Clinical and Radiographic Evaluation of Short Dental Implants in Posterior Atrophic Ridges with a Follow-up Period of 1 Year after Loading: A Controlled Clinical Trial

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Abstract

Objective: to evaluate clinically and radiographically the performance of short dental implants in the posterior atrophic ridges (maxilla and mandible) with deficient vertical bone height as an alternative treatment modality to other more invasive procedures.

Methods: 30 patients, with residual bone height 7-9 mm in the mandibular or the maxillary posterior regions, were selected to receive 6.5 mm short dental implants (Maxi Z Flat-End, Osteo-Care™ Implant System, London, UK). Implants were loaded 4 months (T2) after placement and Patients were followed up 1 year after loading (T3). 32 implants were inserted, 15 implants in the posterior maxilla and 17 implants in the posterior mandible. Outcomes measured included: Implant stability measured by Periotest®M mean values (PTMVs), Implant failure rate, marginal bone loss (MBL) and other complications.

Results: 30 patients were evaluated at 1 year after loading. The PTMVs were -1.23 ± 0.31 in maxilla, and 2 ± 0.23 in mandible. Marginal bone loss in the maxilla recorded -1.55 ± 0.29 mm and in the mandible -1.10 ± 0.12 mm after1 year of loading. The difference between the two groups showed no statistical significance (difference = -0.44 mm; 95% CI: -0.18 to 1.06; P = 0.1549). 2 implants failed in the maxilla with a failure rate of 13.3% while there were no failures in the mandible. Statistical analysis showed no significant difference between the studied groups (P=0.4828).

Conclusion: Short dental implants seem to be an effective alternative treatment for atrophic ridges with a very high success rate in the mandible. They minimize the need for bone grafting procedures and increase the patients` acceptance, as well as, maximizing dental implant placement possibilities.

KEY WORDS: Dental implants, short implants, dental implant survival, atrophic ridges

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INTRODUCTION

Implant dentistry is becoming more popular as a treatment modality especially with the emergence of newer and improved implantation technologies. Much of these improvements can be attributed to the relatively high success rates of implants in both partially and completely edentulous patients.[1] In patients with long-standing edentulous arches, alveolar bone resorption (Both vertical and horizontal or combined defects) is frequently observed. The insertion of dental implants in patients with reduced alveolar bone height is challenging and may require additional invasive bone augmentation procedures.[2]

The use of short dental implants could fulfill various indications where there is insufficient bone volume to avoid complicated bone augmentation or maxillary sinus floor elevation procedures. Owing to the need for rehabilitation of such an increasing number of atrophic jaws, the 7mm standard implant was introduced in 1979. The survival rates of implants shorter than 10mm seem to be comparable to that of longer implants. The success rate of short implants is proposed to be higher in the mandible than the maxilla due to the nature of softer bone in the maxilla.[3,4,5,6] The possibility of restoring the dentition without the need for significant surgical augmentation has widened the scope for treatment options which, in turn, can lead to simplified implant rehabilitation procedures. These factors may increase patients` acceptance, making the treatment option available to more people, further contributing towards improved oral function and general health.[7]

A broad number of cases series,[8,9,10] and reviews,[11,12] have reported favorable outcome in terms of survival rate for short implants placed in posterior areas. Nevertheless, there are still controversies regarding the long-term consequences of peri-implant bone loss around short implants and its impact on the long-term implant success rate. As a consequence, the borderline scenario with 5–8mm of available bone still constitutes a challenging therapeutic dilemma for clinicians.[13] However the development of implant design, surface structure and improved surgical techniques have given a reason to re-evaluate previous results, and recent randomized clinical studies with 3 to 5 years follow-up indicated that short implants survival and success rates were similar to long implants and may support most prosthetic restorations adequately.[14,15,16]

Most recently, a number of systematic reviews evaluated the survival rate of short dental implants, overall concluding that the survival rates are similar to that of long implants.[11,6,5,13,17] Nevertheless, limitations such as a slightly lower survival rate in soft bone or in the posterior maxilla were reported.[5,18] Scientific evidence is scarce on short dental implants placed in the posterior maxilla. In addition, in most clinical studies short implants were splinted to longer ones.[9,19]

Sinus floor elevation procedures with long implants or complicated bone augmentation procedures have been reported to suffer many drawbacks in terms of complications faced and patients` acceptance, besides other considerations including cost, treatment time and morbidity associated with aforementioned procedures.[18,19]

The aim of the present study was to evaluate, clinically and radiographically short dental implants placed in the posterior maxilla and mandible.
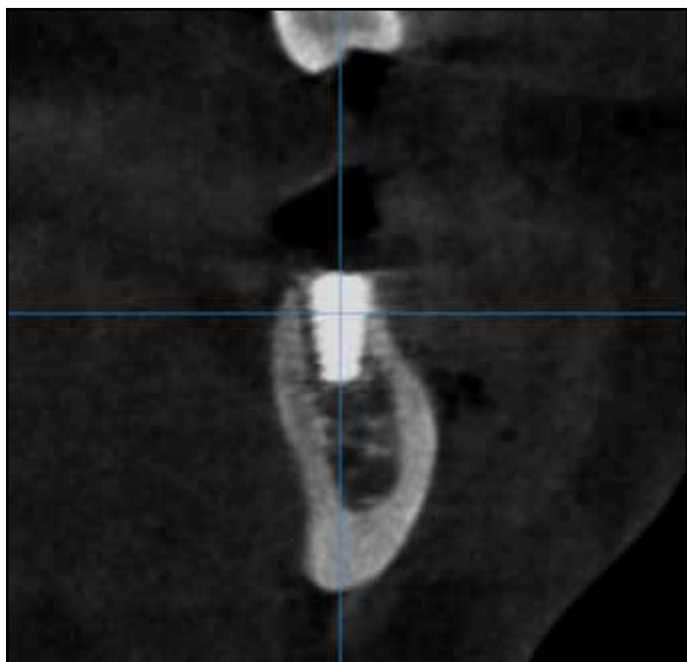
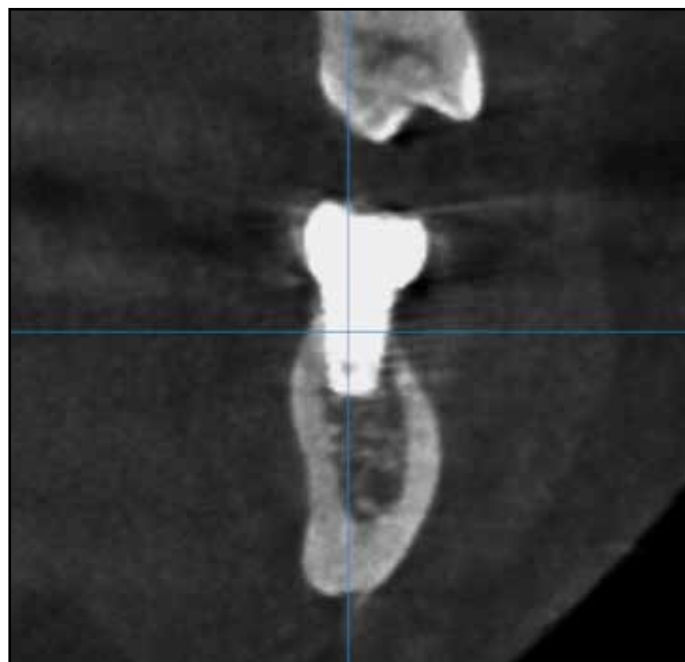**Figure 1:** CBCT cross sectional view of immediate post placement (T1) of short implant in the mandible.

Figure 2: CBCT cross sectional view after 1 year of loading (T3) of short implant in the mandible.

SUBJECTS AND METHODS

Patient Selection

Patients were selected, from the out-patient clinic of the Faculty of Oral and Dental Medicine (Cairo University), according to pre-set eligibility criteria. Any partially edentulous patient missing teeth in the premolar and molar area requiring one to three dental implants, aged 18 years old or older, and able to sign an informed consent form, was considered eligible for inclusion in this trial. Vertical bone heights at implant sites had to be at least 8 - 9 mm above the mandibular canals and 7 - 8 mm below the maxillary sinuses, with bone width of at least 6.0 mm as measured on cone beam computed tomography (CBCT) scans.

Exclusion criteria were as follows: (1) severe systemic diseases that might contraindicate surgical intervention; (2) uncontrolled diabetes mellitus; (3) immune-compromised status; (4) coagulation disorders; (5) radiotherapy; (6) chemotherapy; (7) alcohol or drug abuse; (8) pregnancy or lactation; (9) use of oral and/or intravenous amino-bisphosphonates; (10) untreated active periodontal infections; (11) active infection in the site of implant placement (13) heavy smokers and (12) bruxism.

The study protocol was reviewed by the Ethical Committee for Human clinical trials at the Faculty of Dentistry, Cairo University. The protocol of this study was also registered at the Pan African Clinical Trial Registry (PACTR) in 2015/07/11 and the registration no. is PACTR201610001197438.

Surgical Procedures

All procedures were done under completely aseptic conditions. Patients were anesthetized at the surgical site by infiltration, using Articaine Hydrochloride 4% (Septocaine® 1.8 ml. Articaine Hydrochloride 4% and epinephrine
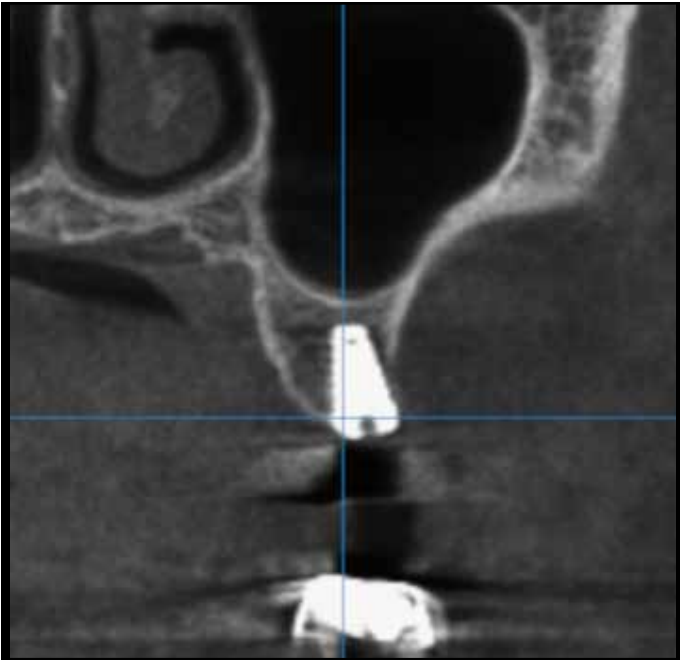
Figure 3: CBCT cross sectional view of immediate post placement (T1) of short implant in the maxilla.

Figure 4: CBCT cross sectional view after 1 year of loading (T3) of short implant in the maxilla.

1:100000. Septodont, USA). Bone width was assessed using a bone caliper. Using a Bard Parker blade no.15, a palatal or lingual sub-crestal incision was created in the surgical site, extending the entire length of the edentulous area. Two oblique releasing incisions were then created on the buccal aspect. A full thickness flap was then elevated to expose the underneath buccal alveolar bone. Under copious saline irrigation, the osteotomy was prepared by sequential drilling. The Maxi Z Flat-End implant 4.5 x 6.5mm (OsteoCare™ Implant System, London, UK) was inserted into the osteotomy using its peek carrier. Then the full seating of the implant was done using the 2.2mm hex-driver until implant platform was flush with the bone level and torqued to 30NCm to check the initial stability. A periapical radiograph was taken to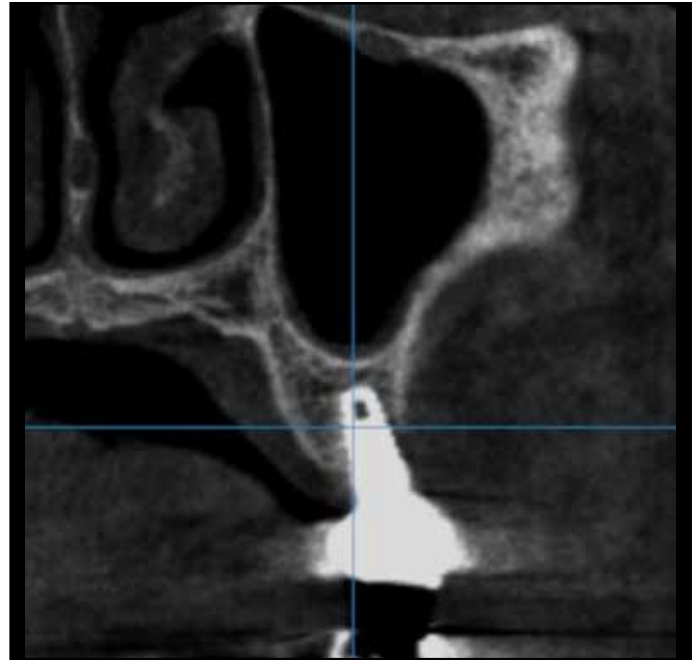 check the final implant position and to esti-mate the initial bone level around the implant. The recipient site area was then sutured with 4-0 silk (Hu-Friedy, USA) interrupted sutures which were removed after 2 weeks.

Post-operative care: post-surgically patients were prescribed 875mg of Amoxicillin and 125mg of Clavulanic acid tablet (1gm Augmentin, Glaxosmith Kline, England) twice daily for 7 days, anti-inflammatory tablets (Brufen 200 mg, Abbott, India ltd.) twice per day for three days. A CBVT (Scanora 3D Soredex, Helsinki, Finland) scan was done within 24 hours post-surgically (T1) to assess marginal bone level (Fig.1, Fig.3)

Four months after implant placement (T2), re-entry using a tissue punch was done to fit a healing collar. A periapical radiograph was taken to check the proper fixation of the healing collar. Seven to 10 days later, impressions were made using impression transfers and

implant replicas and the final ceramo-metallic restorations were delivered and cemented after being checked for shade matching, marginal fitness and occlusion. Stability of implants in the two groups was tested using Periotest® M (Medizintechnik Gulden, Bensheim, Germany).

Outcome Measures

● Stability was tested using Periotest® M at the loading stage (T2) and 1 year after loading (T3). Periotest® M values of (-8 to 0) were considered the ideal values that denote successful osseointegration.

● The marginal bone loss (MBL) around the short implants was assessed using CBVT within the first 24 hours post-surgically (T1) and also after 1 year (T3) (Fig.2, Fig.4). The CBVT raw DICOM data set images CT was imported to the third party software for secondary reconstruction.

● Any biological or prosthetic complications were recorded.

● Implant failure: implant mobility and removal of stable implants dictated by progressive marginal bone loss or infection.

Statistical Analysis

The statistical software used was IBM SPSS (IBM Corp., Armonk, NY, USA), and Excel (Microsoft, Redmond, WA, USA).The patient was the statistical unit of the analyses. A parametric statistical approach was applied. Differences in the proportion of patients with implant failures and complications (dichotomous outcomes) between maxilla and mandible were compared using the Fisher's exact test. The mean differences, standard deviation (SD), confidence intervals, values and results of the Students' T-test for the changes by time in marginal bone level around implants of each group were used.

RESULTS

During the 1 year follow-up period no dropouts occurred. The main baseline patient and intervention characteristics are presented in (Table 1). There were no failures in the mandible while there were two failures in maxillary implants (Table 2). The failure in the maxilla occurred in two patients, one failure occurred in the preloading stage and the other occurred four months after loading (PTMV > 0). Post-operative swelling occurred in five cases, three in the maxilla and two in the mandible. The data of all patients was evaluated in the statistical analyses.

Implant stability was measured by Periotest M at preloading stage (T2) and 1 year after loading (T3). At the pre-loading stage the mean Periotest values were -1.99 ± 0.3 in the maxilla and -2.42 ± 0.26 in the mandible. At 1 year after loading the mean Periotest values were -1.23 ± 0.31 in the maxilla and -2 ± 0.23 in the mandible. Statistical analysis showed no significant differences (P ≥ 0.05) between the mandible and maxilla at T2 and T3 (Table 3).

The marginal bone loss around implants was measured at the mesial, distal, buccal and lingual aspects of all implants. The mean marginal bone loss 1 year after loading in the maxilla was -1.55 ± 0.29 mm while in the mandible it was -1.10 ± 0.12 mm, statistical analysis showed no significant difference (P ≥ 0.05) between the two groups. The results of Students' T-test for the marginal bone loss around implants of each group were presented in (Table 4).

Table 1: Summary of the Main Results		
	Maxilla	**Mandible**
Female	8 (53.34%)	10 (66.67%)
Mean age at recruitment	32.7 ± 0.97	33.67 ± 1.28
No. of patient	15	15
Total of implant inserted	15	17
Implant length and diameter	6.5 (4.5)	6.5 (4.5)
No. of implants placed with less than 25 N/cm torque	6	1
No. of patients receiving 1 implant	15	13
No. of patients receiving 2 implants	0	2
Drop outs	0	0
Implant failure	2	0
Complication	3	2

DISCUSSION

Restoration of the atrophic ridges presented a challenge in the past due to the limitation of implant placement especially in the posterior mandible and maxilla and the risk of approximating vital structures. In the past, the only solution was performing bone augmentation procedures, which required extended treatment periods, extra expenses and surgical complications. An alternative for restoration of such atrophic ridges is the use of short implants. Short implants were commonly associated with lower survival rates due to the reduced bone-to implant contact. Moreover, the posterior region commonly shows moder-

ate to extensive bone resorption which results in increased crown height space and unfavorable crown-to-implant ratio. However, recently, the development of modified implant designs and surface treatments contributed for to the increased survival rates of short implants. Clinical literature has demonstrated no significant differences in the survival rate of short and standard implants.[21,22]

Care was taken to standardize the study conditions for all patients and to exclude conditions that might affect the success of short implants, such as smokers and medically compromised patients and patients exhibiting parafunctional habits - such exclusion was executed in line with

Table 2: Results of Fisher's Exact Test. *:Significant at P ≤ 0.05.					
	Test Group	**Percentage**	**Control**	**Percentage**	**P value**
Implant failure	2 (15)	13.33%	0 (15)	0%	0.4828
Complications	3 (15)	20%	2 (15)	13.33%	> 0.9999

the recommendations of previous studies.[23,24,5] These criteria limited the number of patients recruited in the current study. The primary stability of the implant, which results from the initial inter-locking between alveolar bone and the body of the implant, affects the secondary stability of the implant because the latter results from subsequent contact osteogenesis and bone remodeling.[25,26] Implant stability is a prerequisite for the long-term clinical success of osseointegrated implants.[27]

In this study, implant stability was assessed by means of Periotest®M, which is considered as a fast, safe and non-invasive method of measurement that is useful for long-term implant follow-up. This was in accordance with Wijaya et al.[28] who concluded that the implant mobility checker (Periotest®) was reliable and a reproducible method for dental implant mobility assessment.

At the pre-loading stage (T2) and at 1 year after loading (T3), there was no statistical significance difference in mean Periotest®M values in both mandible and maxilla. The Periotest®M value of one short maxillary implant was (+3) after 1 year of loading (T3) and was considered as a failed implant while the other implant was lost at the pre-loading stage (T2). This was in accordance with Al Hashedi et al.[29] where they considered the positive implants periotest values as questionable and requiring further clinical examination before

loading. Al-ghamdi et al.[30] also reported that from the observed primary stability it can be concluded that short implants are able to achieve desired primary stability in areas with good bone quality.

The percentage of implant failure in maxilla was 13.3% while in mandible it was 0%. Many researchers,[31,32] considered bone quality as a significant risk factor for failures. Goodacre et al.[33] reported that implants placed in poor bone quality areas showed failures rates 16% higher than those placed into greater bone density areas. Another 5-year report of a prospective single-cohort study reported by Perelli and co-workers in 2012,[34] reported that implant failure in 110 short implants placed in posterior atrophic maxilla after 5 years was 10% and at the end of the follow-up period the implant survival rate was 90%, and 93.1% with regard to prosthetic reconstruction. On the other hand another study by Weng et al.[35] reported a 25% failure rate when short implants were placed in the posterior maxilla, especially during the first 18 months of loading.

Crestal bone loss is another important parameter to guarantee long-term clinical service. The maintenance of a stable marginal bone level becomes more critical when short implants are used.[36,37] In the present study the crestal bone loss around implants was measured at the mesial, distal, buccal and lingual aspects of all

Table 3: Mean Periotest Values at T2 (Pre-loading) and T3 (1 Year After Loading).							
Time	**Maxilla**		**Mandible**		**Mean Difference**	**95% CI**	**P value**
	Mean ± SD	**95% CI**	**Mean ± SD**	**95% CI**			
Pre-loading Stage (T2)	-1.99 ± 0.3	-2.14 to -1.84	-2.42 ± 0.26	-2.56 to -2.29	-0.44 ± 0.4	-1.26 to 0.38	0.2795
1 Year After Loading (T3)	-1.23 ± 0.31	-1.39 to -1.07	-2 ± 0.23	-2.12 to -1.88	-0.77 ± 0.39	-1.56 to 0.03	0.0585

Table 4: Marginal Bone Loss Around Implants 1 Year After Loading. *:Significant at P ≤ 0.05							
Data Time	**Maxilla**		**Mandible**		**Mean Difference**	**95% CI**	**P value**
	Mean ± SD	**95% CI**	**Mean ± SD**	**95% CI**			
Insertion (T1) 1 Year After Loading	-1.55 ± 0.29	-1.7 to -1.4	-1.10 ± 0.12	-1.16 to -1.04	-0.44 ± 0.3	-0.18 to 1.06	0.1549
Insertion (T1) 1 Year After Loading (T3)	-1.55 ± 0.29	-1.7 to -1.4	-1.10 ± 0.12	-1.16 to -1.04	-0.44 ± 0.3	-0.18 to 1.06	0.1549

implants by using CBVT which was taken at baseline (T1: immediately after insertion) and 1 year after loading (T3). There was no statistical significant difference between the two groups for the marginal bone level changes around short implants from the baseline (T1) till after 1 year of loading (T3). After 1 year of loading the short implants placed in the maxilla showed a mean marginal bone loss of -1.55 ± 0.29 mm while the short implants placed in the mandible showed a mean marginal bone loss of -1.10 ± 0.12 mm.

Perelli el al.[34] reported a minimal crestal bone resorption around short implants placed in the posterior atrophic mandible after 5 years follow-up, he reported 1 mm marginal bone loss around 5 mm implants and 2 mm bone loss around 7 mm implants. In contrast with our study Renouard and Nisand[9] placed 96 short implants in the posterior atrophic maxilla. The mean marginal bone resorption after 2 years in function was 0.44 ± 0.52 mm. Recently Felice et al.[38] evaluate the efficacy of short (5 or 6 mm-long) dental implants versus 10 mm or longer implants placed in crestally-lifted sinuses. They placed 16 short implants and 18 longer implants and they found that there was no significance difference in the mean crestal bone loss after 1 year follow up.

The use of short dental implants could be con-

sidered as an alternative to avoid complicated bone augmentation procedures. The possibility of restoring the dentition without the need for complicated surgical procedures has widened the scope for treatment options and increased patients` acceptance which contributes towards improved oral function and general health

CONCLUSIONS

Within the limitations of the current study it was concluded that:

1. Short implants are considered a suc-cessful treatment option for restoration of atrophic ridges with deficient vertical bone height in both the maxilla and the mandible.

2. Short implants placed in the atrophic mandible showed higher success rate and less crestal bone resorption than those placed in the atrophic maxilla. ●

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Disclosure
The authors report no conflicts of interest with anything in this article.

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