A Multicenter Retrospective Study Comparing Survival Rates of Short Dental Implants (<10 mm) with Ungrafted Transcrestal Sinus Floor Elevation Procedures and Longer Implants (≥ 10 mm)

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ABSTRACT

Objectives: Investigating whether or not the use of short dental implants (<10 mm) results in similar survival rates to longer implants (≥ 10 mm) in combination with transcrestal sinus lifting procedures without grafting.

Materials and methods: Twenty partially edentulous patients with one or both maxillary posterior segments, treated in the time period between March 2014 and December 2016 with either short dental implants (group I) or had a preoperative transcrestal sinus floor elevation (TSFE) procedure without bone graft (group II), were retrospectively enrolled in this study. Patients were 15 females and 5 males; the mean age, at the time of implant placement, was 42.09 ± 6.96 years for group I and 39.22 ± 6.9 for group II, ranging between 30 years and 54 years. Based on preoperative periapical radiographs, the residual alveolar heights were judged to be less than 10 mm until 7 mm. Postoperatively, the amount of new radiopacity between the sinus floor and the alveolar crest of group II cases was then measured using a digital ruler from the mesial and distal surfaces of each implant. In total, 11 implants were placed in group I and 9 implants were placed in group II.

Results: After a mean follow-up period of 31.9 ± 9.4 months for group I and 30.5 ± 6.13 for group II, with some implants up to 4 years in duty, a survival rate of 100% was reported for both groups. The mean bone level, for group II, at the implant placement was 8.58 ± 0.81 mm and, after 2.5 years, it was 10.8 ± 0.85 mm.

Conclusion: Within the limitations of this retrospective clinical study, the results confirmed the reliability of both, the TSFE without grafting procedure and the use of short dental implants in posterior maxillary edentulous spaces of reduced heights.

Keywords: Short dental implants, Survival, Transcrestal sinus floor elevation.

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INTRODUCTION

Tooth loss results in resorption of the alveolar process and, consequently, in a reduction of the amount of bone available for the insertion of a dental implant.^{1,2}

Moreover, in the posterior maxilla, loss of teeth may induce expansion of the maxillary sinus, which is probably caused by pneumatization (i.e., the positive air pressure created during breathing).³

Migration of the maxillary sinus floor to a more inferior position as a result of the pneumatization, in addition to resorption of alveolar crestal bone, brings the sinus membrane too close to the ridge crest leaving no subantral bony room for the implant to be integrated in.

Several surgical approaches aimed at increasing bone height in the posterior maxilla for the insertion and integration of dental implants have been proposed. Boyne and James were the first to present maxillary sinus floor elevation techniques with a lateral approach, opening a bone window through the lateral wall of the maxillary sinus in which they filled the sinus cavity with autogenous bone marrow harvested from the iliac crest.⁴

Lateral sinus augmentation with the bone harvested from an intraoral donor site was reported by Wood and Moore to limit donor site morbidity to the vicinity of osteotomies.⁵

Implants can be either inserted simultaneously, when there are sufficient bone heights for the primary bone stability > 4 mm, or can be inserted in a second procedure when bone remodeling of the

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graft has taken place. This two-stage procedure is indicated when the residual bone crest presents a residual height of less than 5 mm.⁶

However, Pjetursson et al.⁶ have reported that lateral sinus floor elevation and autogenous bone harvesting can pose an increased risk for some complications including invasiveness and complexity, donor site morbidity, additional treatment duration, increased cost, and compromised success if wound exposed.

If a minor augmentation is needed and the residual bone volume is adequate, transalveolar sinus floor elevation, that was described by Tatum, can be used, in which he proposed a crestal

approach to the maxillary sinus and simultaneous placement of implants.⁷

Summers modified this technique, suggesting the use of a specific set of osteotomes for preparing the implant site and elevating the sinus floor.⁸

This approach has been so reliable that some authors extended this surgical procedure to residual bone heights beneath the sinus by 4 mm.⁹ Even in less than 3 mm thick crest, a transcrestal technique can predictably be used with a long-term clinical and radiological outcome, giving patients excellent stability of the grafted material and healthy clinical results.¹⁰

Although that the use of autogenous bone grafts has been considered the gold standard for bone-augmentation procedures,¹¹ as a result of their osteoinductive properties,¹² different grafting materials of biologic or synthetic origin are commonly used for maxillary sinus floor augmentation, either alone or in combination with autogenous bone grafts.¹³

Lately, the necessity of placing a filling material for sinus elevation procedures has been questioned in crestal approaches.¹⁴

These studies demonstrated the capability of forming the bone into the graft-free volume when the Schneiderian membrane has been merely lifted beyond its anatomical limits of the sinus floor, either crestally or laterally.¹⁵

In a split-mouth designed study, Borges et al.¹⁶ compared sinus membrane elevation without (test side) and with the use of autogenous bone graft. They found no statistically significant differences in new-bone formation between the two groups. A significant, positive correlation was found between the protruded implant length and the gained bone. In addition, the absence of sinusitis was correlated with implant survival.

Although the success of this surgical technique has been reported through clinical studies and case reports, the data on actual gain in alveolar bone height and long-term maintenance are limited.¹⁷

Given the higher risk for complications as intraoperative membrane perforation and the extended surgical time of longer dental implants in the elevated sinus, restoration of the atrophic posterior maxilla by short implants has potential as a preferred alternative.¹⁸

In daily clinical practice, this alternative option sounds attractive to the clinician (shorter chair-side time) and to patients (low morbidity and cost).

At present, there is no consensus on the definition of a short implant. Some authors defined short implants as ≤ 7 mm, ≤ 8 mm, or ≤ 10 mm long.¹⁹

In this study, a short implant is defined as a dental implant that is <10 mm long, whereas a standard length dental implant is ≥ 10 mm.

Fugazzatto et al. demonstrated the cumulative success rates of implants less than 9 mm in length to be 95.1%.²⁰

More recent studies have shown the survival rate of short implants in partially edentulous patients is similar to that of standard implants with better prognosis in the mandible.¹⁸

However, short implants in general can fail 2.5 years earlier compared with standard implants.¹⁹ In a previous meta-analysis, it was not possible to evaluate separately the efficacy of short implants in either the maxillary or mandibular arches because of the lack of studies reporting success of implants placed only in one arch.¹⁹

AIM OF THE STUDY

The aim of this study is to test whether or not the use of short dental implants (<10 mm) in partially edentulous maxillary posterior segments results in similar survival rates to longer implants (≥ 10 mm) in combination with graftless transcrestal sinus lifting (TSFE) procedures.

MATERIALS AND METHODS

A multicenter retrospective cohort study was conducted between March 2014 and December 2016, in which 20 partially edentulous patients in one or both maxillary posterior segments, treated with either short dental implants (group I) (Fig. 1) or had a preoperative TSFE procedure without bone graft (group II) (Fig. 2), were retrospectively enrolled in this study.

Based on preoperative periapical radiographs, the residual alveolar heights were judged, using the software digital ruler, to be less than 10 mm until 7 mm.

Exclusion criteria involved those patients with chronic systemic disease, symptoms of acute or chronic sinus problems, smoking of more than 5 cigarettes a day, habits of bruxism, alcohol or drug abuse, coagulation or immunodeficiency disorders, poor oral hygiene, and cases of lost vertical dimension of occlusion. A signed consent form that was written in Arabic language explaining each step of the procedures and highlighting possible risk factors was a must for each patient to be included in the study.

Patients were 15 females and 5 males; the mean age, at the time of implant placement, was 42.09 ± 6.96 years for group I and 39.22 ± 6.9 for group II, ranging between 30 and 54 years.

The means for initial and gained bone heights, for group II, were obtained from the radiological evaluations. It was assessed as the

Figs 1A to C: Cropped panoramic radiographs showing a short dental implant at the area of the missing tooth #3; (A) Preoperatively; (B) At stage II surgery; (C) At 18 months follow-up

Figs 2A to C: Periapical radiographs showing group II cases before and after TCSFE and simultaneous implant placement procedures

presence of radiopacity around exposed mesial and distal implant surfaces within the created space at the floor of the maxillary sinus.

In total, 11 implants were placed in group I (Table 1) and 9 implants were placed in group II (Table 2). The implant positions are shown in Table 3.

This research study has been conducted in full accordance with the World Medical Association Declaration of Helsinki.

RESULTS

After a mean follow-up period of 31.9 ± 9.4 month for group I, and 30.5 ± 6.13 for group II, with some implants up to 4 years in duty, a survival rate of 100% was reported by both groups (Table 4).

The mean bone level, for group II, at the implant placement was 8.58 ± 0.81 mm and, after 2.5 years, it was 10.8 ± 0.85 mm.

Table 1: Group I implant dimension ($n = 11$ implants)

Implant diameter (mm)	Implant length (mm)		
	7	8	8.5
3.5			
4		2	
4.5		2	2
5	2	1	1
5.3		1	
Total	2	6	3

Table 2: Group II implant dimension ($n = 9$ implants)

Implant diameter (mm)	Implant length (mm)		
	10	11.5	12
3.5	1	1	
3.8			1
4	2	2	
4.5		1	
5	1		
Total	4	4	1

Table 3: Implant positions (*n* = 20)

Teeth	16	15	14	24	25	26
Implants	4	4	–	1	2	9

Table 4: Life table analysis for all implants, groups I and II

	Implants	Failed implants	Cumulative survival rate %
All implants			
Implant placement	20	–	100
Prosthesis delivery	20	–	100
Prosthesis delivery–6 months	20	–	100
6 months–1 years	20	–	100
1 years–3 years	18	–	100

DISCUSSION

When inadequate subantral bone height is available and implant-supported restorations are indicated, sinus floor elevation procedures are considered. There is controversy regarding what is considered to be adequate bone height, and, thus, when sinus floor elevation is indicated.

Moreover, selection of an appropriate sinus floor elevation procedure is complex and lacks consensus in the literature. The choice is mainly based on residual vertical bone height, marginal bone width, local intra-sinus anatomy, and the number of teeth to be replaced, although other factors, such as surgical training and experience, may have an impact.²¹

It is proposed that a TSFE approach could be the first choice for single-tooth gaps in situations where there is sufficient width for implant placement and the intended elevation height does not exceed the height of the available residual bone, i.e., a residual bone height of at least 5 mm.²¹ The lateral sinus floor elevation is indicated when <5 mm of bone is available.²¹

With regard to the time of implant placement, the two-stage technique results in a higher percentage of new-bone formation which gives it a biological advantage.²² However, similar implant survival rates have been reported and, therefore, the one-stage technique is preferred provided that careful case planning and meticulous surgical techniques must be used, and, thus, sufficient primary stability can be achieved.²³

The advantages of the one-stage technique, such as shorter treatment time and a fewer surgical procedures, are obvious.

Selection of the appropriate implant length depends on the residual bone height and the choice of technique. During transcrestal sinus floor elevation procedures, it was proposed to place implants of 8–12 mm length. Longer implants may pose a risk for accidental perforation and collapse of the membrane, and, thereby, impair bone formation in the tented space, or iatrogenic migration of the graft material into the sinus antrum.²⁴

With the two-stage lateral sinus floor elevation technique, the height of the augmentation after healing dictates the length of the implants. It is recommended to place implants of at least 10 mm lengths to ensure an effective tenting effect.²⁵

The necessity of placing a filling material for sinus elevation procedures has been questioned. Boyne et al. showed, in a study on primates, that sinus membrane elevation and implant insertion with the apical part protruding in the sinus cavity under the elevated mucosa result in spontaneous bone formation.²⁶

In a clinical histologic study, Johansson et al. found no differences when comparing lateral sinus floor elevation, with and without autogenous bone grafts, regarding bone formation and bone–implant contacts.²⁷

An interesting aspect of sinus membrane elevation is the healing mechanism and role of the sinus membrane on bone formation during the early healing phase. Several authors have demonstrated the osteogenic potential of the maxillary sinus membrane.^{28,29}

Surface-modified oxidized implants showed a stronger bone response than machined implants.³⁰

With regard to short dental implants, <10 mm, their reported cumulative survival rate was 99.1% after a follow-up period of 3.2 ± 1.7 years. Even 5 mm implants had an estimated survival rate of 93.1% after 2 years.¹⁹

To minimize short implant failure rates and compensate for the reduction in implant length, modifications to the micro and macro designs of dental implants, for example, increasing implant diameter, thread depth, surface treatment, and decreasing thread pitch, have been made¹⁹ (Figs 1 and 3).

These measures were made so that short implants can be used predictably, especially in nonideal clinical situations and when the patient declined advanced bone-grafting procedures because of the associated morbidity, increased cost, and treatment time.³¹

A higher survival rate was reported with short dental implants placed in the mandible than those placed in the maxilla.³² This phenomenon could be attributed to an increase in bone density, improved mechanical properties of the implant–bone interface, and reduced stress concentration in the bone,³³ therefore, facilitating primary stability and early osseointegration, which compensated for the reduction in implant lengths. However, the evaluation of the efficacy of short implants in either the mandibular or maxillary arches separately was not possible because of the shortage of studies reporting success of implants placed only in one arch.¹⁹ Our study findings are in agreement with the results achieved by two recent meta-analyses.^{34,35}

Panoramic and intraoral radiography can provide sufficient information when a TSFE procedure is considered for a minor augmentation, often limited to replacement of one or two teeth. At present, cone-beam computed tomography (CBCT) is the preferred radiographic technique as it provides high-quality images in three dimensions using low doses of irradiation compared with conventional computed tomography.³⁶ The CBCT examination can reveal information about the thickness of the lateral bone wall, presence of septa, flat vs oblique sinus floor, status of the Schneiderian membrane, and width of the sinus, and, in addition,

Fig. 3: Design parameters enhancing short dental implant survival

the amount of grafting material can be estimated.³⁶ Some CBCT techniques even allow for measurements of bone density, which can be used to estimate the primary stability.³⁷

CONCLUSION

Within the limitations of this retrospective study, the results confirmed the reliability of both, the graftless TSFE procedure utilizing ≥ 10 mm implants and the use of short dental implants to replace missing teeth in partially edentulous posterior maxillary segments. However, the follow-up periods need to be extended to highlight the long-term survival rates of either option and the sample size needs to be enlarged to raise the study power.

The recent local availability of CBCT will facilitate a 3-dimensional analysis of the residual bone quantity more precisely than periapical radiographs. In addition, virtual implants can be placed in the 3-dimensional reconstructions, thus, assisting in planning the optimal position for the implant. Moreover, this will raise the concern for the affordability of dedicated software that can be used to create 3-dimensional radiological surgical guides to control implant depth and angulation.

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