Clinical outcomes of reamer- versus osteotome-mediated sinus floor elevation with simultaneous implant placement: A 2-year retrospective study

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Abstract

Purpose: This retrospective study evaluated and compared the 2-year outcomes for sinus floor elevation performed via either an osteotome-mediated sinus floor elevation (OSFE) technique or a reamer-mediated sinus floor elevation (RSFE) technique. Implant survival, as well as surgical and post-operative complications, were utilized as measures of comparison.

Materials and Methods: Patients were analyzed according to defined inclusion criteria. Orthopantograms were employed to assess pre-operative, immediate post-operative, and 6-, 12-, and 24-month post-operative bone level changes. Implant survival and the incidence of complications, including Schneiderian membrane perforation, were evaluated with the performance of appropriate statistical tests.

Results: From 2008 to 2010, 126 implants were placed simultaneously with sinus floor elevation in 85 patients (n = 43 females and 42 males; mean age ± standard deviation (SD) = 58.1 ± 10.2 years). The OSFE procedure (control) was used to place 65 implants in 45 patients, and the RSFE procedure (experimental) was used to place 61 implants in 40 patients. The mean maxillary residual bone height (RBH) was 7.1 ± 1.6 mm. Endosinus bone gains were 5.7 ± 1.5 and 5.6 ± 2.3 mm for the experimental and control groups (p = 0.164), respectively, and the 2-year survival rates were 98.4 and 98.5%, respectively. Although no significant differences were observed between the two groups, three (6.7%) membrane perforations occurred in the OSFE group, while none occurred in the RSFE group. Other post-operative complications, including nasal bleeding, post-operative headache, and dizziness, were documented in 7/45 (15.6%) OSFE cases and 3/40 (7.5%) RSFE cases.

Conclusion: The results presented herein indicate that comparable survival rates were

achieved for implants placed in conjunction with a reamer- versus an osteotome-mediated technique. Therefore, RSFE is a reliable and predictable procedure for implant placement in the posterior maxilla, with a low incidence of complications.

Keywords: Dental implant, maxillary sinus, bone graft, sinus floor elevation, osteotome, reamer.

Introduction

The posterior maxilla is a challenging site for dental implant rehabilitation because of deficient bone height and the likelihood of poor bone quality.[1] Sinus floor elevation can overcome the problem of deficient residual bone height (RBH) of the upper maxilla when placing a dental implant. Two approaches are commonly employed in clinical practice for maxillary sinus floor elevation: the lateral approach and the crestal approach. The lateral approach, also called the lateral window technique, was first described by Tatum,[2] whereas the crestal approach, or the osteotome-mediated technique, was first introduced by Summers.[3]

Summers' technique uses an osteotome to cut or prepare bone, and reportedly reduces operation time compared with the conventional lateral approach. Therefore, Summers' osteotome-based technique is considered more conservative and less invasive than the lateral approach for sinus floor elevation.[3] However, Summers' technique is associated with certain disadvantages, including possible perforation of the Schneiderian sinus membrane and intraoperative patient discomfort due to the tapping procedure. Moreover, benign paroxysmal positional vertigo (BPPV) may occur during osteotome-mediated sinus floor elevation (OSFE), although this complication is relatively rare. For example, the incidence of Schneiderian membrane perforation ranges from 10% to 33% depending on initial bone height,[4] whereas the incidence of OSFE-related BPPV is less than 3%.[5] Nonetheless, several cases of iatrogenic BPPV were recently documented during the osteotome-mediated preparation of the implant bed. Despite the fairly low incidence of BPPV, its symptoms, including severe dizziness and nausea, can be very unpleasant for the patient.[6-9]

Recently, a specially designed reamer with one cutting edge and one reaming edge was developed to minimize the possibility of damage to the sinus membrane and to overcome complications related to the osteotome technique. A 2-year retrospective study published in 2012 evaluated the application of the reamer-mediated technique in the placement of 391

implants in 380 patients. Based on the results of the study, the authors concluded that the reamer-mediated technique was less invasive than the osteotome-mediated technique, resulting in diminished patient discomfort during surgery.[10] However, no comparisons of implant survival or complication rates were made when using a reamer versus an osteotome for transalveolar sinus floor elevation. Furthermore, no data were available regarding the bone level changes after reamer-mediated sinus floor elevation (RSFE) throughout the 2-year observation period.

Accordingly, the aims of the current retrospective analysis were to assess and compare the 2-year outcomes for RSFE and OSFE. Surgical and post-operative complications (i.e., Schneiderian membrane perforation, nasal bleeding, headache, and dizziness), bone level changes, and implant survival were utilized as measures of comparison.

Materials and methods

Study design

This investigation was a retrospective survey of patients who received sinus floor elevation via OSFE (control group) or RSFE (experimental group) between 2008 and 2010. The patients were analyzed to identify bone augmentation materials and implant types, and to assess changes in pre- versus post-operative endosinus bone height, the presence of membrane perforations, intra- and post-operative complication rates, and implant survival rates.

Inclusion criteria for enrollment in the study were as follows:

(1) Implant treatment in the posterior maxilla.

(2) An RBH of > 3 mm and < 10 mm at the planned implant site.

(3) Achievement of implant primary stability.

(4) Patient enrollment in regular supportive periodontal therapy at 6-month intervals,

including attainment of orthopantograms.

The study design was approved by the Ethics Committee at Asan Medical Center (Seoul, Korea).

Standard protocol

To the best of the authors' knowledge, the following protocol was followed for all patients. However, given the retrospective nature of this study, it cannot be ensured that a specific protocol was respected for every patient.

- Diagnosis and treatment planning, including attainment of pre-operative orthopantograms.
- Sinus floor elevation was performed by using either the OSFE or RSFE technique, with simultaneous implant placement (n = 126 total implants, 61 RSFE- and 65 OSFE-placed implants).
- Attainment of post-operative orthopantograms at 6-month intervals.
- Implant uncovery and healing abutment connection after a healing phase of 4–6 months.
- Prosthetic rehabilitation.
- Patient follow-up at intervals of ≤ 6 months, including recall checks and performance of orthopantograms.

Sinus floor elevation was performed by using either an osteotome (Osseotite, Biomet 3i, Palm Beach Gardens, FL, USA) or a specially designed reamer (Hatch-Reamer®, Sinustech, Seoul, Korea). The RSFE technique was previously described[10] and is briefly presented as a schematic diagram in Figure 1. Schneiderian membrane perforation was verified by visual examination and by the Valsalva maneuver test during the surgical procedure, and reconfirmed with a post-operative orthopantogram after the surgery was completed. When a membrane perforation was detected during surgery, the sinus-lifting OSFE or RSFE

procedure was aborted, the wound was closed, and the surgery was again attempted at a later date. All procedures were performed by faculty members of the Department of Periodontics, Asan Medical Center, or by residents in the same department with direct supervision from faculty members.

Bone augmentation materials and implant types

Bovine bone mineral material (Bio-Oss®, Geistlich Pharma AG, Wolhusen, Switzerland) with a small particle size (0.25–1.0 mm) was preferentially used for both sinus floor elevation procedures. The bovine bone material was employed for 56/65 (86.2%) OSFE-placed implants and 47/61 (77%) RSFE-placed implants. In some cases (2/65 (3.1%) and 9/61 (14.8%) OSFE- and RSFE-placed implants, respectively), a mixture of bovine bone material and autogenous bone collected during the drilling process was employed. Alternatively, no grafting material was used. The latter situation accounted for 7/65 (10.8%) OSFE-placed implants and 5/61 (8.2%) RSFE-placed implants.

One to six implants were placed per patient. The average number of implants per patient was 1.4 for OSFE patients and 1.5 for RSFE patients. Various implant systems were used, including 77 Branemark implants (Nobel Biocare, Göteborg, Sweden), 29 Astra implants (Astra Tech AB, Mölndal, Sweden), 13 Osstem implants (Osstem Implant C., Busan, Korea), and 7 Implantium implants (Dentium Co., Ltd., Seoul, Korea). All implants were loaded for at least 6 months.

Radiographic analysis

Radiographic analysis was performed by an investigator blinded to the type of surgical procedure. Orthopantograms, which were taken before surgery, immediately after surgery, and at 6, 12, and 24 months postoperatively, were used to measure the RBH, endosinus bone

gain, and change of endosinus bone height at the mesial and distal sides of the implant. To improve image analysis, image enhancement operations, such as sharpening, brightness, and contrast manipulations, were performed as necessary. Internal calibration was performed for each radiograph by measuring the length of the implant(s). The precision of the measuring system was 0.1 mm.

Documentation and statistical analysis

The number of membrane perforations and the occurrence of intra- and post-operative complications (i.e., nasal bleeding and patient discomfort, including headache and dizziness) were chosen as primary outcomes. Statistical evaluations were performed by using SPSS software for Windows, version 16 (IBM Corp., Armonk, NY, USA). The chi-square test and the repeated measures analysis of variance (ANOVA) were used to compare the implant survival rate, intra- and post-operative complication rates, and bone level changes between the OSFE and RSFE groups. The implant survival rate was determined by using the Kaplan-Meier technique. To evaluate intra-examiner agreement, the intraclass correlation coefficient (ICC) was calculated by comparing two series of measurements collected at 4-week intervals. Descriptive statistics are presented as the mean ± the standard deviation (SD). Values of $P < 0.05$ were considered statistically significant.

Results

From 2008 to 2010, 126 implants were placed simultaneously with sinus floor elevation in 85 patients (43 females and 42 males; mean age = 58.1 ± 10.2 years, age range = 21–78 years). The OSFE technique was used to place 65 implants in 45 patients, and the RSFE technique was used to place 61 implants in 40 patients. The implant diameters ranged from 4.0 to 5.0 mm and the implant lengths ranged from 8 to 13 mm. The patient demographics,

implant characteristics, and technical baseline data are shown in Table 1.

Pre-operative and post-operative orthopantograms revealed a significant degree of vertical bone gain after both types of sinus floor elevation (Fig. 2). Overall bone gains were 5.6 ± 2.3 mm in the OSFE group and 5.7 ± 1.5 mm in the RSFE group. A reduction in the augmentation height was observed in a high percentage of cases, and mainly occurred within the first 6 months after surgery. However, no significant differences were found in bone level changes between the two groups throughout the 2-year observation period ($p = 0.164$). Details of the bone level changes are shown in Figure 3. The ICC was 0.99, indicating excellent agreement between repeated measurements.

The most frequent surgical complication was rupture of the Schneiderian membrane, which occurred in three of the OSFE cases, but not in any of the RSFE cases; however, the difference between the two groups was not statistically significant ($p = 0.244$). None of the punctured lesions required special treatment, and all healed spontaneously. Other post-operative complications (e.g., nasal bleeding, post-operative headache, and dizziness) were noted in 7/45 (15.6%) OSFE cases and 3/40 (7.5%) RSFE cases. BPPV was not discerned in the present study, although one case of pronounced dizziness occurred in the OSFE group immediately after surgery. Nevertheless, this complication resolved within 2 weeks (Table 2).

Two implants (one in the OSFE group and one in the RSFE group) failed due to loss of osseointegration after prosthetic rehabilitation. After 2 years of follow-up, the implant survival rates were statistically similar between the two groups, at 98.5% for the OSFE group and 98.4% for the RSFE group.

Discussion

This study retrospectively analyzed 126 implants (n = 65 OSFE-placed implants and 61 RSFE-placed implants) placed simultaneously with transalveolar sinus floor elevation in 85

patients (n = 45 OSFE patients and 40 RSFE patients) over a 2-year follow-up period. The outcomes and complications of the RSFE and OSFE techniques were evaluated and compared.

The basic principle of the reamer-mediated technique is based on the repetitive action of its cutting and reaming edges. A thin bone shell, known as a "hatch", prevents direct contact between the reamer and the sinus membrane, and thus, the chance of membrane perforation is slight.

Numerous studies have shown that the RBH and sinus floor augmentation influence the survival rate of implants. For example, Rosen et al.[11] reported a 96% survival rate for 174 osteotome-placed implants when the RBH was ≥ 5 mm, but noted a decrease from 96% to 85.7% survival when the RBH was ≤ 4 mm. Furthermore, a recent systematic review summarizing 19 studies through meta-analysis estimated a survival rate for osteotome-placed implants of 92.8% after a mean follow-up time of 3.1 years,[12] while an earlier systematic review of implants placed in transalveolar sinus floor-augmented sites reported a 96% survival rate after a follow-up time of 3 years.[13] Implant survival rates in the current study were > 98% for both OSFE- and RSFE-placed implants, which is higher than that documented in the earlier studies. However, due to the relatively small sample size and short observation period employed in the present study, comparisons with previous literature must be made with caution.

The current investigation showed that the grafted area above the implant significantly decreased from immediate post-operative values of 13.1 ± 1.4 and 12.6 ± 1.0 mm for the OSFE and RSFE groups, respectively, to 11.8 ± 0.9 and 11.7 ± 0.9 mm at 1 year postoperatively. These results are in good agreement with those from other studies.[14-16] The reduction in graft height stabilized after 1 year, and no significant differences were observed

between the 1- and 2-year bone levels.

Tan et al.[12] reported that Schneiderian membrane perforation was the most common surgical complication of implant placement with simultaneous sinus floor elevation, varying from 0% to 21.4%, with a mean value of 3.8%. Three perforations occurred in the current OSFE group (6.7%), and were in each case associated with a diminished RBH (≤ 5 mm) and a small opening to the sinus cavity. However, these ruptures healed spontaneously without the need for further treatment, and they did not adversely affect implant survival. No detectable perforations were observed in the RSFE group, and the rate of membrane perforation was statistically similar between the OSFE and RSFE groups. Importantly, complications encountered during transalveolar sinus floor elevation were fewer in the RSFE group than in the OSFE group. Therefore, the use of a reamer rather than an osteotome apparently circumvented some of the negative aspects associated with the osteotome tapping procedure.

Although the present analysis did not reveal any episodes of BPVC, this condition has been reported in several previous studies as a post-operative complication of OSFE. The tapping procedure utilized during OSFE may cause transmission of percussive forces on the upper maxilla, followed by displacement of detached crystalline particles of calcium carbonate termed otoliths into the posterior semicircular canal. The floating of the detached otoliths in the endolymph system can subsequently lead to vertigo.[6,17,18] The reaming action does not produce such percussive forces, and is therefore expected to reduce the incidence of otoliths and iatrogenic BPPV. However, this hypothesis requires evaluation in a larger patient cohort.

With respect to patient perceptions, Pjetursson et al.[19] disclosed that 23% of the patients included in their study reported OSFE as an unpleasant experience, and 5% of the patients experienced vertigo, nausea, and disorientation after the osteotome procedure. Conversely, Ahn et al.[10] investigated a cohort of RSFE patients and found that only 2.4% (9/380) of the patients who underwent RSFE complained of discomfort during the reamer-mediated

procedure and, moreover, that the discomfort was minimal. The authors concluded that the reamer-based technique attenuated patient discomfort during the lifting surgery, while generating comparable clinical outcomes as those achieved with OSFE. Likewise, the current RSFE group exhibited fewer surgical and post-operative complications than the OSFE group, but showed similar clinical and radiographic results.

Because an irrigation system is unnecessary during RSFE, autogenous bone chips are removed and collected via the vertical groove during the reaming procedure. The collected autogenous bone chips can be used together with an additional bone grafting material for sinus augmentation, according to the preference of the operator. The current retrospective analysis revealed that a bovine bone material, Bio-Oss®, was used in the majority of OSFE and RSFE cases, whereas a mixture of autogenous bone plus bovine bone mineral was used in only 11/85 (12.9%) of the combined OSFE and RSFE cases (n = 2 OSFE patients and 9 RSFE patients). In the latter situation, the percentage of bone substitute material generally exceeded that of autogenous bone.

Sinus floor elevation was performed without bone grafting in 12/85 patients, and mainly in cases with adequate RBH (≥ 8 mm). Other investigators have suggested that elevation of the Schneiderian membrane creates a space in which a clot is stabilized, potentially stimulating peri-implant bone formation.[20, 21] More recently, Nedir et al.[22] concluded that a grafting material is not required to achieve bone gains of at least 3 mm in the atrophic maxilla, and that bone grafting is therefore not a prerequisite for bone formation beneath the sinus membrane.

This study is associated with certain limitations. Due to the inherent weakness of the retrospective study design, some important factors, such as the inclusion criteria for the use of bone grafts, the selection of bone grafting materials, and the choice of implant type, were not standardized. In addition, no radiographic analysis with three-dimensional (3D) projection

was available, which is much more accurate and reliable than the currently employed orthopantograms. Instead, changes in bone height around the implant were only analyzed by using post-operative orthopantograms with two-dimensional (2D) projection.

Conclusions

The survival rate of implants placed via a reamer-mediated technique was comparable to that of implants placed via an osteotome-mediated technique. Therefore, RSFE is a reliable and predictable procedure for implant insertion in the posterior maxilla, with a low incidence of intra- and post-operative complications. Nevertheless, further studies in a larger patient cohort are warranted to better understand long-term implant survival and patients' perceptions of OSFE versus RSFE.

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Tables

Table 1 Patient demographics, implant characteristics, and technical baseline data.

Patient demographics and implant characteristics	**OSFE**	**RSFE**
Patient (n)	45	40
Implant (n)	65	61
Gender		
Female (n)	22	21
Male (n)	23	19
Age (years, mean ± SD)	59 ± 9.5	57 ± 10.7

Number of implants		
First premolar	3	2
Second premolar	14	10
First molar	33	36
Second molar	15	13
Implant diameter (d)		
4 mm	41	20
4 < d < 5 mm	4	0
5 mm	20	41
Implant length		
< 10 mm	3	0
10–11mm	20	32
11–12 mm	35	29
>12 mm	7	0
Residual alveolar bone height (mm)	7.4 ± 1.6	6.9 ± 1.5
Observation period (months)	35.7 ± 11.7	27.7 ± 9.7

OSFE, osteotome sinus floor elevation; RSFE, reamer-mediated sinus floor elevation; SD, standard deviation.

Table 2 Incidence of surgical complications.

Complication	OSFE (n = 45 patients)		RSFE (n = 40 patients)	
	Patients (n)	%	Patients (n)	%
Intraoperative complications				
Rupture of the Schneiderian membrane	3	6.7	0	0.0
Post-operative complications	7	15.6	3	7.5
Nasal bleeding	3	6.7	2	5.0
Post-operative headache	3	6.7	1	2.5
Dizziness	1	2.2	0	0.0
BPPV	0	0.0	0	0.0

BPPV, benign paroxysmal positional vertigo; OSFE, osteotome sinus floor elevation; RSFE, reamer-mediated sinus floor elevation.

Figures

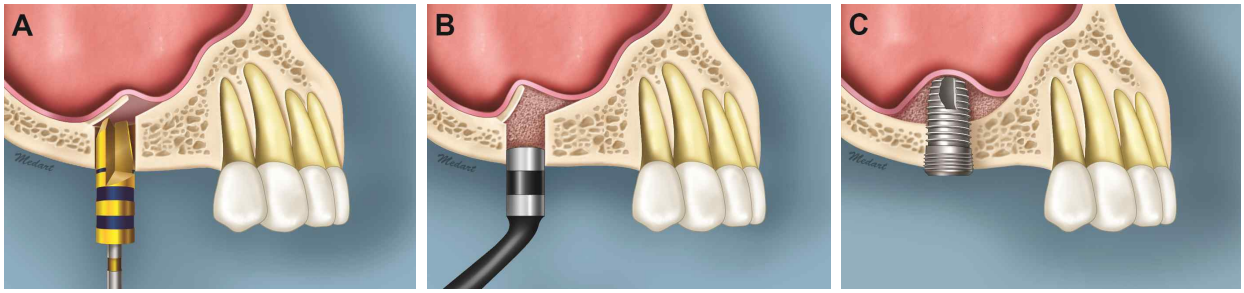

Fig. 1. Illustration of the reamer-mediated sinus floor elevation (RSFE) procedure. (A) Sequential enlargement and sinus floor lifting is performed by using a series of reamers with increasing diameters. As a result, the "hatched" cortical bone elevates the sinus membrane. (B) Bone grafting is performed by using a condenser, and the membrane is elevated by pushing the graft into the sinus. (C) The implant is positioned at the prepared site.

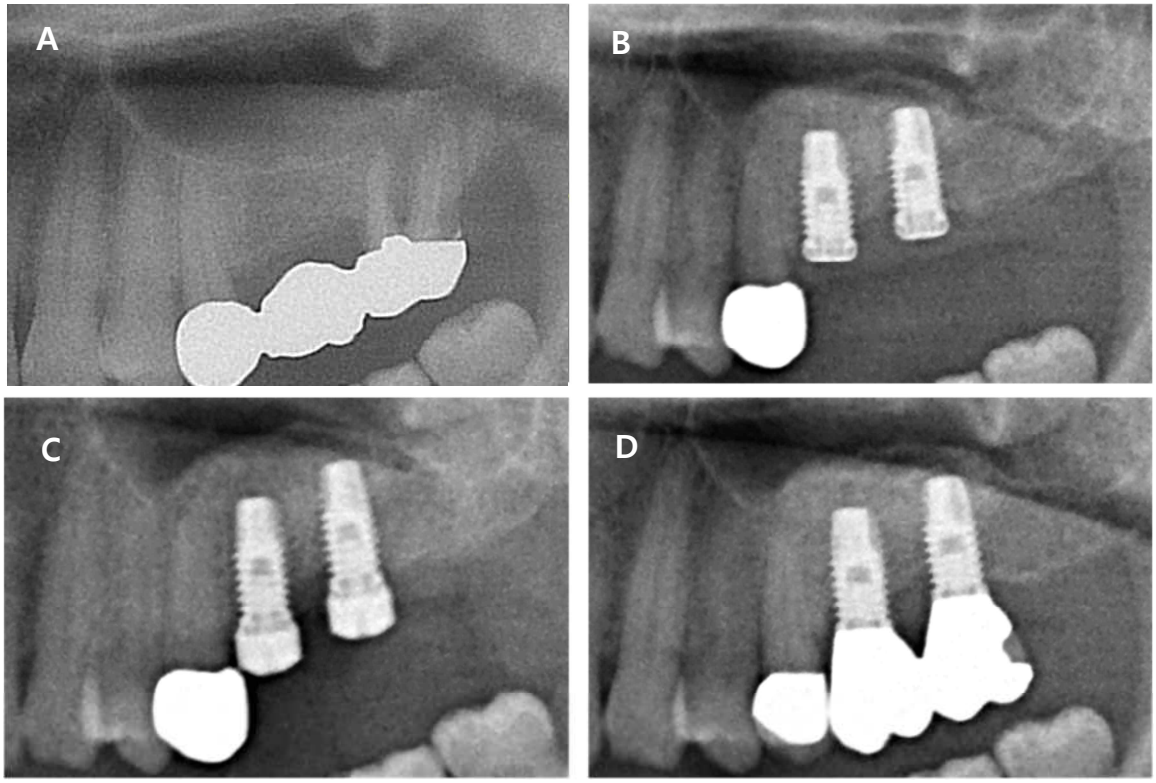

Fig. 2. Clinical case of a 52-year-old male patient. A) Pre-operative orthopantogram of the maxillary left molar area. The residual bone height (RBH) was 5–6 mm. B) Radiograph immediately after surgery. C) Post-operative radiograph at 6 months. D) Post-operative radiograph at 12 months.

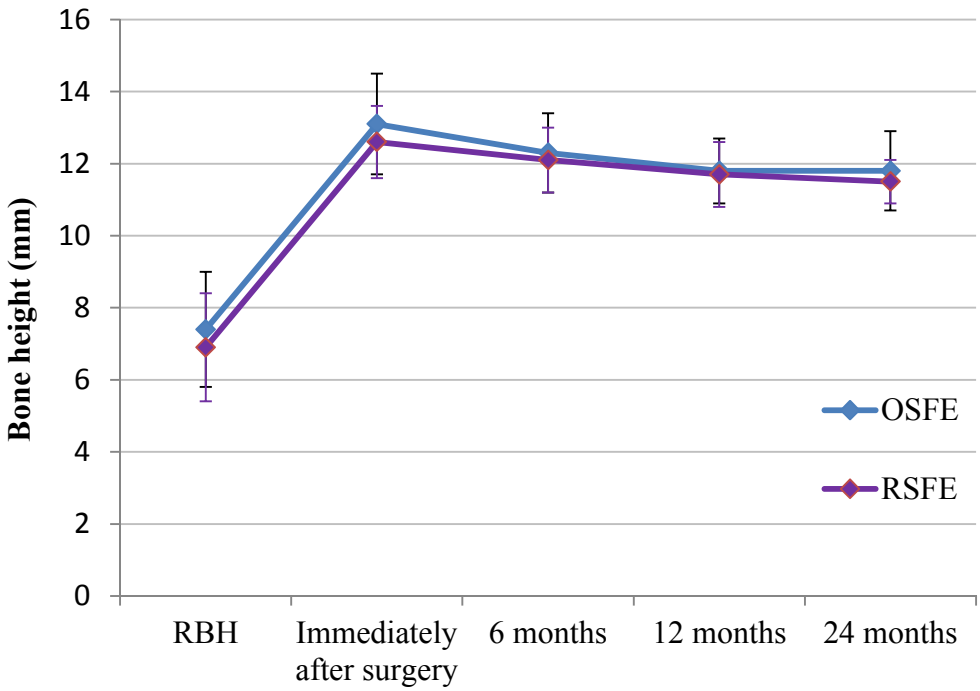

Fig. 3. Bone level changes in the OSFE and RSFE groups. OSFE, osteotome sinus floor elevation; RSFE, reamer-mediated sinus floor elevation; RBH, residual bone height.