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Nasal Floor Augmentation for the Reconstruction of the Atrophic Maxilla: A Case Series

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Abstract

Purpose—The severely atrophic edentulous maxilla imposes a challenge for dental implant rehabilitation. Nasal floor augmentation (NFA) is a method of augmenting bone height in the anterior maxilla. Autogenous bone has been commonly used as a graft material. Because of variations in results and lack of insufficient studies reporting the use of bone substitutes to graft the nasal floor, this study aims to evaluate the survival and success of dental implants placed in nasally grafted maxillae with osteoconductive bone substitutes.

Materials and Methods—Six patients with completely edentulous maxillae and inadequate height in the anterior to support implants underwent NFA. The nasal floor was exposed through an intraoral approach and grafted with osteoconductive bone graft substitutes. Twenty-four dental implants were placed, restored with a bar-retained implant-supported overdenture after a traditional healing period, and followed up after prosthetic loading. Patient satisfaction was evaluated with a questionnaire, and responses were expressed on a visual analog scale from 1 to 10. Bone levels were quantified radiographically based on a score ranging from 1 to 3, where 3 represented the highest bone support. Implants were evaluated for thread exposure and soft tissue health and were considered successful if the following criteria were met: absence of mobility; lack of symptoms; bone score of 3; and healthy peri-implant soft tissue without thread exposure.

Results—The age of patients ranged from 48 to 84 years, with a mean of 71.2 years. Three patients underwent NFA and simultaneous implant placement, whereas the other 3 had a mean healing period of 6.5 months before implant placement. Post-loading follow-up ranged from 4 to 29 months, with a mean of 14.2 months. The implant survival rate was 100%, with no

complications. Ninety-three percent of the responses to the treatment satisfaction questionnaire had a score of 7 or greater. Bone scores ranged from 2 to 3, with 87.5% of implants having a score of 3 and 12.5% having a score of 2. None of the implants had a bone score of 1.

Conclusions—The use of osteoconductive bone substitutes for NFA, as shown in this small case series, is a reliable method for reconstruction of the anterior atrophic maxilla for implant-supported overdentures.

The rehabilitation of the atrophic edentulous maxilla presents a challenge because of the resorption patterns that occur after tooth loss. Disuse atrophy, hormonal-metabolic action, loading by dental prosthesis, traumatic occlusion, parafunctional habits, and iatrogenic causes have been described as causes for such resorption.¹ The end result is poor quality and quantity of residual bone. It has been estimated that only 0.1% of the global partially and totally edentulous population have benefited from treatment with dental implants,² and the number of elderly persons will increase.³ Complete dentures may have direct (residual ridge resorption and mucosal reactions) and indirect effects on the health of oral and denture-supporting tissues. Indirect effects include reduction in bite force, atrophy of masticatory muscles, dietary modifications, and impaired nutrition.^{4,5} Placement of dental implants to support a fixed or removable prosthesis is known to have a positive effect on minimizing bone resorption after tooth loss, in comparison with use of complete dentures.⁶

Dental implant placement in the anterior maxillary alveolar ridge is limited by the nasal cavity, and penetration of the implants can frequently occur.⁷ Maxillary onlay bone graft, interpositional bone graft (IPG) through a Le Fort I osteotomy, and nasal floor augmentation (NFA) by use of autogenous bone have been described as methods of reconstruction to permit dental implant placement in the atrophic maxilla.⁸⁻¹⁶ In 1987 Keller et al⁸ were the first authors to report on maxillary Le Fort I osteotomies with interpositional iliac crest bone graft and implant placement in the nasal cavity, as a 1- or 2-stage approach. Later, Sailer⁹ reported a modified approach where autogenous grafts are placed simultaneously with dental implants. In 1993 Tolman¹ described a method used at the Mayo Clinic to tackle advanced maxillary ridge resorption. After autogenous bone harvest from the mediosuperior iliac crest, an incision at the mucogingival junction of the premaxilla is made and the nasal mucosa is carefully dissected. The harvested autogenous block is then secured by strategically placed titanium fixtures.

Autogenous bone harvest has been associated with complications including donor-site morbidity, wound dehiscence, unpredictable graft resorption, and significant hemorrhage.^{8,17-19} In 1997 Garg¹⁴ described the NFA as a technique for implant placement in severely resorbed maxillae with less than 10 mm of residual ridge height. He advocated the use of intraoral donor sites for autogenous bone harvest to predictably lift the nasal mucosa 3 to 5 mm. He further recommended that implants be placed after consolidation of the graft. A modification of this technique was reported by Hising et al,²⁰ where a mixture of autogenous bone harvested from the chin, a bovine bone mineral, and a biologic adhesive was utilized for augmentation of 3 nasal cavities. A total of 5 implants were placed in these grafted sites after a mean healing period of 11.9 months, and all 5 were lost before or at the time of abutment connection. Mazor et al²¹ have recently reported on 32 consecutive

patients treated with nasal floor elevation and simultaneous dental implant placement, with a survival rate of 100%.

Given the variations reported in the literature when NFA is accomplished by use of autogenous bone grafts or bone graft substitutes and because of a lack of sufficient studies reporting the use of bone substitutes to graft the nasal floor, this study aims to evaluate the survival and success of dental implants placed in nasally grafted maxillae with osteoconductive bone substitutes.

Materials and Methods

This case series included 6 patients with completely edentulous maxillae and inadequate alveolar bone height to support dental implants. Local institutional review board approval was obtained for this study, and the study followed the guidelines outlined in the Helsinki Declaration. Patients were subjected to the pertinent diagnostic workup before surgery and were treatment planned for placement of 4 implants in the anterior maxilla for a bar-retained overdenture (Fig 1). In 3 patients the anterior maxillary alveolar ridge had adequate horizontal dimension but was deficient vertically, whereas the other patients had a combination of horizontal and vertical bone loss. The preoperative available bone height, according to computed tomography scans, ranged from 5.6 to 9 mm, with a mean of 7.7 mm, and the width ranged from 2.3 to 5.9 mm, with a mean of 4.1 mm (Table 1). Patients were treated with NFA at the University of California, Los Angeles Dental Implant Center under intravenous sedation over a period of 3 years. The piriform rim and the anterior nasal spine were exposed through an intraoral approach. A Woodson elevator and a modified Freer elevator were used for nasal mucosa elevation while the soft tissue and nasal septum attachment to the anterior nasal spine were maintained (Fig 2). The extent of posterior elevation was determined by the position of the most distal implants in the surgical template. For vertical augmentation, the nasal floor was grafted with particulate coral-derived bone graft substitute (Pro Osteon 200R; Biomet Biologics, Warsaw, IN) in 5 patients and with a mineralized freeze-dried bone allograft (Puros allograft; Zimmer, Carlsbad, CA) in 1 patient. In patients with horizontal and vertical alveolar ridge deficiency, a block from the mandibular ramus or symphysis was used for horizontal augmentation. We placed 24 dental implants at positions of maxillary first and second bicuspid and maxillary lateral incisors as a 2-stage procedure: 20 Nobel Biocare Brånemark MK III implants (Nobel Biocare, Zurich, Switzerland) (4 mm in diameter and length ranging from 10 to 13 mm) and 4 Straumann Bone Level implants (Straumann USA, Andover, MA) (diameter ranging from 3.3 to 4.1 mm and 10 mm in length) (Table 1). All implants were placed at the crest of the residual alveolar ridge. In patients requiring vertical and horizontal augmentation, the implants were placed 6 months after graft healing, whereas in patients requiring vertical augmentation only, the implants were placed simultaneously (Fig 3). Second-stage surgery was performed after a traditional healing period, and the implants were restored with a Hader bar and extracoronary resilient attachments. Patient satisfaction with form and function was evaluated with a questionnaire, and responses were expressed on a visual analog scale. Crestal bone levels were quantified radiographically based on a numeric score ranging from 1 to 3, where 3 represented the highest bone support. Postoperative periapical radiographs were taken, and the implant length was divided into thirds. Scores were assigned depending on the level of

crestal bone on the mesial and distal aspects: score 1 for the apical one-third, score 2 for the middle one-third, and score 3 for the coronal one-third (Fig 4). The stability of the nasal floor bone graft was assessed by evaluating postoperative radiographs. The graft was considered stable if the apex of the implant remained covered with bone. Soft tissue health around implants was evaluated for the absence or presence of inflammation as evidenced by visible plaque, changes in soft tissue color, and presence of exudate. Dental implant thread exposure was recorded. The status of soft tissue health was documented by obtaining intraoral photographs (Fig 5). Implants were considered successful if the following clinical and radiographic criteria were met: absence of mobility, asymptomatic, radiographic bone score of 3 on the mesial and distal aspects, and healthy peri-implant soft tissue without thread exposure. Success rates were calculated accordingly.

Results

This case series comprised 6 female patients ranging in age from 48 to 84 years, with a mean of 71.2 years. Four patients had no significant medical history and no identifiable risk factors. Of the 2 remaining patients, 1 had a medical history significant for severe rheumatoid arthritis, Sjögren syndrome, and systemic steroid therapy and the other had osteoporosis and received an oral bisphosphonate, 70 mg of alendronate once a week for 2 years. Three patients underwent NFA and simultaneous implant placement, whereas the remaining patients had a mean healing period of 6.5 months before implant placement. Vertical bone gain after NFA ranged from 4.1 to 5.2 mm, with a mean of 4.8 mm (Table 1). The apices of the implants remained covered with bone, and the nasal graft was considered stable in all patients (Figure 6). The amount of horizontal bone gain from block autografts ranged from 3.5 to 3.9 mm, with a mean of 3.7 mm (Table 1). Osseointegration time ranged from 6 to 9 months, with a mean of 6.8 months. Post-loading follow-up ranged from 4 to 29 months, with a mean of 14.2 months. The maxillary overdenture was opposed with overdentures in 3 patients, natural dentition in 2, and hybrid prosthesis in 1. The survival rate was 100% with no complications, and the success rate was 75% (Fig 7). The visual analog scales of the treatment satisfaction questionnaire were averaged (Table 2). Of the responses, 93% had a score of 7 or greater. Bone scores ranged from 2 to 3, with 87.5% of implants having a score of 3 and 12.5% having a score of 2 (Fig 7).

Discussion

With the growing elderly population, increase in life expectancy, and demand for a better quality of life, office-based procedures that are associated with minimal morbidity become a necessity. The increased cost of health care is an added incentive to find cost-effective, predictable treatment modalities.

A Le Fort I osteotomy with autogenous IPG⁹ corrects alveolar bone deficiencies and intermaxillary discrepancies, but it comes with the added cost of hospitalization and donor-site surgery. The overall complication rate of this surgical procedure is 3.1% (range, 0%-10%).²² Intraoperative fracture of the palate, postoperative sinusitis, bone fragment exfoliation, and minor dehiscences are reported as complications.²² Donor-site morbidity rates from the iliac crest harvest site generally range from 25% to 30%^{23,24} and include

hemorrhage, nerve injury, chronic pain, instability of the sacroiliac joint, hernia, adynamic ileus, and gait disturbance. The overall survival rate of implants placed in conjunction with Le Fort I osteotomy and IPG is 87.9% (range, 66.7%-95%).²²

Onlay bone graft is another surgical procedure described for the treatment of the atrophic maxilla.^{25,26} Soft tissue closure poses a limitation for reconstruction of the severely atrophic maxilla. In a review article,²² partial loss of the graft because of wound dehiscence/infection occurred in 3.3% of the cases, whereas total loss of the graft occurred in 1.4% of the cases,^{27,28} the majority being related to extensive reconstructions of the atrophic maxillae with iliac grafts. The overall survival rate of implants placed in conjunction with onlay bone graft was 79.5% (range, 60%-100%).²²

The patients treated in our case series were affected by extreme atrophy of the edentulous maxilla, class V and VI according to the Cawood and Howell²⁹ classification of 1988, and were treatment planned for bar-retained overdentures where correction of the intermaxillary discrepancy is not necessary. NFA was performed as an office-based procedure with osteoconductive bone graft substitutes and was not associated with complications. Possible complications might include bleeding, swelling, pain, hematoma, infection, implant displacement, and rhinitis.²¹ The nasal mucosa is thicker and more tear resistant than the antral mucosa, and in this study perforations were not encountered. In a study by Jensen et al,¹⁵ the incidence of nasal perforations was reported to be 15% but did not result in any change of the planned treatment. In our case series, implants placed in association with NFA had a 100% survival rate and 75% success rate, according to the success criteria described in our study. Although 6 implants survived but were not considered successful because of our established criteria, they remained functional. Of the 6 implants, 3 were observed in a patient with a history of rheumatoid arthritis, Sjögren syndrome, and systemic steroid therapy. Difficulty in carrying out routine oral hygiene because of severe hand deformity, decreased salivary flow, and heavy plaque deposits were detrimental to the soft tissue health and the crestal bone levels, with subsequent thread exposure. The remaining unsuccessful implants were because of crestal bone loss (bone score of 2); according to our study's success criteria, that could not be attributed to a clear cause. However, crestal bone loss is multifactorial³⁰⁻⁴¹ and is likely not related to NFA. A simplified radiographic bone score system is presented in this study to evaluate crestal bone loss. This system eliminates the need for radiographic standardization or magnification factor calculation, because the bone score is based on bone levels relative to the implant length, provided that the implants were placed at the crest of bone. This system is not recommended for evaluation of bone levels in single-crown or multiple-crown restorations, where a more refined quantitative method is indicated. The results of the treatment satisfaction questionnaire were based on responses from 6 patients. Ninety-three percent of the responses had a score of 7 or greater. The remaining 7% included 1 patient with a history of rheumatoid arthritis, Sjögren syndrome, and systemic steroid therapy and had a score of 1.

NFA, as shown in this case series, is a reliable method for reconstruction of the anterior atrophic maxilla when the residual height is less than 10 mm for implant-supported overdentures. The use of osteoconductive bone graft substitutes with simultaneous implant placement is a predictable approach for augmentation of up to 5 mm in height and eliminates

the need for more invasive procedures such as Le Fort I osteotomy, as well as donor-site morbidity associated with autogenous bone graft harvest.

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Figure 1. Preoperative computed tomography scan with residual ridge measurements in patient 3 with radiographic guide showing deficiency of anterior maxilla.

Figure 2.
A modified Freer elevator was used in patient 3 for nasal mucosa elevation.

Figure 3.
Implants in patient 3 in position with alloplastic bone substitute for NFA.

Figure 4. Periapical radiograph in patient 3 showing newly generated bone surrounding apical portion of implant placed in nasal cavity. Bone scores (1-3) are given accordingly.

Figure 5.
Intraoral photograph in patient 3 with Hader bar and extra-coronal resilient attachment (ERA) in place.

Figure 6.

Computed tomography scans obtained preoperatively and at 6 months postoperatively in patient 6. Postoperative scans show a significant amount of newly grafted bone both in the nasal cavity and in the buccopalatal direction.

Figure 7.
Survival, success, and bone scores.

Table 1
Residual Alveolar Ridge Dimension, Implant Size, and Amount of Bone Gain

Patient No.	RH (mm)	RW (mm)	VG from NFA (mm)	HG from RA (mm)	IL (mm)	ID (mm)
1	6.4	5.9	5.2	NA	10	4.0
2	8.1	3.4	5	3.9	13	4.0
3	5.6	4.8	4.9	NA	10	3.3 and 4.1
4	8.8	5.3	4.5	NA	13	4.0
5	9.0	3.1	4.1	3.5	13	4.0
6	8.1	2.3	4.9	3.8	13	4.0

Abbreviations: HG, horizontal gain; ID, implant diameter; IL, implant length; NA, not applicable; RA, ridge augmentation; RH, ridge height; RW, ridge width; VG, vertical gain.

Table 2
Treatment Satisfaction Questionnaire and Mean Scores Obtained From The Visual
Analog Scale

Treatment Satisfaction Questionnaire	Visual Analog Scale Mean Score
Are you satisfied with the prosthetic appliance in your upper jaw?	8
Are you satisfied with the esthetic appearance of the construction?	9.7
Are you always sure that the construction will not fall down?	9.7
Are you satisfied with your phonetics?	9.3
Is your chewing ability satisfactory?	8