Three-Year Clinical and Radiographic Implant Follow-up in Sinus-Lifted Maxilla With Lateral Window Technique

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Introduction: *The aim of this study was to evaluate retrospectively the 3-year outcome of implants placed in augmented maxillary sinuses with minimal residual alveolar bone heights (≤3 mm).*

Materials and Method: *A total of 28 sinus floors were augmented with xenograft, and 58 implants were placed. The outcome measures were implant success based on implant stability and the absence of periimplantitis, and marginal and apical bone resorption on periapical radiograph and prosthesis survival.*

Results: *Fifty-seven of 58 implants with their prostheses remained functional with a success rate of 98.28%. None of the implants showed any signs of mobility or periimplantitis. Both apical and cervical bone resorption around the implants were highest by the end of the first year.*

Conclusions: *The success rate of the implants placed with staged approach in augmented maxillary sinuses with the residual alveolar bone height of ≤3 mm was high in a 3-year term. Bio-Oss is an acceptable substitute autogenous bone and can be used as an augmentation material during the maxillary sinus lift procedure. (Implant Dent 2016;25:214–221)*

Key Words: sinus floor elevation, bone substitute, long-term implant follow-up

Dental implant placement to the posterior edentulous maxilla can be challenging due to the pneumatization of the maxillary sinus and low-quality bone. Many studies have addressed this problem, and numerous techniques for maxillary sinus floor augmentation have been presented. Short dental implants, having an intrabony length of 6 mm or more, are used as an alternative to the sinus lift procedure.[1] However, when the residual alveolar bone height is <6 mm, maxillary sinus lift procedure is mandatory. This surgical procedure by the maxillary lateral wall approach is well documented and proved to be safe to increase bone volume in the maxillary sinus floor by the elevation of the Schneiderian membrane.[2] The procedure is referred to as 1 staged when the implants and graft are placed simultaneously, whereas in the 2-stage procedure, implant placement is delayed for several months to allow graft maturation.[3,4] Although the simultaneous approach has been advocated by several studies,[2,5] the decision whether implants can be placed simultaneously with sinus floor elevation or a staged approach should be preferred is depend on the amount of available residual alveolar bone.[6] When it is more than 3 mm and adequate primary stability is ensured, implants can be placed simultaneously with the sinus lift surgery.[2,7–11] In case, if the residual bone height is ≤3 mm, staged approach (2-stage surgery) is a better option with a higher implant success rate.[12,13] Implant success for simultaneous approach ranges between 64% and 98%,[6,14,15] whereas the success rate of staged approach is 92% to 100%.[6,12,16]

Several biomaterials have been advocated with trustable results for sinus lift procedures when used alone or mixed with autogenous bone grafts.[2,7,10,17,18] Autogenous bone grafts have osteogenic, osteoconductive, and osteoinductive capacities,[3,4] and they can be harvested intraorally or extraorally. However, the amount of bone graft that is harvested from intraoral donor sites is limited, and extraoral donor sites have considerable postoperative morbidity.[19] Also, the autogenous bone graft, used in the sinus augmentation procedure, may lose its initial volume up to 49.5% during the healing period.[20] To overcome these disadvantages of the autogenous bone, many different bone biomaterials have been proposed, such as xenografts.[3,21] Besides, in recent years, the idea of a graftless maxillary sinus augmentation, but patient's blood usage, has evolved.[22] However,

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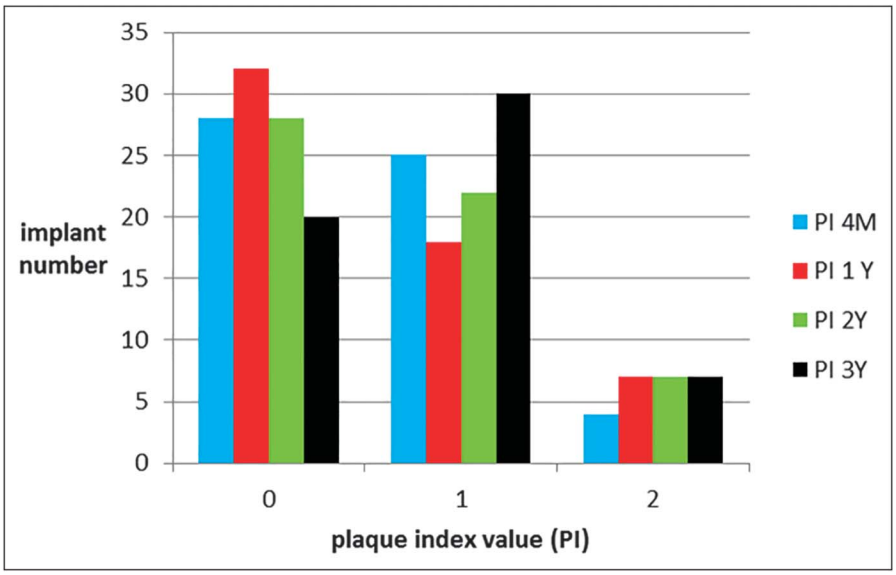

Fig. 1. The plaque index values of studied implants at 4-month, 1-year, 2-year, and 3-year follow-up periods. At 4 months, 1 year, and 2 years of follow-up, implants with plaque index value scored 0 was the highest.

simultaneous implant placement and residual alveolar bone height of >3 mm is necessary for graftless maxillary sinus augmentation technique.[7]

Long-term success or survival of dental implants is directly related to the health of periimplant tissues. Periimplant diseases can occur in 2 different forms: periimplant mucositis and periimplantitis. Periimplant mucositis is an inflammatory response of the soft tissue around the implant and is reversible when treated. In contrast, periimplantitis can be irreversible and defined as an inflammatory process affecting the tissues around an osseointegrated implant in function, resulting in the loss of supporting bone. Crestal bone resorption of less than 1.5 mm during the first year after loading and 0 to 0.2 mm annually thereafter is acceptable for a successful implant.[23] However, marginal bone resorption greater than 3 mm combined with bleeding on probing or the presence of purulence, and swelling and redness of the gingival tissue are the signs of periimplantitis.[24] Hence, initially recorded clinical and radiographic data at the time patients received their prosthesis will be the reference from which the development of periimplantitis can be recognized and followed in subsequent examinations.

Implant should serve as a prosthetic abutment with ideal clinical conditions for a period of at least 12 months to label as successful.[25] After the prosthetic restorations are in function, there should be no or limited bone resorption, and implants that are placed in a grafted maxillary sinus should stay stable. This retrospective study describes clinically and radiographically the 3-year outcome of 58 implants placed in 28 grafted maxillary sinuses *via* the staged approach in a patient population with residual alveolar bone height of ≤3 mm.

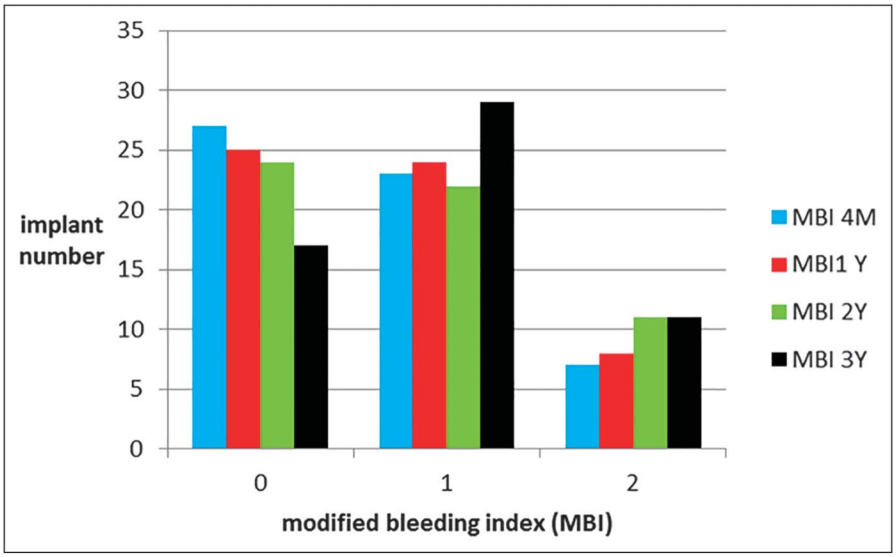

Fig. 2. The modified bleeding index of studied implants at 4 months, 1 year, 2 years, and 3 years of follow-up. At the end of the 3-year follow-up period, implants scored 1 was the highest.

MATERIALS AND METHODS

Patient Population

A total of 58 implants were placed in 28 augmented maxillary sinuses of 24 patients (9 women and 15 men) presenting severe atrophy of alveolar process in the posterior maxilla with ≤3 mm of residual alveolar bone. The mean age of the patients was 48 years with a range of 19 to 78 years. In 20 patients, a unilateral procedure was performed, and 4 underwent bilateral surgery. Seventeen of the patients included in the study were systemically healthy, 7 of them had mild systemic diseases, and 10 of them were smokers. Patients with poor oral hygiene, bruxism, drug or alcohol abuse, and heavy smokers were not included in the study. Panoramic radiographs and computed tomography scans were taken preoperatively to determine the presence of any ongoing pathology in the mucosal lining, the height and width of residual bone, the location of the sinus floor and anterior wall, and the existence of septa. Patients with sinus pathology were excluded. In all cases, written informed consent was obtained previous to maxillary sinus lift and implant surgeries. Preoperative antibiotics were

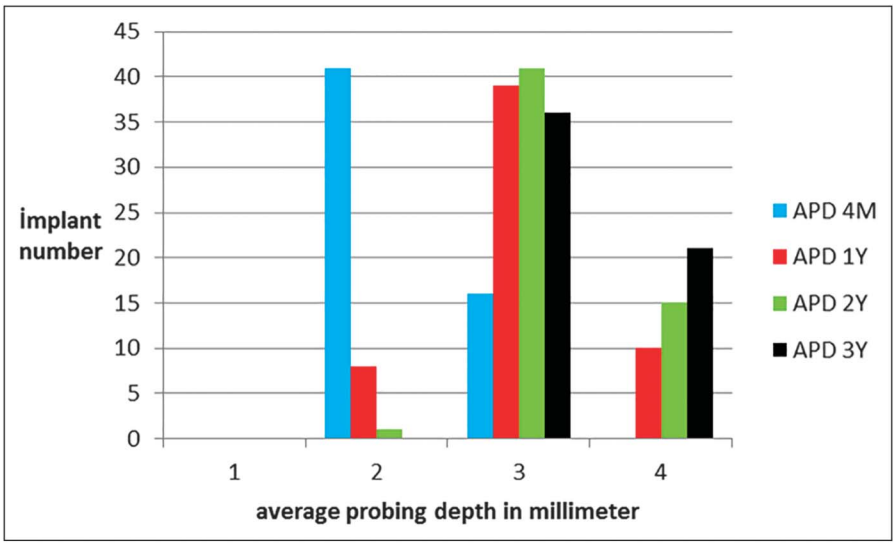

Fig. 3. The average probing depths of studied implants at 4 months, 1 year, 2 years, and 3 years of follow-up periods. Thirty-six implants had 3 mm of average probing depth, and the rest 21 ones had 4 mm of average probing depth at the end of the 3 years.

orally administered 1 hour before the surgery and continued for 7 days postoperatively. Amoxicillin-clavulanic acid (2 g per day) was the first choice of antibiotic, and in case of allergy, clindamycin (600 mg per day) was administered.

Surgical Technique

All surgical procedures were performed under local anesthesia by the same surgeon. The edentulous posterior maxilla with the lateral maxillary sinus wall was exposed *via* a crestal incision and mucoperiosteal flap elevation. An osteotomy was performed on the lateral wall of the sinus with a number-4, round, diamond bur under saline irrigation. After the Schneiderian membrane was exposed, specially designed curettes were used to carefully elevate the sinus membrane with its attached maxillary cortical plate in all directions. The osteotomy size was sufficient enough to allow good access for the dissection and elevation of the sinus membrane and insertion of the graft material. Bovine bone (Bio-Oss, Geistlich Pharma, Wolhusen, Switzerland) was used as graft material, and the defect of the lateral sinus wall was covered by a resorbable collagen membrane (Bio-Gide, Geistlich Pharma, Wolhusen, Switzerland). The mucoperiosteal flap was repositioned and sutured. Even though all surgical procedures were performed with high accuracy to avoid perforation of the sinus membrane, we experienced 5 minor perforations. None of the patients needed further bone augmentation. Patients were followed up at the first and the fourth weeks for any signs of sinus infection postoperatively. After 8 months of healing period, the new alveolar bone height of each patient was radiographically assessed with Panorex (Sirona, Bensheim, Germany). A total of 58 screw-type titanium implants, 38 Straumann bone level with SLA surface and 20 Camlog screw line, were inserted in accordance with the conventional implant surgery protocol.

Table 1. Statistic Analysis of Bone Resorption at the Implant Apex by Time

	Implant Apex/Sinus Floor Distance (Mean ± SD)	*Post Hoc* Test
At loading	1.46 ± 0.55	
4th mo	1.34 ± 0.54	At loading >4th mo–1st y–2nd y–3rd y†
1st y	0.97 ± 0.56	4th mo >1st y–2nd y–3rd y†
2nd y	0.92 ± 0.56	1st y >2nd y–3rd y†
3rd y	0.92 ± 0.56	
‡*P*	**0.001**†	

Significant bone resorption at the apex of each implant was seen between the 4-month and 1-year follow-up periods with a mean value of 0.49 ± 0.19 mm ($P < 0.01$).
*Adjustment for multiple comparisons: Bonferroni.
†$P < 0.01$.
‡Repeated-measures analysis of variance.

Clinical Follow-up Protocol

Patients received their prosthetic restorations and their first periapical radiographic images 3 to 4.2 months after implant surgery. Following implant loading, patients were examined clinically and radiographically 4 months later and thereafter annually.

The outcome measures were implant success, cervical and apical bone resorption, and prosthetic survival within 3 years of period. Implant success was clinically evaluated based on the stability of the implant and signs of periimplantitis. Implant mobility was tested manually using the handles of 2 dental mirrors. Periimplantitis criteria were evaluated based on the following clinical parameters: modified plaque index (scored 0–3; 0 = no plaque, 1 = plaque recognized only by running a probe around the marginal surface of implant, 2 = plaque is visible to naked eye, 3 = abundance of soft matter), modified bleeding index (scored 0–3; 0 = no bleeding when probing, 1 = isolated bleeding spot, 2 = a confluent blood line on the margin, 3 = heavy or profuse bleeding),[9] probing depth that was calculated based on the average of the 4 obtained values of 4 surfaces of each implant, and the presence or absence of suppuration.

The most commonly used clinical method to assess the marginal bone level and its change over time is the conventional periapical radiograph. Hence, in this study, the cervical and apical bone resorption by time was evaluated by digital periapical radiograph (Dürr Dental, Bietigheim-Bissingen, Germany). Digital periapical radiographs were taken based on the long-cone paralleling technique with a film holder, and all measurements were performed on these images. Implant lengths were used for calibration. Clear images on both sides of the implants, marginal and apical regions, were obtained on the same film. The marginal

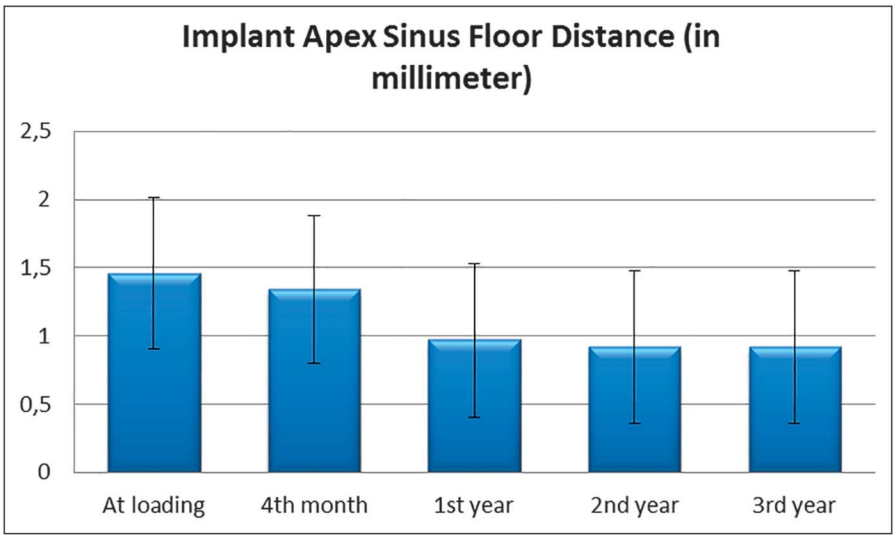

Fig. 4. Change in bone volume at implant apex by time. The highest and statistically significant bone resorption at the apex of each implant was only seen between the 4-month and 1-year follow-up periods.

bone level changes over time were evaluated based on the bone resorption on the mesial and distal aspects of the implants, whereas the apical bone level changes were evaluated based on bone resorption at the most apexes of the implants. Cervical bone resorption of each implant was calculated by the change in the distance between the implant abutment-prosthesis junction and the bone tissue-implant surface junction at each follow-up periapical radiographic examination. Likewise, the apical bone resorption of each implant was calculated by the change in the distance between the new sinus floor and the most apical point of the implant. Measurements were made digitally with a millimeter scale on the radiographs.

Patients received either fixed prosthetic restorations with metal ceramic crowns or implant supported bar retained removable prosthetic restorations. Prosthesis that fulfilled its function without any discomfort was considered as a successful restoration.

Statistical Analysis

The IBM SPSS 22 (IBM SPSS, Istanbul, Turkey) program was used for statistical analysis. Repeated-measures test was used to analyze the bone resorption between loading time and each follow-up visit, whereas the adjustment for multiple comparisons, Bonferroni test, was used to evaluate the bone differentiation between 4-month, 1-year, 2-year, and 3-year follow-up.

Table 2. Statistic Analysis of Bone Resorption at the Implant Mesial Cervical Region by Time

	MCB (Mean ± SD)	*Post Hoc* Test
At loading	1.69 ± 0.32	
4th mo	2.05 ± 0.36	At loading <4th mo–1st y–2nd y–3rd y†
1st y	2.66 ± 0.41	4th mo <1st y–2nd y–3rd y†
2nd y	2.84 ± 0.42	1st y <2nd y–3rd y†
3rd y	2.87 ± 0.4	2nd y <3rd y†
‡*P*	**0.001**†	

During the 4-month, 1-year, 2-year, and 3-year follow-up examinations, the average cervical bone resorptions at the mesial aspect of implants were 0.36 ± 0.16, 0.97 ± 0.21, 1.15 ± 0.26, and 1.18 ± 0.25 mm, respectively.
*Adjustment for multiple comparisons: Bonferroni.
†$P < 0.01$.
‡Repeated-measures analysis of variance.

Table 3. Statistic Analysis of Bone Resorption at the Implant Distal Cervical Region by Time

	DCB (Mean ± SD)	*Post Hoc* Test
At loading	1.76 ± 0.26	
4th mo	1.96 ± 0.34	At loading <4th mo–1st y–2nd y–3rd y†
1st y	2.64 ± 0.35	4th mo <1st y–2nd y–3rd y†
2nd y	2.83 ± 0.35	1st y <2nd y–3rd y†
3rd y	2.92 ± 0.34	2nd y <3rd y†
‡*P*	**0.001**†	

During the 4-month, 1-year, 2-year, and 3-year follow-up examinations, the average cervical bone resorptions at the distal aspect of implants were 0.19 ± 0.32, 0.88 ± 0.23, 1.07 ± 0.24, and 1.16 ± 0.25 mm, respectively.
*Adjustment for multiple comparisons: Bonferroni.
†$P < 0.01$.
‡Repeated-measures analysis of variance.

RESULTS

The surgical treatment procedures were well tolerated by the patients under local anesthesia. Before any treatment, every patient had a residual alveolar bone height of ≤3 mm. However, after sinus lift surgery, the new alveolar bone heights ranged between 10 and 14.6 mm with a mean height of 11.9 ± 0.85 mm. In this retrospective study, the shortest implant that was placed in augmented maxillary sinuses was 9 mm, whereas the longest one was 13 mm in length. Implants were placed 8 months after the sinus lift surgery, and adequate primary stability of each implant was achieved in all cases. All implants were left to heal submerged for 3 to 4.2 months. One implant was lost before loading and excluded from the study. Thus, during the 36-month follow-up, 57 of 58 implants remained functional with a success rate of 98.28%. Other than 5 minor Schneiderian membrane perforations (18%), which were treated by a collagen membrane (Bio-Gide), no major postoperative complication had occurred. After sinus lift surgery, 19 of the 24 patients complained of mild pain and swelling. Due to the fact

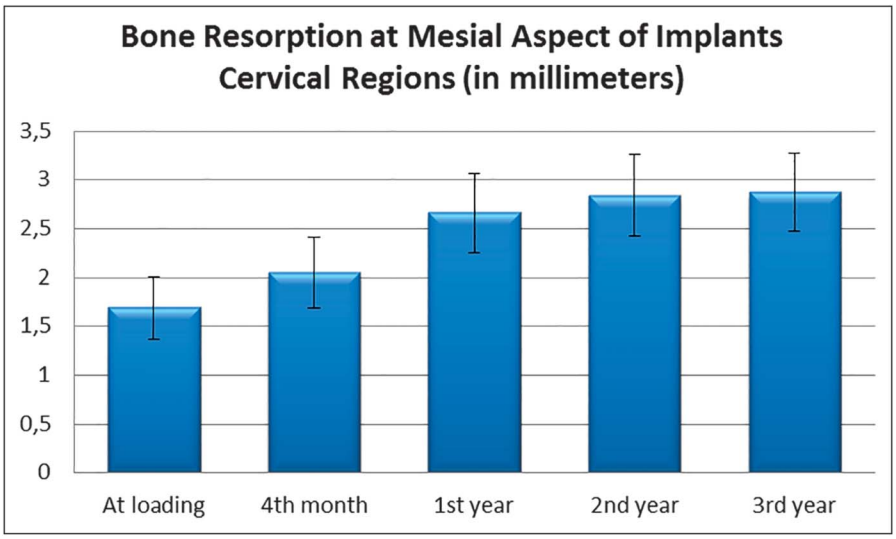

Fig. 5. Change in bone volume at the mesial aspects of implants by time. Statistically significant bone resorption was only seen between the 4-month and 1-year follow-up periods with a mean value of 0.97 ± 0.21 mm.

that only 1 implant was lost before loading, it was not possible to find any correlation between early implant failure and the complications.

Periodontal indices were used to evaluate the periimplant tissue health. Both the plaque index values and modified bleeding index values ranged from 0 to 2 during 4-month, 1-year, 2-year, and 3-year follow-up periods (Figs. 1 and 2). At 4-month, 1-year, and 2-year follow-up periods, the plaque index values and modified bleeding index parameters for the majority of implants were scored 0, whereas at the 3-year follow-up period, the majority of them were scored 1 (Figs. 1 and 2). The average probing depth at the implant sites for 4-month, 1-year, 2-year, and 3-year follow-up periods were 2.28, 3.05, 3.25, and 3.37 mm, respectively. None of the implants had an average probing depth of 4 mm at the 4-month follow-up period but lower (Fig. 3). Likewise, none of the implants had an average probing depth of 2 mm at the 3-year follow-up period but higher (Fig. 3). The average probing depth was 3 mm for 36 implants and 4 mm for 21 implants by the end of the 3-year follow-up period. Exudate, swelling, redness of the gingival tissue, and implant mobility were absent clinically.

The average distance between the implant apex and the newly formed sinus floor was 1.46 ± 55 mm at loading based on the radiographic images (Table 1). During the 4-month, 1-year, 2-year, and 3-year follow-up periods, the average apical bone resorptions were measured as 0.12 ± 0.09, 0.49 ± 0.19, 0.54 ± 0.21, and 0.55 ± 0.20 mm, respectively (Table 1). Radiographic change in the mean values of the distances between implant apexes and sinus floors by time were shown in Figure 4. Statistically significant bone resorption at the apex of each implant was observed only between the 4-month and 1-year follow-up periods with a mean value of 0.49 ± 0.19 mm ($P < 0.01$) (Table 1).

During the 4-month, 1-year, 2-year, and 3-year follow-up radiographic examinations, the average cervical bone resorptions at the mesial aspect of implants were measured as 0.36 ± 0.16, 0.97 ± 0.21, 1.15 ± 0.26, and 1.18 ± 0.25 mm, whereas at the distal aspect, the average cervical bone resorptions were 0.19 ± 0.32, 0.88 ± 0.23, 1.07 ± 0.24, and 1.16 ± 0.25 mm, respectively. Statistically significant bone resorption at the mesial and distal aspects of implants were seen only between the 4-month and 1-year follow-up periods with a mean value of 0.97 ± 0.21 and 0.88 ± 0.23 mm, respectively ($P < 0.01$) (Tables 2 and 3). The mean values of distances between the implant abutment-prosthesis junction and bone tissue-implant surface junction at the mesial and distal aspects during each follow-up period were shown in Figures 5 and 6.

There was no correlation between the implant brand and the amount of the bone resorption at both the cervical and apical regions. Cervically and apically, the highest amount of bone resorption occurred at the end of the first year of loading. None of the patients claimed

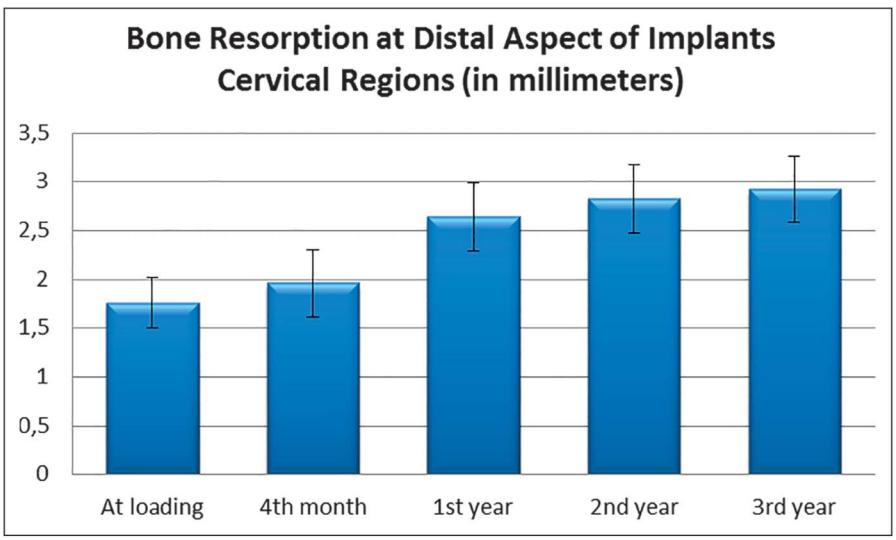

Fig. 6. Change in bone volume at the distal aspects of implants by time. Statistically significant bone resorption was only seen between the 4-month and 1-year follow-up periods with a mean value of 0.88 ± 0.23 mm.

discomfort or loss of function of the implant-supported prosthesis during the 36-month follow-up period.

DISCUSSION

Alveolar bone resorption after teeth removal, poor bone quality in the posterior maxilla, and pneumatization of the maxillary sinus often preclude implant placement or force placement of shorter implants. Because the success rate of sinus lift procedure is high, it has been performed to augment the sinus floor, thereby augmenting the alveolar ridge to place implant of sufficient length. Our study reveals that sinus floor augmentation can provide the necessary bone mass to place and stabilize implants of adequate length.

According to the International Congress of Oral Implantologists (ICOI) Pisa Implant Quality of Health Scale, the success criteria of an implant is represented by its optimal health conditions, which includes no pain in function or percussion, no implant mobility in any direction, no history of exudate, and less than 2 mm of cervical bone resorption radiographically.[25] Based on these criteria, this study demonstrated that implants placed in augmented maxillary sinuses with xenograft (Bio-Oss) in a patient population with a residual alveolar bone height of ≤3 mm have a success rate of 98.28% in the long term.

The survival rate of the implants placed in augmented maxillary sinuses *via* lateral window technique using different bone augmentation materials varies from 61.7% to 100% with an average rate of 91.8%.[9,26,27] Xenograft (Bio-Oss), as an alternative for autogenous bone, can be used alone for reconstructing the maxillary sinus and supporting the dental implant with a healing period of at least 5 months.[3,4,26,28,29] Oliveira et al[29] histologically showed that Bio-Oss particles were connected to each other *via* bone bridges and covered by the newly formed woven bone when used as graft material in maxillary sinus lift procedure. Thus, we preferred to use Bio-Oss as the graft material and placed the implants 8 months after sinus lift surgery.

The necessity of graft usage during sinus lift procedure is controversial.[2,7,27,30] Thor et al did not use any type of bone substance or autogenous bone but patients' blood during the sinus lift procedure together with simultaneous implant installation. Their study ended up with a survival rate of 97.7%.[5] Sohn et al[31] did a similar study to investigate the clinical, radiographic, and histologic results of new bone formation after membrane elevation in 10 maxillary sinuses and simultaneous placement of 21 dental implants without additional bone graft materials. However, in case of perforation of the sinus membrane or lack of primary stability of the implant, this surgical procedure cannot be successful due to the instability of the implants and/or blood clot within the maxillary sinus.

Based on the literature, sinus membrane perforation is the most common complication during sinus lift surgery with a complication range of 10% to 35%, especially in the presence of septa.[5,6,32] Different materials and techniques such as suturing or placing collagen membrane at the perforation site have been proposed to restore Schneiderian membrane.[6] When the membrane perforation is repaired properly, it has no effect on the success rate of the implant and has no connections to postoperative complications.[33] In this clinical study, Schneiderian membrane perforations, which were easily repaired with the collagen membrane, occurred in 5 (18%) of 28 maxillary sinus lift procedures.

Clinical and radiographic parameters are significant indicators for periimplant tissue health. The evaluation of the periimplant soft tissue condition include the assessment of several clinical parameters using the indices such as modified plaque index, modified bleeding index, and average probing depth.[34,35] According to ICOI Pisa Consensus that was published in 2007, there is a controversy in the literature regarding the benefit of probing around the implant sulcus with further study being needed in this area.[25] Lin et al[36] stated that the cervical bone resorption around the implant mostly occurred on the buccal site and followed by the distal, lingual, and mesial sites. Although computerized tomography is the first choice to evaluate the bone resorption at the buccal and lingual sites of implants, probing can also be performed. We preferred probing to prevent patients from further radiation exposure.

In this study, the periapical radiographs and the sulcus depths of the implants showed that after 1 year from loading, the bone in contact with the implant at the cervical and apical region remained statistically stable. Herzberg et al[37] found better marginal bone level behavior for implants placed in simultaneously with the sinus lift procedure compared with staged approach. However, there should be enough residual alveolar bone height to provide the primary implant stability. Jurisic et al[38] showed that implants placed in augmented maxillary sinuses have high survival rates within an observation period of 3 years, which correlates with the result of this study.

CONCLUSIONS

During the 3-year follow-up period, the prognosis of the implants placed at the posterior maxilla with augmented maxillary sinus was similar to those placed in pristine alveolar bone both clinically and radiographically. Thus, sinus floor elevation is a predictable treatment modality to insert dental implant *via* staged approach into the posterior maxilla with reduced residual vertical bone height of ≤3 mm. Because there is little research in the literature regarding bone resorption at the apex of the implants placed in augmented maxillary sinuses, the results of this study can be informative. Further clinical studies may focus on the long-term follow-up of implants placed in augmented maxillary sinus using different augmentation techniques and bone graft materials.

DISCLOSURE

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

APPROVAL

This study was approved by the Review Board of the Bezmialem-Vakif University Clinical Studies (Approval No. 71306642-050.01.04-2015-3026).

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