

EFFECT OF IMPLANT LENGTH ON OSSEOINTEGRATION IN MAXILLARY SINUS AUGMENTATION (CLINICAL AND RADIOGRAPHIC STUDY)

Abdel Badia A. Abdelmabood *, Mohammed A .El Sholakamy ** and Gehan G Eldswikey***

ABSTRACT

Purpose: The aim of the present study is to maximally increase the amount of bone graft and to correlate between the subantral implant length and the implant success rate, both clinically and radiographically.

Patients and Methods: The study was performed on twenty patients with mean age of 40 years who required implant therapy but suffered from decreased vertical bone height in the posterior maxilla. Each patient received one implant after a Caldwell Luc osteotomy. The patients were divided into two groups according to the length of the implant used. Panoramic and cone beam CT were used to evaluate the radiographic bone density while clinical assessment was used to evaluate implant stability at the successive follow ups.

Results: Results of the present study revealed that the success rate of implant osseointegration in maxillary sinus augmentation cases depends mainly on increasing graft dimensions and primary stability of implants.

Conclusion: The main parameters in sinus augmentation procedures were to increase the augmented implant length under the sinus membrane and above the maxillary sinus floor. Both bone quality with implant stability are the two dependent factor correlate positively with the implant length.

INTRODUCTION

Placement of implants in the maxillary posterior region is considered one of the significant clinical solutions to many edentulous patients nowadays, however, some complications may limit the completion of this procedure. Of these limitations is

inadequate alveolar bone height due to atrophy of the alveolar ridge and pneumatization of the maxillary sinus cavity, especially after a prolonged period of being edentulous. This physiological process leads to expansion in the size of the sinus further reducing the available alveolar bone height in this region ^(1,2).

* Lecturer of Oral and Maxillofacial Surgery, Faculty of Dentistry, Suez Canal University

** Associate Professor of Oral and Maxillofacial Surgery, Faculty of Dentistry, Suez Canal University

*** Professor of Oral Radiology, Faculty of Dentistry, Suez Canal University

To increase the bone height and width in the posterior maxilla to accommodate implant therapy, it is necessary to elevate the sinus membrane and insert bone graft under this membrane; a procedure referred to as sinus augmentation or lifting. Augmentation is then followed by implant insertion and is considered a routine procedure for these categories of patients ⁽³⁾.

Summers osteotomy or the axial approach to the maxillary sinus with simultaneous elevation of the sinus floor depends on the osteogenic features of Schneiderian membrane to develop bone around the implant tip. This process is considered less invasive since it does not involve surgical exposure of the sinus and aims to decrease the amount of graft around the simultaneous inserted implants ⁽⁴⁾.

Caldwell Luc operation is the first main surgical technique that facilitates direct vision for maxillary sinus augmentation, and at the same time, direct implant insertion in the posterior maxilla through lateral approach osteotomy ⁽⁵⁾.

Selection of the lateral approach using Caldwell operation or Summer osteotomy depends on the post extraction residual height of the alveolar ridge in the posterior maxilla. Although the axial approach is considered a more simple and less painful technique that saves waiting time till implant insertion, but has some limitations as sever alveolar atrophy and difficulty of insertion of multiple implants in this critical area. Caldwell operation on the other hand overcomes these limitations and introduces wider exposure of surgical area ⁽⁶⁾.

Recently, a third technique was introduced based on the principle of guided bone regeneration. Many researches revealed that a full sinus lift can be performed using the lateral approach with the introduction of blood being the sole graft material ^(7,8).

This approach depends on the implants being stabilized in the residual bone height and maintaining the Schneiderian membrane pushed in the highest

possible position using implant tips as stents used for support. This concept of bone regeneration leads to very natural bone reconstruction around implants. However, this technique requires a skilled surgeon since a perfect sinus membrane lifting without tears is necessary to maintain its osteogenic potential, in addition, filling the sinus cavity with a stabilized blood clot remains quite difficult to control⁽⁹⁾.

Ideally, grafting bone materials should be osteoinductive and osteoconductive for the success of the sinus augmentation procedure. Osteoinduction is a process of inducing osteogenesis through bone forming cells, while osteoconduction allow the newly formed bone particles to grow on the surface and down into the grafts. Various graft materials can be used in maxillary sinus augmentation such as autologous bone, allografts and xenograft bony substitute ⁽¹⁰⁾.

The use of autogenous bone is still considered the gold standard for maxillary sinus augmentation due to its excellent osteogenic potential ⁽¹¹⁾

The use of β -TCP bone grafting materials has been well documented in numerous clinical cases in implant dentistry, as well as in oral and maxillofacial surgery, and excellent success rates have been demonstrated⁽¹²⁾

β -TCP is currently regarded as a bone grafting material well suited for various clinical applications, such as maxillary sinus augmentation procedures. As the vascularization and the surface area of the sinus floor, from which osteoprogenitor cells can migrate and interact with the grafting material, are limited compared to other bone defects, there is a greater clinical need for this particular application to add a given amount of autogenous bone to the synthetic bone grafting material. Autogenous bone particles were added to the grafting materials to ensure a sufficient supply of osteogenic cells, such as osteoblasts, and osteoprogenitor cells. This addition sustains new bone formation and graft consolidation via the osteoprogenitor cells from

the sinus floor interacting with the material into the grafted area^(13,14)

β -tricalcium phosphate (β -TCP) is amply used for sinus augmentation there was study evaluated the clinical and osteogenic performance of β -TCP granules (TCP-G) and a β -TCP putty (TCP-P) bone graft material. TCP-P consisted of TCP-G in a hyaluronic acid (HyA) carrier. Cone-beam computed tomography was used to calculate the graft volume and its stability. Both materials allowed excellent bone regeneration and volume stability. TCP-P displayed better surgical handling properties⁽¹⁵⁾

The objective of the present study was to evaluate β -TCP used for sinus augmentation and to correlate between the subantral implant length and the success rates of osseointegration based on clinical and radiographic parameters.

PATIENTS AND METHODS

The present study was performed on 20 patients selected from the outpatient clinic of the Oral and Maxillofacial Department, Faculty of Dentistry, Suez Canal University, Ismailia, Egypt, between years 2014 to 2016. The patients' age ranged from 35 to 45 years with average age 40 years.

Patient selection and grouping:

All the patients included in the present study required implant therapy in the posterior maxillary region after unilateral extraction of premolars or molars. They were selected according to the following *inclusion criteria*: systemically healthy patients, bone quality type two, and required sinus lifting procedure since the vertical bone height in the proposed implant site ranged between 4 to 6.5 mm as revealed by preoperative radiographic measurements.

On the other hand, the *exclusion criteria* included any systemic disorders that interfered with the surgical procedures or healing such as bone

diseases or uncontrolled diabetes, heavy smoking patients who consumed more than 10 cigarettes per day, and patients suffering from chronic/acute sinusitis or any infection from the ear or throat (patients consulted an ENT specialist prior to the surgical procedure).

Patients included in the present study were divided into two groups according to the length of the received implant:

Group I: Included ten patients who received sinus augmentation surgery with simultaneous insertion of a single implant with diameter 4 mm and length 8 mm. Residual bone height of patients ranged from 4 - 5 mm.

Group II: Included ten patients who received sinus augmentation surgery with simultaneous insertion of a single implant with diameter 4 mm and length 12 mm. Residual bone height of patients ranged from 5 - 6.5 mm.

Preoperative patient assessment:

Preoperative digital panoramic radiographs were taken for patients to determine if they required sinus augmentation procedure, using ORTHOPHOS XG 5 DS/Ceph panoramic machine (Sirona Dental systems, Germany). Patients who met the inclusion criteria were subjected to cone beam computed tomography (CBCT) scans using SCANORA 3D imaging system (Soredex, Helsinki, Finland) to accurately assess the alveolar bone height, width of the ridge and quality of bone in addition to sinus anatomy and absence of sinus pathology.

The CBCT x-ray tube used to scan all the patients has a current intensity 16 mA, kilo voltage 85Kvp and a focal spot size 0.5mm. The scanning time was 10 seconds of pulsed exposure resulting in an effective exposure time of 3 seconds to scan FOV of 7cm height \times 10cm width \times 10 cm depth.

A preoperative written consent was obtained from every participant in the present study explaining the details of the radiographic and surgical procedure

including prognosis, rehabilitation of implants and possible complications. The participants were instructed to limit smoking, to avoid any future hazards jeopardizing the sinus lift technique or the implant stability.

Dentium implant system

Dentium implant system was used in the present study were of fixed diameter of 4 mm while the implant length was the changing variable in our study, where 8 mm length was used for group I and 12 mm length was used for group II. After implant insertion, the radiographic length of the implant as assessed by CBCT and the length of the implant was divided into:

L1: Describing the subantral implant length under maxillary sinus floor.

L2: Describing the implant length under the sinus membrane and above the maxillary sinus floor which is the length to be augmented with Beta tricalcium phosphate as the sinus grafted material.

The surgical procedure:

All the study participants received antibiotic coverage including 2 g of Amoxicillin trihydrate in combination with Clavulanate potassium or 600 mg of clindamycin 30 minutes prior to the surgery.

The surgery was done under local anaesthesia (2% Lidocaine and 1:100,000 epinephrine) as a full thickness buccal incision (Caldwell Luc osteotomy) was performed with one or two oblique incisions to facilitate the reflection of the mucosa.

After elevation of the designed flap, access to the buccal bone window wall of the sinus was approached as (Fig 1). A 5 mm buccal window was obtained using a large round stone with special care to avoid perforation of the sinus membrane. Continuous irrigation with saline was maintained throughout the osteotomy procedure. Once the membrane was exposed, it was dissected from the sinus wall and from the sinus floor by blunt edge retractors.

After sinus membrane lifting or elevation and testing for absence of perforations as (Fig 2), all implants of the Dentium system were secured by obtaining primary stability through preparing the osteotomy site smaller than the demonstrated via the Dentium Implant system. In this stage the implant inserted simultaneously to be withdraw in the prepared osteotomy . To be able to place and condense the graft material around the implant through the lateral sinus aspect and to asses L1 , L2 at this stage. The sinus compartments around the implant and under the sinus membrane were augmented completely by the selected graft material.



Fig (1) Buccal bone window wall of the sinus was approached

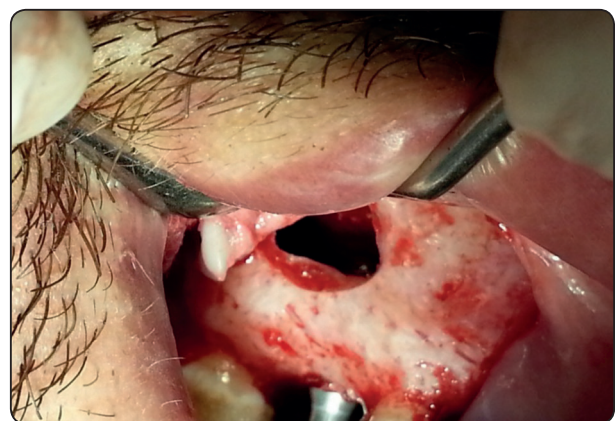


Fig. (2) Sinus membrane lifting or elevation and implant inseration

After complete implant insertion, packing of the graft β -tricalcium Phosphate powder pack was opened and placed within the augmented sinus cavity (**Fig.3**). The granule size of the used material ranging from 500 to 1000 μ m.

After testing for absence of perforations, the flap was repositioned and the incisions were closed with tension free closure using Vicryl resorbable sutures.

Postoperative instructions and follow up:

Participants were instructed to avoid positive blowing to prevent any sinus pressure and complications, avoid smoking on the day of the operation and for another two days after the operation and maintain adequate oral hygiene measures. Antibiotic coverage and analgesia were administered postoperatively for at least 7 days (300 mg clindamycin three times daily and ibuprofen as analgesics, nasal decongestant to decrease the nasal secretions).

Postoperative digital panoramic radiographs were taken immediately as in (**Fig 4**) following the operation to assess implant position. Patients returned after one week for suture removal and clinical evaluation of the operation. The patients returned after three and six months for clinical follow-up and CBCT scans to assess the healing of the implant and evaluate L1, L2 and the bone density around the implants as in (**Fig 5**). The DICOM data set images obtained from cone beam computed tomography were imported to the software (On Demand 3D software – Cybermed- Korea) for secondary reconstruction. Linear measurements were drawn from the sagittal images of the sinus and the bone density was measured using built-in tools as in (**Fig 6**).

The clinical parameters used to assess the surgical procedure and the osseointegration were implant stability (using OSSTEL device), infection, persistence of pain, presence of swelling, sinus perforations, nasal bleeding and/or implant mobility denoting failure of implants.



Fig (3) Packing of the β -tricalcium Phosphate within the augmented sinus cavity



Fig (4) Immediate postoperative digital radiographs

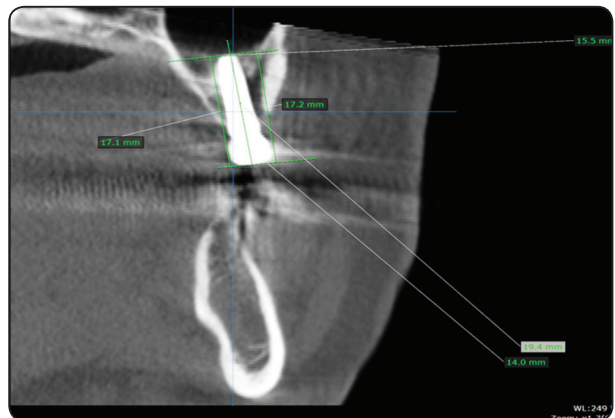


Fig (5) CBCT scans to assess L1, L2 of inserted implants.

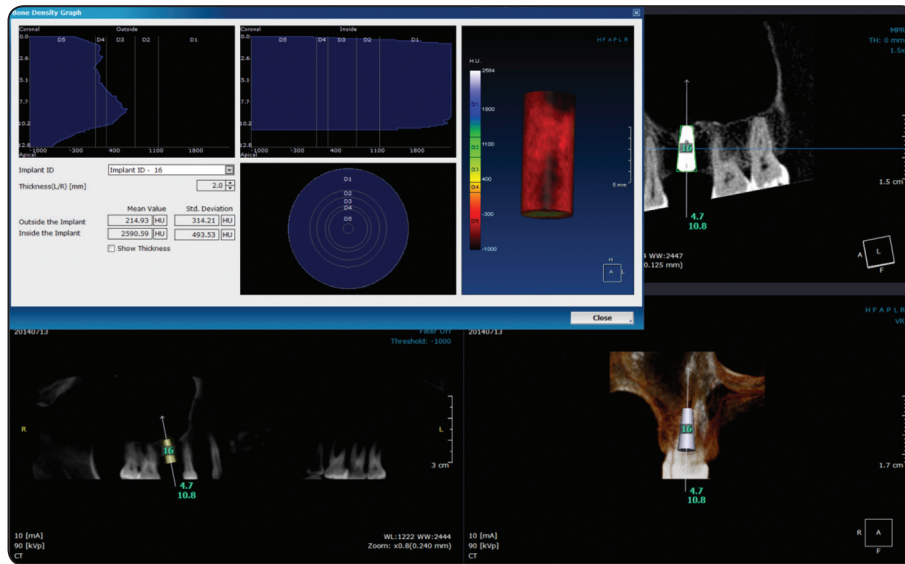


Fig (6) CBCT scans to evaluate the bone density around the implants .

Statistical analysis

Statistical analysis was conducted for quantitative data of the present study. Descriptive measures including mean, standard deviation, standard error, minimum and maximum values were calculated for all variables, followed by independent t-test for testing the significant differences between means of the two groups.

Association and relationship between most of variables were incorporated using Pearson's product moment correlation coefficients (PCC) according to Snedecor and Cochran, 1989⁽¹⁶⁾. Data were analyzed using commercially available softwares such as SAS system for windows, 2005, release 9.1.3 and SPSS version 20, 2006^(17,18). Results were considered significant at probability level < 0.05 .

RESULTS

Quantitative parameters under comparison between the two study groups are represented in table (1) as radiographic linear values (L1 and L2) and density values while implant stability was represented as Ostell readings. There was a significant difference ($P < 0.05$) for all quantitative parameters between group I and group II.

Two implants in group II were associated with acute sinusitis and these two implants after administration of antibiotics and nasal decongestant, there was a degree of infection resolution and tenderness at the area of surgery.

All the implants in the two groups were osseointegrated and according to the follow up time there was a positive correlations between the implant length and the radiographic parameters including the implant stability and bone density as explained in table (1)

TABLE (1) Descriptive statistics (mean, SD, SE, minimum and maximum values) for the two studied groups:

Group	Quantitative Parameters	Mean ^a	SD	SE	Minimum	Maximum
Group I	L1	5.04	0.427	0.135	4.60	5.90
	L2	2.96	0.427	0.135	2.10	3.40
	Bone density (3 months)	343.04	83.69	26.47	243.0	503.0
	Bone density (6 months)	446.78	125.90	39.81	291.1	623.0
	Implant stability (baseline)	62.64	2.78	0.879	56.0	65.1
	Implant stability (3 months)	63.75	2.06	0.650	60.10	66.20
	Implant stability (6 months)	65.23	3.03	0.959	60.30	70.0
Group II	L1	6.21	0.268	0.085	5.60	6.60
	L2	5.79	0.268	0.085	5.40	6.40
	Bone density (3 months)	464.50	70.89	22.42	362.0	562.0
	Bone density (6 months)	616.60	77.72	24.58	463.0	696.0
	Implant stability (baseline)	65.79	2.583	0.817	60.90	69.60
	Implant stability (3 months)	67.14	2.656	0.840	62.0	70.20
	Implant stability (6 months)	70.80	2.358	0.745	67.0	74.0

Group I: Augmented sinuses with inserted implant length 4×8 mm in posterior maxilla including ten patients.

Group II: Augmented Sinus with inserted implant length 4×12 mm in posterior maxilla, including ten patients.

SD: Standard deviation.

SE: Standard error of mean.

L1: The subantral implant length under maxillary sinus floor.

L2: Implant length under the sinus membrane and above the maxillary sinus floor which is the length to be augmented.

a: Independent t-test revealed significant differences ($P < 0.05$) for all quantitative parameters between group I and group II.

TABLE (2) Relationships and correlation coefficients between all studied parameters within group I and within group II in the following correlation matrix.

	L1	L2	BD_3 mon.	BD_6 mon.	Stability_B	Stability_3	Stability_6
L1		- 1.0**	0.00	0.116	- 0.236	- 0.253	- 0.076
L2	- 1.0**		0.00	- 0.112	0.236	0.253	0.076
BD_3 mon.	- 0.104	0.104		0.839**	- 0.052	- 0.174	0.463
BD_6 mon.	0.247	- 0.247	0.722*		0.151	0.038	0.484
Stability_B	- 0.314	0.314	- 0.406	- 0.130		0.942**	0.659*
Stability_3	- 0.379	0.379	- 0.470	- 0.306	0.937**		0.588
Stability_6	- 0.077	0.077	-0.666*	- 0.487	0.508	0.720*	

Correlation coefficient is considered high if > 0.70

*: Correlation is significant at 0.05 level ($P < 0.05$).

** : Correlation is significant at 0.01 level ($P < 0.01$).

Positive correlations imply the positive relationship between the two variables.

Negative correlations imply the inverse or negative relationship between the two variables. Zero correlation between any two variables suggests no association between these variables. In other words, a change in one variable is not followed by a change in the other.

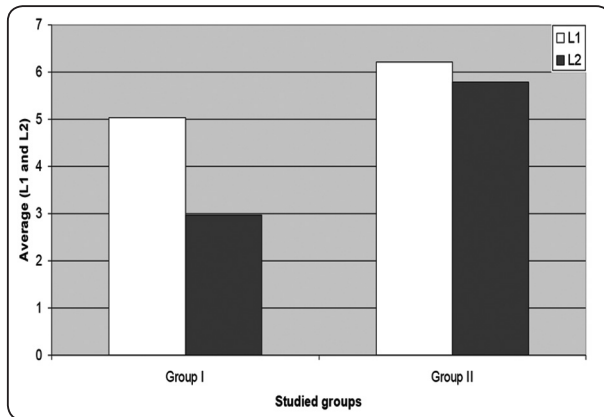


Fig. (7) Diagram of average length of L1 and L2 in two studied groups.

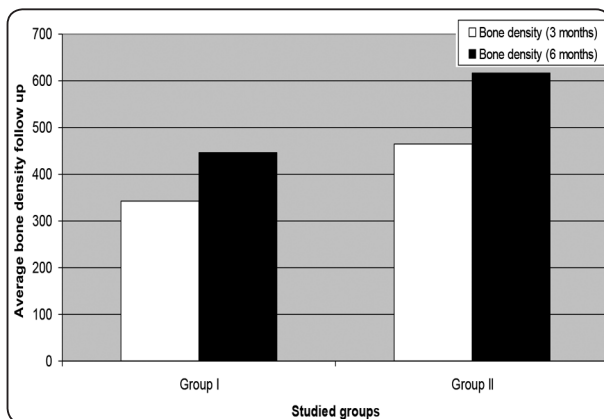


Fig. (8) Diagram of average bone density follow up two studied groups.

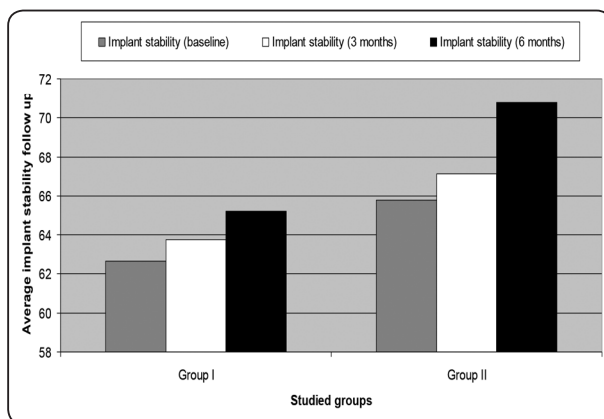


Fig. (9) Average implant stability follow up two studied groups.

DISCUSSION

The present study was performed on 20 patients with atrophic maxillary posterior alveolar bone and high volume of the maxillary sinus as result of increased pneumatization process. The main goal of the study was to evaluate the effect of implant length on success rate of osseointegration with sinus augmentation. The patients were classified into two groups, group I of implant length 8 mm and group II of 12 mm.

This study was done to evaluate these categories of patients with sinus augmentation by using B tricalcium phosphate and this as explained by others studies in the past few years, researchers with application of organic and inorganic materials for sinus augmentation such as demineralized freeze-dried bone allograft, xenogeny bone graft, bone morphogenic protein, and mixtures of them (19,20)

The results of the research demonstrated that increase the implant stability at the ends stage of follow up for the group II to be of (SD 70.8) to be highly increased than those of group I (SD 65.23). Bone density of the group II were within mean of 616.6 at the end follow up time to be more than those in group I of mean range 446.7. And by correlates these radiographic parameters with the implant length it was found that L2 for group II was 5.7 mm than those in group I about 2.9mm.

Bone quality, a host-related factor, is believed to be the strongest predictor of the outcome of immediate implant loading (2). It has been reported that most of the immediate loading implants are placed in anatomical sites with bone quality D1 or D2. It is well known that the mandible (especially the inter-foraminal region) has better bone quality than the maxilla, and this is probably the reason why several reports are available regarding immediate implants inserted in the mandible with a high success rates (21,22)

According to a study performed Zijdeveld et al(20) according to the study that were focused on

the effect of autogenous chin graft compared with B tricalcium phosphate in sinus floor augmentation and found a mean of 17% new bone formation after 6 months. They concluded no statistically significant difference between implant success rate in both test and control groups. And this to be explained that the effect of B tricalcium phosphates that used pure graft material in our study inspect of our study missed the side of core biopsy we recommended it to be in further studies.

Many studies⁽²³⁻²⁵⁾ discussed the relevance of using a biomaterial during a sinus lift to reconstruct a significant bone volume for implantation or at least maintain space for bone regeneration. The sinus cavity shows a high osteogenic potential and is a very strong model of an osteogenic chamber for bone regeneration.

Implant placement performed with sinus augmentation and bone graft material have many different variables that can be responsible to the survival and the failure rates such as the bone graft material, grafted bone volume, residual bone volume, implants surface and design, patients' age, smoking habits, bone graft and implant healing time etc⁽²⁶⁾.

In this study we compared the effect of implant augmented length as effect on the bone formation around the implant after sinus lifting procedure using lateral approach technique. Lateral approach to the sinus was the selected one to facilitate the surgical procedure. The grafted β -TCP material was be packed around the implant and complete seal the sinus augmented cavity. Another study was similar in the lateral sinus approach was performed to treat a total of 8 patients with extended large size OAF. In this study OAF were closed with the buccal advancement flaps but the augmented graft were the outogenous mandibular grafts⁽²⁷⁾

Migration and differentiation of osteogenic cells into osteoblasts are necessary for bone formation and the most important factor is the closed

compartment with the blood clot underneath the Schneiderian membrane to provide a possibility for bone formation. The implant also helps to keep the Schneiderian membrane from collapsing⁽²⁸⁾.

In this study we used the CBCT to detect the bone density around the implant after 3 and 6 months and the results were very significant in the two groups which with implant length 12 mm of group II.

Degidi et al⁽²⁹⁾ in 2007 explained that longer implants (length >13 mm) have higher success rates than standard implants (length = 13mm). Some researches focus on long implants and none specifically address the clinical outcome of immediate loading of longer implants. This study was performed to compare between two different implant length and were attended to increase the sub antral implant length in most of cases. The clinical and radiographic outcomes of long implants were be of highly benefits than those with group I of short implants.

OPG was used immediate postoperative to check the position and the angulations of the implant, we did not use the immediate CBCT postoperative because it was to give false values about the density. In the current study also OSSTELL was used to detect the stability of the implants in group I and group II and the results showed that the group I was very significant after six months while group I was less significant. The method presented in the current study for processing the CBCT data sets and determining the graft volume, implant. Moreover, the computational procedure developed in this study enabled, in a reproducible manner, determining the volume of the grafted area in the anatomical situation present clinically. TCP-G and TCP-P had different volume graft reductions within a same patient. This is of great clinical importance as the insertion of implants of a specific length requires a minimal volume for a successful anchorage and stability. Volume graft reductions proved to be statistically significant. Due to safety and ethical

considerations regarding the amount of radiation exposure for the patient, it was only possible to acquire one CBCT at a single time point, *i.e.*, three and six months after the sinus augmentation. This is in agreement with different studies that demonstrated that it was not possible to assess the shrinkage of the graft volume occurring at early stages within the first postoperative days and to differentiate that occurring due to the bone regeneration and to the graft resorption. The β -TCP with smaller grain size present in the TCP-P may have had a positive effect on damping the graft shrinkage as these particles are packed in a more dense way when introduced into the sinus floor^(30,31)

Postoperative healing was uneventful in the follow up of the cases except some nasal bleeding in some cases and minimal swelling was observed. Clinical and radiographic assessment showed that all implants were successfully osseointegrated, with no reported complications after the end of follow up to in similar with the study performed by Emam et al⁽³²⁾.

Our study was concentrated on B-TCP and there was another study utilized of meta-analysis was to compare the histological outcomes of deproteinized bovine bone (natural calcium phosphate) and technically derived calcium phosphate, two commonly used materials for sinus augmentation and maxillary dental implants. Although the results suggested that calcium phosphate was associated with a greater percentage of new bone formation, but high percentage of bone formation with B-TCP⁽³³⁾.

Our study depend on utilization of and this was agreement of recent authors as they consider B-TCP is one of alloplastic material which were rapidly resorbed. This differs from hydroxy-apatite, which has a low or absent resorption capacity.36 chronOS granules range in size from 0.5 mm to 0.7 mm and have 60% porosity. Many researchers consider the autogenous bone graft to be the most favourable for bone reconstruction⁽³⁴⁾.

CONCLUSIONS

The main parameters in sinus augmentation procedures were to increase the augmented implant length under the sinus membrane and above the maxillary sinus floor. Both bone quality with implant stability are the two dependent factors that correlate positively with the implant length.

Competing interests

None declared.

Patient consent

Consent was obtained; none of the pictures submitted can be used for patient identification.

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