Stability and Osteointegration of Short Implants Versus Long Ones in Poor Residual Bone Height in Posterior Maxilla with and without Sinus Elevation

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Abstract

The aim of this study is testing the hypothesis that short implants might satisfy the desired outcomes of a successful implant therapy as longer implants in atrophied jaws.

This present study was conducted on 21 patients with limited bone height below the floor of the maxillary sinus. Group I, 7 patients received short implants. Group II, 7 patients received long implants in combination with crestal sinus approach technique without the use of augmentation material. Group III, 7 patients received long implants in combination with crestal sinus approach technique with the use of augmentation material. The patients were evaluated for implant stability, pocket depth and keratinized mucosa marginal bone loss (MBL), endo sinus bone gain and bone density (BD).

Regarding pocket depth, keratinized mucosa width and implant stability at 7 months result showed no reliable difference between all groups. Radiographically by CBCT, no significant difference in MBL and bone density between all groups immediately after surgery and at 12 months post operatively. However significant difference in endo sinus bone gain was found between group II and III.

Short implant placement is an effective alternative option to long implant placement with maxillary sinus augmentation.

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Introduction

Dental Implants have become one of the most exciting and rapidly developing topics in dental practice. They offer a suitable alternative treatment to conventional prosthodontics.[1]

Poor residual bone height (RBH) in the posterior maxilla beneath the sinus is still a challenge for the oral implantologist. To recreate a sufficient volume of bone, various surgical procedures have been developed over the years.

Summers introduced the OSFE method, which is less invasive, less time-consuming, and minimizes the patient's post-operative suffering.[2-5]

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The procedure consists of using osteotomes through a crestal approach with elevating the Schneiderian membrane and placing simultaneously the bone grafting material and the implant. After a healing period of 3–6 months, implants are osseointegrated and implant apex become surrounded with bone.[6]

The need of inserting grafting material under the raised sinus membrane is questioned. Without any grafting material, regeneration of intra-sinus bone volume can occur around implants placed in sinus. Regenerated bone was obtained using sinus lift or OSFE.[7-11] By raising the schneiderian membrane, a compartment is produced, which is then filled with a blood clot that acts as a matrix for bone regeneration.[12]

The use of cone beam computed tomography (CBCT) has significantly eased proper implant placement in correct positions.[13]

CBCT allows the examination of images obtained from the craniofacial region in multi-axial (axial, sagittal, coronal) directions without creating growth or deviation from reality.[14]

The design of an implant impacts its main stability and its capacity to withstand loads during or after osseointegration. Osseointegration is a sequential four phases of wound healing process which includes hemostasis, inflammatory phase, proliferative phase, and remodeling phase. The hemostasis occurs within minutes to hours, inflammatory phase in hours to days, proliferative phase in days to weeks, and the remodeling phase in about 3 weeks and even years.[15]

Resonance frequency analysis (RFA) is one of the most widely used instruments created to quantitatively quantify the implant-bone interface stability.[16]

The primary objective of this study is to Compare initial stability and osseointegration of short implants versus long implants with sinus elevation with and without grafting.

The aim of this study is: Testing the hypothesis that short implants might satisfy the desired outcomes of a successful implant therapy as longer implants in atrophied jaws.

Materials and methods

Study design and Patient selection

A randomized controlled clinical study was performed upon patients attending the outpatient clinic of Oral Medicine, Periodontology, Oral Diagnosis and Radiology department, Faculty of Dentistry, Tanta University. Each patient had edentulous post maxilla.

Inclusion criteria: The patient in need of posterior maxillary implant therapy, The remaining subantral alveolar bone height must be at least 7 mm, All implants had the same diameter 4.5 mm., The shorter implant measured 7 mm in length, whereas the longer implant measured 10 mm, The bone density of the remaining alveolar ridge varied between D3 and D4.

The exclusion requirements: hemorrhagic disorders, uncontrolled diabetes, and other factors that might impair wound healing processes., Use of immunosuppressive medication., Head and neck irradiation history., Evidence of chronic or acute sinusitis., Presence of tumor or cyst in maxillary sinus., Drug abuse or alcohol., Heavy smoking.

Study design: The Patients in this study were separated into three groups.

- ***Group I:*** *(*seven patients) short implants without crestal sinus approach technique and without augmentation material (Control group).
- ***Group II:*** (seven patients) long implants with crestal sinus approach without the use of augmentation material (Test group1).
- ***Group III:*** **(**seven patients) long implants with crestal sinus approach with the use of augmentation material (Test group2).

Materials:

A. Implant fixture: Twenty-one MegaGen (AnyRidge®[1]) with progressive thread

B. Implant armamentarium: AnyRidge ®surgical kit (full type), MICA Kit (MegaGen implant crestal approach kit)

C. Bone graft type: Hypro-Oss®[2] is a natural bovine bone substitute material.

Preoperative Evaluation

I- History: Personal information (name, age, sex, etc.), past medical and dental history were evaluated.

II- Preoperative planning

1. All patients were given oral hygiene instructions and have their teeth scaled and root planed, Measurement of keratinized mucosa width, Diagnostic study models were made to produce a surgical template for directing the location of implant fixtures.[17]

(CBCT) was performed preoperatively to confirm the bone height and assess the density of the surgical region, as well as to identify any abnormalities in the sinus.

III-Surgical technique

Preoperative bone height underneath the sinus was measured.

- **Group 1**, AnyRidge® surgical kit was used for insertion of short implants following standard conventional drilling method with sequence of burs according to manufacturer's instructions.
- **Group 2,** MICA kit was used.

a) A point trephine bur 3540 was used to drill until laser marking is reached.
b) ASPE trephine bur 3540 was used to drill until 1-2 m of bone is left.
c) mushroom depth gauge was used to measure residual bone height.
d) The express bur 3.4 was adjusted 0.7-1mm smaller in size than the diameter of the fixture and the position of the stopper was adjusted

to 1mm longer than the remaining bone height until approach the sinus.

e) The mushroom and the cobra were used to lift the membrane through the hole.

f) The implant fixture was placed and sinus membrane was elevated and maintained by the implant apex.

– **Group3,** same as group 2 but after sinus floor elevation with mushroom and cobra instrument.

a) The spreader was used to carry harvested bone and Hypro-Oss bone graft.

b) The stopper of condenser was adjusted and bone was condensed after that implant fixture was inserted in osteotomy site.

All groups underwent resonance frequency analysis shortly after implant implantation using the Osstell Mentor and Smartpeg to evaluate implant stability. During the surgical operation (time 1) and seven months (time 2) following surgery, the ISQ values were assessed.

III) Post-operative care:

All individuals received instructions, which included washing with 0.1% chlorhexidine A combination of antibiotics, metronidazole 250 mg pills and amoxicillin/clavulanate 375 mg tablets, were administered for three days Following 14 days, the sutures were removed.

IV) Prosthetic phase:

After 6 months the healing cap was placed for all. The ISQ values was measured at 7months from surgery (time 2) after that, the abutment and crown were inserted.

V) Evaluation phase:

1. Clinical assessment:

***Patients were examined clinically postoperatively for the following criteria:**

a) Probing depth according to Salvi and Lang, 2004[18], keratinized mucosa width[19] ,Implant stability by using Osstell® device immediately after implant insertion and at 7 months from surgery by means of Implant Stability Quotient (ISQ).

Survival were evaluated after 1 year from insertion according to Cochran e*t al., 2002*.[20]

Criteria of implant success was included the following:

- Absence of pain and foreign body sensation, absence of mobility, absence of peri-implant infection accompanied by pus discharge, absence of recession.

2. Radiographical evaluation:

CBCT was conducted on all patients in all groups immediately following surgery and 12 months post-operatively to evaluate:

1) Marginal bone level around implant, endosinus bone, mean bone density was measured in HU before starting treatment plan, immediately after surgery and at 12 months post operatively.
2) Cone beam images were analyzed using Simplant program.

Statistical analysis: Using the SPSS software statistical computer program, the gathered data were organized, tabulated, and statistically evaluated. Range, mean, and standard deviation were computed for each variable.

Results

1.Clinical assessment:

A) Probing depth

- ***At 7 and 12 months***

The mean probing depth at 7 months in Group I was 2.32 ± 0.18, 2.57 ± 0.40 in group II and 2.46 ± 0.17 in group III and at 12 months in Group I was 2.35 ± 0.13, 2.60 ± 0.37 in group II and 2.5±0.14 in group III. there was no statistically significant variation in the mean probing depth between groups at 7 and 12 months.

B) Keratinized mucosa width

- ***Before implant placement, at 7 and 12 months***

The mean keratinized mucosa width before implant placement in Group I was 3.28 ±1.11, 3.42 ±1.13 in group II and 3±0.816 in group III and at 7 months in Group I was 3.42±0.97, 3.57±0.97 in group II and 3.14±0.69 in group III and at 12 months in Group was 3.14±1.06, 3.28±1.11 in group II and 2.85± 0.69 in group III. there was no statistically significant variation in the mean keratinized mucosa width between groups before implant placement, at 7 and 12 months.

C) Implant stability

- ***Immediately after implantation***

The mean stability immediately after implant placement in Group I was 69.28 ± 2.69, 63.57 ± 2.63 in group II and 65.14 ± 1.34 in group III. there was no statistically significant variation between group II and group III. However, a statistically significant difference was noted between group I and group II, also between group I and group III.

- ***at 7 months***

The mean stability at 7 months in Group I was 72.57± 3.20, 69.85 ± 2.34 in group II and71.85 ± 2.54 in group III. there was no statistically significant variation between groups. (Fig. 1,2,3,4,5,6)

Groups	Mean±SD	t	p-value
at 7 months			
GI	2.32 ± 0.18	1.50	0.15 ns
GII	2.57 ± 0.40		
GI	2.32 ± 0.18	1.49	0.16 ns
GIII	2.46 ± 0.17		
GII	2.57 ± 0.40	0.66	0.51 ns
GIII	2.46 ± 0.17		
at 12 months			
GI	2.35 ± 0.13	1.68	0.11 ns
GII	2.60 ± 0.37		
GI	2.35 ± 0.13	2.07	0.06 ns
GIII	2.50 ± 0.14		
GII	2.60 ± 0.37	0.66	0.51 ns
GIII	2.50 ± 0.14		

Table 1. Showing the Mean±SD of probing depth and t values at 7 and 12 months for all groups.
Significance: p*<0.05, p**<0.01, p***<0.001; ns=not significance; SD = standard deviation.

Groups	Mean±SD	t	p-value
before implant placement			
GI	3.28±1.11	0.23	0.81 ns
GII	3.42±1.13		
GI	3.28±1.11	0.53	0.59 ns
GIII	3±0.81		
GII	3.42±1.13	0.79	0.43 ns
GIII	3±0.81		
at 7 months			
GI	3.42±0.97	0.28	0.77 ns
GII	3.57±0.97		
GI	3.42±0.97	0.62	0.54 ns
GIII	3.14±0.69		
GII	3.57±0.97	0.95	0.35 ns
GIII	3.14±0.69		
at 12 months			
GI	3.14±1.06	0.24	0.81 ns
GII	3.28±1.11		
GI	3.14±1.06	0.60	0.55 ns
GIII	2.85± 0.69		
GII	3.28±1.11	0.87	0.40 ns
GIII	2.85± 0.69		

Table 2. Showing the Mean±SD of keratinized mucosa width and t values before implant placement , at 7months and at 12 months for all groups.
Significance: p*<0.05, p**<0.01, p***<0.001; ns=not significance; SD = standard deviation.

Groups	Mean±SD	t	p-value
Immediately after implantation			
GI	69.28 ± 2.69	4.01	0.001***
GII	63.57 ± 2.63		
GI	69.28 ± 2.69	3.64	0.003**
GIII	65.14 ± 1.34		
GII	63.57 ± 2.63	1.40	0.18 ns
GIII	65.14 ± 1.34		
at 7 months			
GI	72.57± 3.20	1.81	0.09 ns
GII	69.85 ± 2.34		
GI	72.57± 3.20	0.46	0.64 ns
GIII	71.85 ± 2.54		
GII	69.85 ± 2.34	1.53	0.15 ns
GIII	71.85 ± 2.54		

Table 3. Showing the Mean±SD of stability immediately after implant placement and t values and at 7 months for all groups.
Significance: p*<0.05, p**<0.01, p***<0.001; ns=not significance; SD = standard deviation.

Groups	Mean±SD	t	p-value
Immediate after implant placement			
GI	1.26 ± 0.30	1.89	0.08 ns
GII	1.51 ± 0.18		
GI	1.26 ± 0.30	1.30	0.21 ns
GIII	1.45 ± 0.24		
GII	1.51 ± 0.18	0.52	0.60 ns
GIII	1.45 ± 0.24		
at 12 months			
GI	1.25 ± 0.14	1.78	0.10 ns
GII	1.42 ± 0.21		
GI	1.25 ± 0.14	1.13	0.28 ns
GIII	1.38 ± 0.27		
GII	1.42 ± 0.21	0.30	0.76 ns
GIII	1.38 ± 0.27		

Table 4. Showing the Mean±SD of marginal bone level around implant and t values immediately after implant placement and at 12 months for all groups.
Significance: p*<0.05, p**<0.01, p***<0.001; ns=not significance; SD = standard deviation.

Groups	Mean±SD	t	p-value
Immediately after implantation			
GII	1.33±0.56	2.61	0.02**
GIII	2.06±0.48		
at 12 months.			
GII	1.39±0.59	2.38	0.03**
GIII	2.11±0.54		

Table 5. Showing the Mean±SD of endo-sinus bone and t value immediately and at 12 months in group II and III.
Significance: p*<0.05, p**<0.01, p***<0.001; ns=not significance; SD = standard deviation.

Groups	Mean±SD	t	p-value
at baseline			
GI	281.63 ± 103.51	0.85	0.40 ns
GII	246.19 ± 34.73		
GI	281.63 ± 103.51	0.40	0.69 ns
GIII	265.48 ± 25.17		
GII	246.19 ± 34.73	0.40	0.69 ns
GIII	265.48 ± 25.17		
immediately after implant placement			
GI	420.28 ± 92.59	0.33	0.74 ns
GII	407.44 ± 42.61		
GI	420.28 ± 92.59	0.11	0.91 ns
GIII	415.90 ± 49.29		
GII	407.44 ± 42.61	0.34	0.73 ns
GIII	415.90 ± 49.29		
at 12 months			
GI	643.44 ± 92.00	0.81	0.43 ns
GII	592.58 ± 137.89		
GI	643.44 ± 92.00	0.99	0.34 ns
GIII	596.62± 84.36		
GII	592.58 ± 137.89	0.06	0.94 ns
GIII	596.62± 84.36		

Table 6. Showing the Mean±SD of bone density and t values at baseline for all groups.
Significance: p*<0.05, p**<0.01, p***<0.001; ns=not significance; SD = standard deviation.

The implant survival after 1 year from insertion

The implants survival rate was 100% after 1 year from insertion with absence of pain, foreign body sensation, peri-implant infection and recession in group I, group II, and group III.

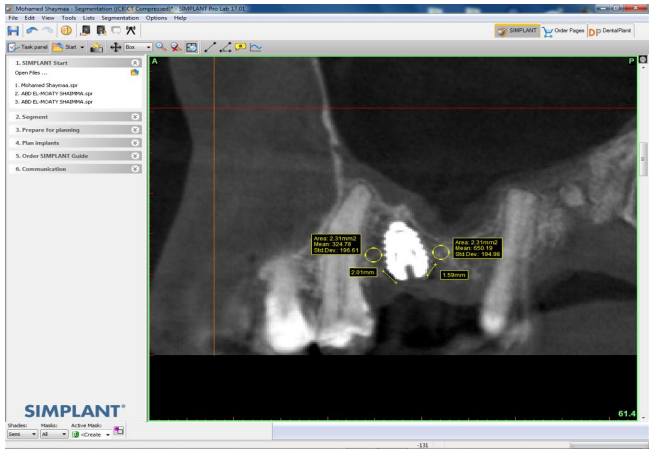

Figure 1. Marginal bone level and bone density in HU immediately after surgery (Sagittal view).

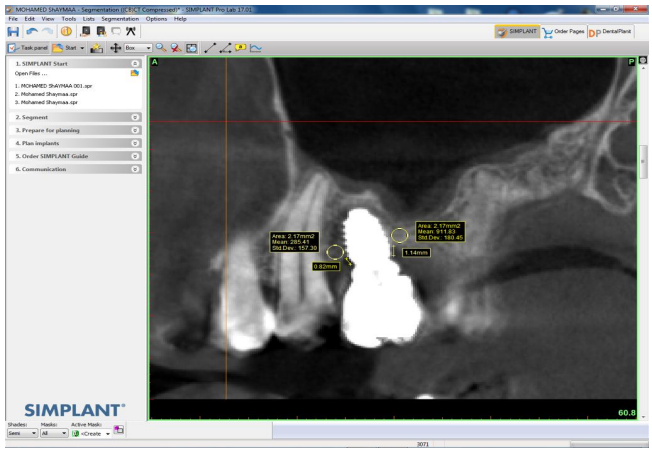

Figure 2. Marginal bone level and bone density in HU at 12 months (Sagittal view).

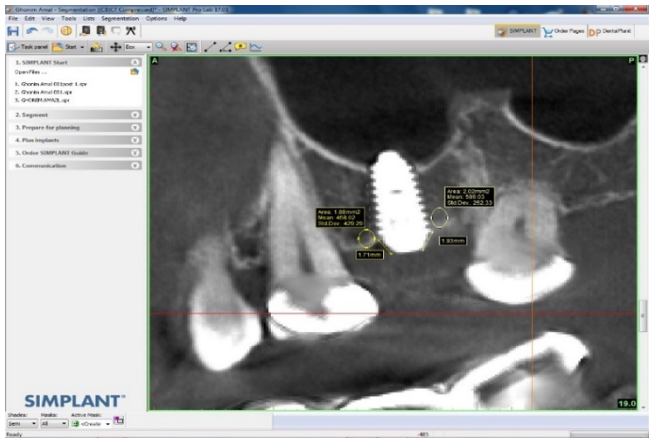

Figure 3. Marginal bone level and bone density in HU immediately after surgery (Sagittal view).

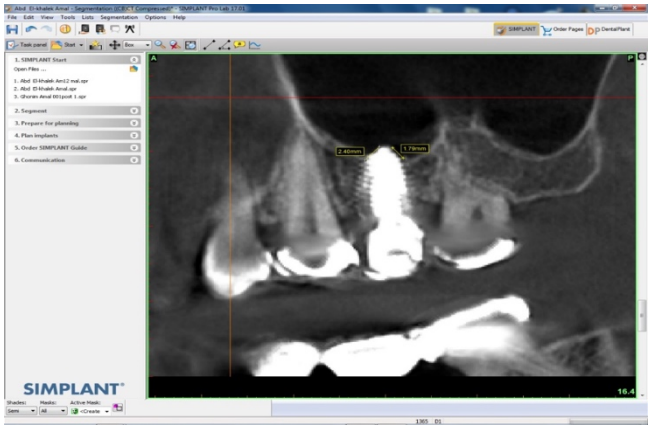

Figure 4. Endo-sinus bone level at 12 months (Sagittal view).

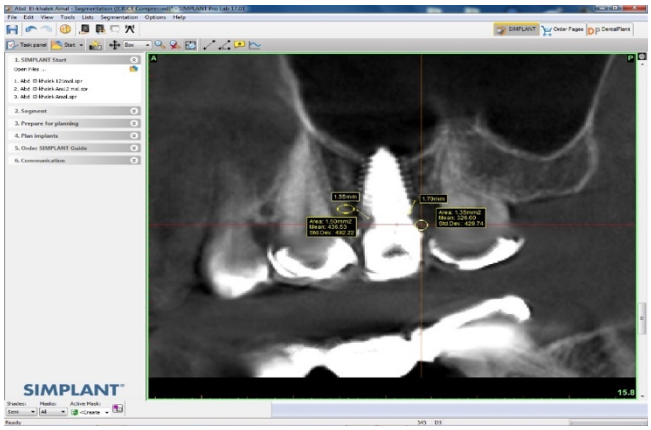

Figure 5. Marginal bone level and bone density in HU at 12 months (Sagittal view).

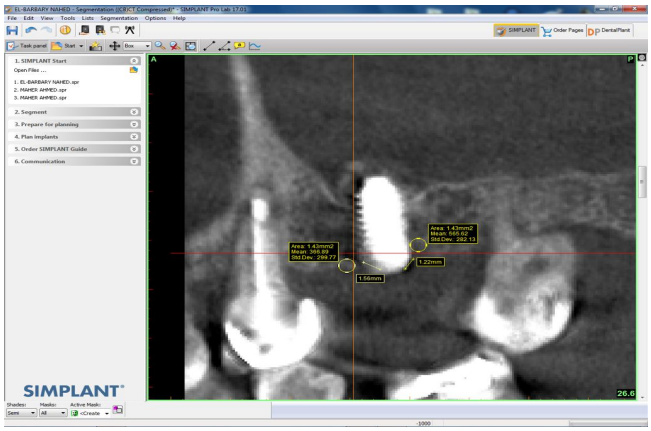

Figure 6. Marginal bone level and bone density in HU immediately after surgery (Sagittal view).

2.Radiographical evaluation:

A) Marginal bone level around implant

- ***Immediate and at 12 months***

The mean marginal bone level around implant immediately in Group I (fig. 1) was 1.26 ± 0.30, 1.51± 0.18 in group II (fig. 3) and 1.45±0.24 in group III (fig. 6) and at 12 months in Group I (fig. 2) was 1.25± 0.14, 1.42 ± 0.21 in group II (fig. 5) and 1.38± 0.27 in group III (fig. 8). there was no statistically significant variation between groups.

B) Bone level change mainly endo-sinus bone

- ***Immediately after implantation and at 12 months***

The mean bone level change mainly endo-sinus bone Immediately after implantation in Group II was 1.33±0.56 and 2.06±0.48 in group III and at 12 months in Group II (fig. 4) was 1.39±0.59 and 2.11±0.54 in group III (fig. 7). There was statistically significant variation between 2 test groups.

C) Density of bone

- Base line, Immediate and at 12 months

The mean bone density at baseline before implant placement in Group I was 281.63 ± 103.51, 246.19 ± 34.73 in group II and 265.48 ± 25.17 in group III, immediately after implant placement in Group I was 420.28 ± 92.59, 407.44 ± 42.61 in group II and 415.90 ± 49.29 in group III and at 12 months after implant placement in Group I was 643.44 ± 92.00, 592.58 ± 137.89 in group II and 596.62± 84.36 in group III. there was no statistically significant variation between groups.

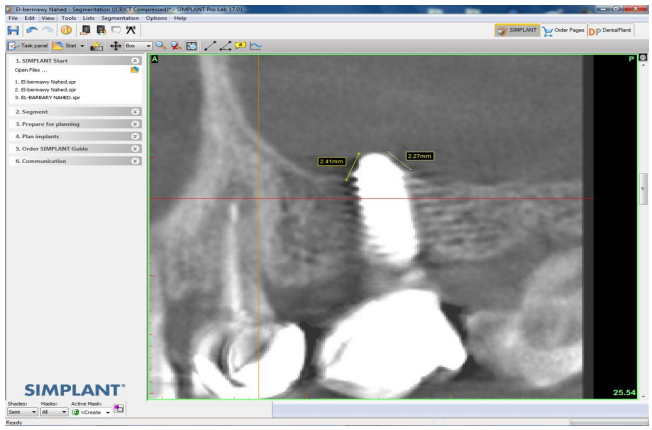

Figure 7. Endo-sinus bone level at 12 months (Sagittal view).

Group I short implants without crestal sinus approach technique and without augmentation material.

Group II long implants with crestal sinus approach without the use of augmentation material.

Group III long implants with crestal sinus approach with the use of augmentation material.

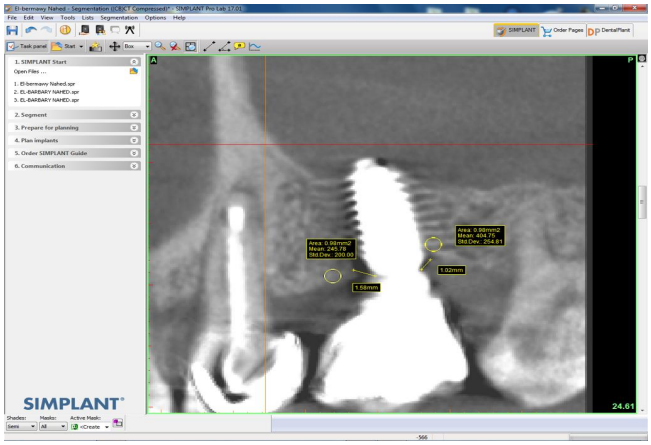

Figure 8. Marginal bone level and bone density in HU at 12 months (Sagittal view).

Discussion

This study was done on 21 patients who required implant placement for their missing posterior maxillary teeth (premolars and molars) and had limited bone height below the floor of their maxillary sinus.

As smoking diminishes leukocyte activity, interrupted wound healing, and decreases infection resistance, all patients in the present study were nonsmokers.[21] This in agreement with Clementini et al. from 2014 who concluded that, smoking causes implant failure due to its harmful influence on peri-implant bone loss. [22]

The crestal approach was choiced in the present study due to its several benefits over the lateral approach. As, the lateral strategy is more aggressive than the crestal strategy. Additionally, the crestal method needs less time for wound healing and is an easier approach.[23]

In the present study, we ensured absence of membrane perforation. Perforation was indicated by using mirror in front of the osteotomy site, air bubbles were found or mist appears on it . This is consistent with the findings of of Gabbert et al., in 2009 as they reported that no treatment usually need for minor perforations, because during elevation the membrane folds on itself.[25-27]

The goal of common successful implant procedures is to be atraumatic to bone tissues. This was achieved by the use of high torque, low speed hand piece during the implant bed preparation with a copious amount of cold normal saline for adequate cooling .[28] As overheating of the bone during implant site preparation might result in necrosis of bone, loss of osseointegration and consequently loosening of the implant so a delicate bone surgery was applied. This invoices for success were in accordance with Porter and Von Fraunhofer and Augustin et al. [29,30]

Different materials have been employed to elevate the sinus floor include allografts, xenografts, hydroxyapatite (HA) products and tricalcium phosphate with different outcomes.[31] Hypro-Oss® was selected in the present study, which was used as augmentation material in group III.

Multiple studies have established the effectiveness of xenogenic materials and advocate their sole use for sinus floor.[32-35] This substance reduces morbidity associated with surgical techniques to harvest autogenous bone.[35]

AnyRidge ® implants were selected in the present study, which was used in all groups as its tapered implants with knife-edge threads could facilitate fixture stabilization in challenging situations.[36]

Resonance frequency analysis (RFA) by osstell device was selected for better standardization the present results. This technique is straightforward, rapid, no risk of patient discomfort and easy to accomplish as part of a routine clinical procedure. This device can detect changes in micro motion that could be associated with an decrease or increase in the degree of osseointegration.[37]

In brief, the present study's findings on implant stability were as follows: Group I had a higher implant stability quotient (ISQ) immediately after implant implantation than groups II and III. There was a statistically significant difference between groups I and II, and there was also a statistically significant difference between groups I and III. This may be due too short implant had bone at apical region during insertion but long implants with sinus floor elevation had only bone mesial, distal, buccal and lingual but no apical bone. However, no statistically significant difference between groups II and III.

It must be noted that the mean values of primary stability achieved in the challenging clinical situation of present study were rather high. This outcome was undoubtedly influenced by the rigorous insertion technique and precise surgical site preparation but it was also influenced by the macro-topographic features specialization of the implants utilized in various trials.[38,39]

Surprisingly after seven months, there is no

statistically significant change in ISQ scores between any of the groups. This was in accordance with Bechara S et al., who concluded that neither during installation nor at final restoration delivery did the mean ISQ values of the short dental implants group and long implant group differ from one another.[36]

In monitoring the probing depth, there was no statistically significant variation in the mean probing depth between groups at 7 and 12 months. This was in accordance with Guarineri et al., who determined that the soft tissue alterations, including PI, PD, BOP, and recession, did not differ significantly between the two groups in the split mouth design research.[40]

In our study, the mean keratinized mucosa (KT) width before implant implantation, at 7 months, and at 12 months did not differ significantly between. This was in agreement with 2014 systematic review by Brito et al., which evaluated the relationship between KT width and peri-implant tissue health by choosing current studies with a follow-up of >12 months. Seven papers supported the conclusion that an appropriate zone of KT may be important since it has been proven to be associated with healthier peri-implant tissue.[41]

In the present research, the implant survival after 1 year from insertion show 100% for all groups. This was in accordance with systematic review Fan T et al., published in 2017. They concluded that that there was no statistically significant difference between the survival rates of short implant group and long implant group in atrophic posterior maxilla with Sinus lifting.[42] The group with shorter implants reported fewer complications. Clinical result was found to be hand to hand with radiographic result.

Computed tomography (CT) has been utilized as a trustworthy method for evaluating bone amount and quality.[43] During a CT scan for maxilla and mandible, the radiation dose absorbed by the patient is 2000 while cone beam CT for dento-alveolar focus field of view is 5 to 38.3.[44,45] This restricts its use for regular diagnostic procedures or periodic examinations.[46]

In the present study, there was no statistically significant difference in marginal bone loss (MBL) surrounding implants across all groups immediately and after 12 months. this was in agreement with Nielsen HB et al., in 2021 who reached the conclusion that short implants with single-crown restorations appear equivalent to standard-length implants with maxillary sinus floor augmentation as no statistically significant differences for implant survival, MBL, or mechanical problems for both groups.[47]

However, the current results were in contradiction with findings of Bechara S et al., who concluded that the mean MBL was considerably greater in long implant group than in the short implant group.[36] The conflicting result between our study could be due to use different sinus approach technique (lateral technique) with the use of same implant design and difference in time of evaluation.

It was interesting to notice that the mean bone level change, primarily endo-sinus bone, exhibited statistically significant differences between Group II and Group III immediately after implantation and at 12. this was in agreement with Nedir R et al., assessed and compared endo-sinus bone levels surrounding randomly inserted implants using an osteotome sinus floor elevation (OSFE) method in grafted (control) and non-grafted (test) sinuses.[11] They Concluded that although more bone is gained when grafting material is employed, this may not be necessary to enhance endo-sinus bone growth.

In the current study, there was no statistically significant difference in mean bone density between groups before implant insertion, either immediately or 12 months afterwards. At each evaluation interval, bone density increased in all groups. This was consistent with Gamalat et al., who reported that bone density increased over the follow-up periods as a result of bone compression caused by the implant insertion procedure.[48]

Our study concluded that short implant may be favorable alternative option to long implant placement with maxillary sinus augmentation because of similar survival and marginal bone loss, fewer biological complications, short surgical time and less costs in comparison to long implants.

Conclusion

It was concluded that short implant placement is an excellent alternative to long implant placement in conjunction with maxillary sinus augmentation.

Recommendations;

1) Additional research is necessary to confirm our findings through long-term investigation.

2) Prospective studies are required to evaluate different widths of short implants with the same length in atrophic mandibular ridges.

Declaration of Interest

The authors report no conflict of interest.

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