure, grafting, and implants.

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