Maxillary Sinus Augmentation Using Sinus Membrane Elevation and Peripheral Venous Blood for Implant-Supported Rehabilitation of the Atrophic Posterior Maxilla: Case Series

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ABSTRACT

Background: Dental implants need appropriate bone volume for adequate stability in the rehabilitation after tooth loss. In the severely atrophic posterior maxilla, the clinical success of implant treatment sometimes requires a vertical ridge augmentation in the maxillary sinus floor.

Purpose: The purpose of this investigation was to evaluate a maxillary sinus floor augmentation technique using a replaceable bone window, elevation of the membrane, placement of implants, and injection of the patient's own venous blood to fill the voids.

Materials and Methods: Six patients with need of maxillary sinus floor augmentation participated in the study. After preparation of a replaceable bone window in the lateral aspect of the sinus and careful elevation of the Schneiderian membrane, a total of 14 Brånemark implants (TiUnite, MK III, Nobel Biocare AB, Göteborg, Sweden) were installed in the residual bone penetrating into the sinus cavity. The sinus cavity was then filled with peripheral venous blood and the bone window replaced and stabilized with a medical tissue glue (Aron Alpha A, Sankyo, Inc., Tokyo, Japan) to prevent blood leakage from the created compartment in the maxillary sinus.

Results: After a healing period of a minimum of 6 months, new bone was successfully generated in all 14 implant sites as judged from radiographs. One of the 14 implants failed, corresponding to a survival rate of 92.9% after a follow-up period ranging 12 to 34 months.

Conclusions: The present case series demonstrate that the creation of a secluded space in the maxillary sinus and filling with venous blood results in bone formation at simultaneously installed dental implants over a 6-month period.

KEY WORDS: augmentation, clinical study, maxillary sinus, titanium implant, venous blood

Tooth loss leads to resorption of the alveolar bone which, together with expansion of the sinus, may limit the possibilities of using endosseous implants for prosthetic rehabilitation of the posterior maxilla.[1,2] In 1980, Boyne and James[3] reported the first sinus lifting procedure and since then, many modifications of the technique have been reported.[4–8] It is anticipated that sinus lifting techniques require space makers such as autografts[9] or allografts[9,10] for new bone generation. There are many reports comparing the efficacy of different graft materials[11–13] and window opening techniques as well as different barrier membrane usage to close the cavity. However, recently, Lundgren and colleagues[14] reported that elevation of the sinus membrane per se and insertion of implants in the residual bone allowed new bone to fill the created compartment in the antral sinus. According to Simion and colleagues,[15–19] the survival rates for implants in vertical ridges augmented with guided bone regeneration and blood clot are only comparable to those of implants in bone augmented

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with autographs and/or alloplasts. Thus, the blood clot has the potential for stimulation of bone formation in secluded spaces at bone surfaces, which can explain the results reported by Lundgren and colleagues.[14] A recent experimental study in primates has shown no differences in bone formation when comparing membrane elevation with and without the use of autogenous bone grafts.[20] Since growth factors capable of stimulating bone formation are present in blood, it can be speculated that placement of additional venous blood collected from the patient during surgery may further facilitate and improve the results from the sinus membrane elevation technique.

The purpose of this clinical study was to evaluate the simplified method using the patients' own venous blood for maxillary floor augmentation in conjunction with the sinus lifting procedure.

MATERIALS AND METHODS

Patients

Six patients (five females and one male, range 49–69 years) with need of implant treatment in the posterior maxilla were included. The inclusion criteria were (1) severe atrophy of the posterior maxilla precluding conventional implant placement, (2) sufficient primary implant stability at surgery, (3) healthy maxillary sinus, and (4) no pathology of neighboring teeth.

All patients were healthy and there were no smokers. Radiographic examinations showed healthy conditions of the maxillary sinuses prior to implant treatment. The patients were carefully informed about the procedures and signed a consent form prior to surgery. The first patient was treated in May 2003 and the last in March 2005.

Surgical Procedures

Surgery was performed under local anesthesia with intravenous sedation introducing Doyle (Sawai Pharmaceutical Co., Ltd., Osaka, Japan) (2 g/sedation package). The technique for exposure of the maxillary sinus was performed according to the protocol reported by Lundgren and colleagues.[14] In brief, a mid-crestal incision (Figure 1A) was made in the posterior maxilla, a muco-periosteal flap elevated, and the lateral wall of the maxillary sinus exposed (see Figure 1B). The sinus wall was penetrated at four points with #2 round bur to mark out a bone window (see Figure 1C). The bone window was prepared using a micro reciprocal saw (Aesculap, Tuttlingen, Germany) (see Figure 1D). In the case of sufficient thickness of the bone, the preparation was made with a beveled technique, resulting in a smaller inner diameter compared with the outer diameter in order to enable a stable replacement of the bone window after the implants were inserted. The Schneiderian membrane was gently elevated to make sure there was space enough for implant placement in the sinus (see Figure 1E). Drilling for the site preparation followed a standard one-stage surgical protocol. After bone preparation, the thickness of the sinus basal bone was measured, and the membrane was elevated to make 10-mm space at least for implant placement (see Figure 1F). The implant sites were prepared in accordance with a conventional Brånemark system implant protocol and the implants placed (MKIII TiUnite, Nobel Biocare AB, Göteborg, Sweden) (see Figure 1G). The remaining sinus space was then filled with venous blood retrieved from the patient, collected from a brachial vein (see Figure 1H). After closing the sinus by replacing the bone window, the window was further stabilized using a medical tissue glue (Aron Alpha A, Sankyo, Inc., Tokyo, Japan) (see Figure 1I). Then, the oral mucosal flap was replaced and sutured (see Figure 1J). An antibiotics (Varacillin 250 mg, Organo Japan, Inc., Osaka, Japan) four tablets per day and anti-inflammatory agent (Neuzym 30 mg, Sannova Co., Ltd., Gunma, Japan) four tablets per day were prescribed for the first 7 days to prevent postoperative infection.

Abutment connection was performed after a healing period of a minimum of 6 months (Table 1). After another 2 to 3 weeks of soft tissue healing, final prosthetic screw-retained restorations were manufactured and delivered to the patients.

Clinical Follow-Up

In the first 3 to 6 months of placing physiological loads on implants, intraoral radiographs were taken to assess the bone formation around the implants. Implant success was evaluated according to Albrektsson and colleagues.[21]

RESULTS

Mild postoperative edema and pain associated with the surgical operation was noted in three patients. These symptoms resolved within a week. Bleeding from the nose was found in three cases postoperatively, which disappeared the next day. No other complications

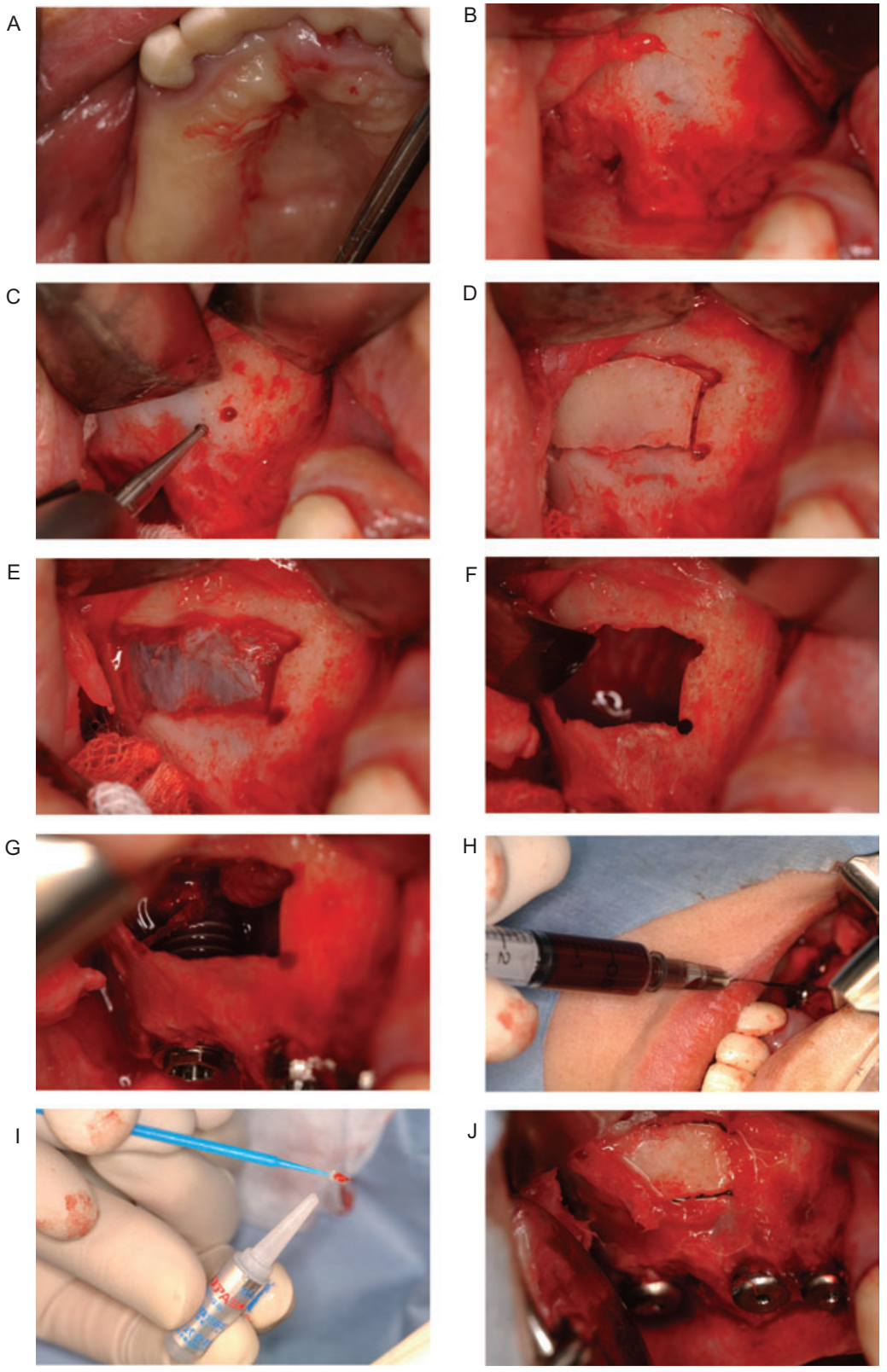

Figure 1 (A) Intraoral view of the maxilla, (B) exposure of the maxillary sinus, (C) opening the window with a round bur, (D) bone preparation with a micro saw, (E) removal of the bone window, (F) lifting up the basal membrane, (G) implant placement, (H) filling the sinus space with the patient's own venous blood, (I) closure of the window with a medical glue, (J) suturing of the flap.

TABLE 1 Fourteen Implant Distributions in Six Patients after Vertical Augmentation of the Maxillary Sinus following Membrane Elevation and Venous Blood Injection

Patient	Age, year	Sex	Implant			Site	Surgical date	Thickness of base bone (mm)		Height of bone needed (mm)		Abutment connection date
			Type	Length (mm)	Diameter (mm)			Mesial	Distal	Mesial	Distal	
1	69	F	MK III	13	4	15	May 16,	8.0	7.0	5.0	6.0	February 06,
			MK III TiU	15	3.75	24	2003					2004
2	68	F	MK IV TiU	15	4.0	26	January 09,	6.0	4.0	9.0	11.0	July 27,
			MK III TiU	15	3.75	27	2004					2004
3	49	F	MK III TiU	15	3.75	14	June 25,	4.0	4.0	11.0	11.0	January 20,
			MK III TiU	15	4.0	15	2004					2005
			MK III TiU	13	3.75	14		11.0	9.0	2.0	4.0	
4	66	M	MK III TiU	15	3.75	15	July 13,	3.0	2.0	12.0	13.0	February 04,
			MK III TiU	15	3.75	16	2004	2.0	3.0	13.0	12.0	2005
			MK III TiU	11.5	3.75	25		3.0	2.0	8.5	9.5	
5	66	F	MK III TiU	10	3.75	26	September	1.0	1.0	9.0	9.0	July 17,
			MK III TiU	13	3.75	27	14, 2004	2.0	6.0	11.0	7.0	2005
6	55	F	MK III TiU	13	4.0	25	March 23,	10.0	7.0	3.0	6.0	December 08,
			MK III TiU	13	5.0	26	2005	3.0	2.0	10.0	11.0	2005

attributable to the surgical procedure were observed. Perforation of the Schneider membrane did not occur.

The height of the residual alveolar process below the maxillary sinus varied from 2 to 10 mm (see Table 1). One of 14 fixtures failed to integrate as observed at abutment connection. The failed implant of healing soft tissue was replaced 3 weeks after with a longer implant placed into the same position and was immediately used in the prosthetic construction. Based on the original 14 implants, the implant survival rate was 92.8% after a minimum of 6-months follow-up. All patients received and maintained a fixed prosthetic construction.

The radiographic examinations revealed signs of bone formation in all patients. Figure 2A presented the bone level at baseline. Bone formation from the coagulum around the implant is shown in Figure 2B.

DISCUSSION

The present study describes a new maxillary sinus augmentation method using the patients' own blood, collected from a brachial vein, for the treatment of posterior maxillary atrophy. This technique is similar to the technique previously described by Lundgren and colleagues[14] wherein the maxillary sinus membrane was

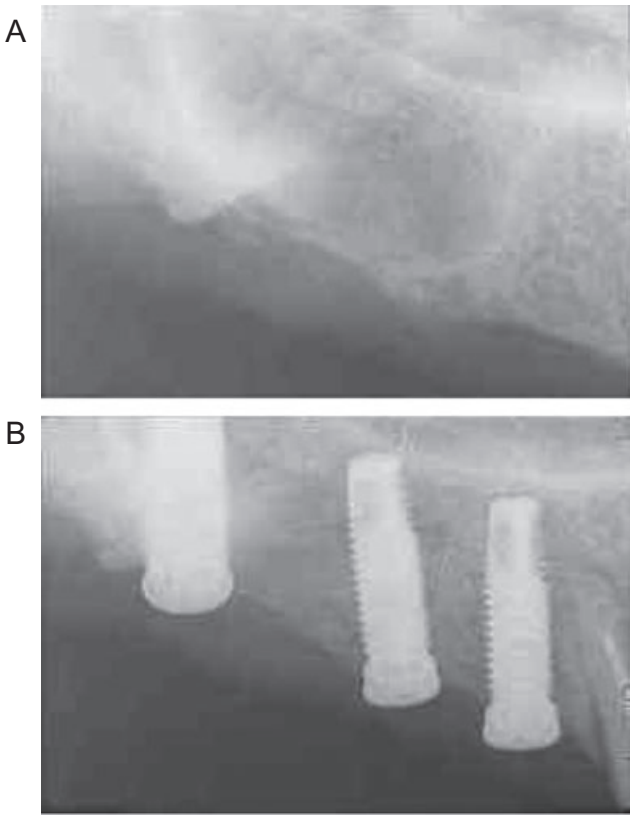

Figure 2 (A) Radiograph of proposed implant site, (B) bone formation at the second surgery.

elevated and bone was spontaneously formed in the blood clot around implants which had been simultaneously placed in the residual alveolar bone.

There are many reports presenting predictable clinical outcomes from sinus lift techniques irrespective of the type of bone grafting material used.[22–24] This may be explained by the fact that the maxillary sinus has a great potential for bone formation, as seen in the present patients, and that a grafting material is not a prerequisite for predictable bone formation. Recently, Ferrigno and colleagues[25] reported that new bone was generated in the maxillary sinus from both the lateral wall and the floor of the sinus after membrane elevation using an osteotome technique. Although the mechanisms are not fully understood, it is obvious that the controlled trauma when lifting the sinus membrane results in the formation of a blood clot and subsequent bone formation.[14,20] The displacement of the membrane probably triggers a series of events, including blood and fibrin clot formation, cellular migration and differentiation, angiogenesis, and osteogenesis. Here, the role of the sinus membrane itself is unclear, but a recent study in primates indicates a potential for bone formation.[20] The study also showed a distinct difference between machined and surface-modified implants with regard to osseointegration. Bone formation by contact osteogenesis was evident at the implants with a moderately rough surface but not at the smooth implant surface. This means that an implant with some surface roughness can integrate in situations of no primary bone contacts, such as with the membrane elevation technique. However, it can be anticipated that the implant must be placed in an osteogenic environment where the blood clot formed following surgery and its relation with the implant surface has an important role. The present study presents a technique to ensure proper blood fill of the sinus following a sinus membrane elevation procedure. The new technique used venous blood collected from the patient and a medical tissue glue to improve the stability of the replaced bone window. The replacement of the original bone window in addition to the use of a tissue glue excludes the need to use membranes and there is no need for the additional surgery to remove nonresorbable material.

No significantly serious complications were reported during the follow-up period ranging from 12 to 34 months when the sinus was augmented with the described procedure. The mean bone height gained after 6 months of healing was 10 mm in average comparable to the bone gained in the report by Simion and colleagues[16] and Lundgren and colleagues,[14] respectively.

One of 14 fixtures failed to integrate in the first few months after loading because uncontrolled bending force was introduced on this implant resulting in micromotion in situ and loss of osseointegration. The rather low implant failure rate found during this study was consistent with data from previous studies.[14,16,25,26]

The preliminary results from this study are encouraging, with results comparable to the results achieved with traditional augmentation using autogenous bone or bone substitutes. However, further studies are required to evaluate the predictability of this maxillary sinus floor augmentation protocol using membrane elevation and peripheral blood.

REFERENCES

1. Adell R, Lekholm U, Rockler B. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. J Oral Surg 1981; 10:387–416.
2. Henry P. Tooth loss and implant replacement. Aust Dent J 2000; 45:150–172.
3. Boyne P, James RA. Grafting of the maxillary floor with autogenous marrow and bone. J Oral Surg 1980; 38:13–616.
4. Lundgren S, Moy P, Johansson C, Nilson H. Augmentation of the maxillary sinus floor with particulated mandible: a histologic and histomorphometric study. Int J Oral Maxillofac Implants 1996; 11:760–766.
5. Summers RB. The osteotome technique: part 3-less invasive methods of elevating the sinus floor. Compend Contin Educ Dent 1994; 15:698–708.
6. Bahat O. Brånemark system implants in the posterior maxilla: clinical study of 660 implants followed for 5 to 12 years. Int J Oral Maxillofac Implants 2000; 15:646–653.
7. Aparicio C, Perales P, Rabgert B. Tilted implants as an alternative to maxillary sinus grafting: a clinical, radiologic, and periotest study. Clin Implant Dent Relat Res 2006; 3:39–49.
8. Smiler DG. The sinus lift graft: basic technique and variations. Pract Periodontics Esthet Dent 1997; 9:885–893.
9 Rodoriguez A, Anastasov GE, Lee H, Buchbinder D, Wettan H. Maxillary sinus augmentation with deproteinated bovine bone and platelet rich plasma with simultaneous insertion of endosseous implants. J Oral Maxillofac Surg 2003; 61:157–163.
10. Butz SJ, Huys LW. Long-term success of sinus augmentation using a synthetic alloplast: a 20 patients, 7 years clinical report. Implant Dent 2005; 14:36–42.
11. Hallman M, Sennerby L, Lundgren S. A clinical and histological evaluation of implant integration in the posterior maxilla after sinus floor augmentation with autogenous

bone or bovine hydroxyapatite, or with a 20:80 mixture. Int J Oral Maxillofac Implants 2002; 17:635–643.
12. Haas R, Baron M, Donath K, Zechner W, Watzek G. Porous hydroxyapatite for grafting the maxillary sinus: a comparative histomorphometric study in sheep. Int J Oral Maxillofac Implants 2002; 17:337–346.
13. Hurzeler MB, Quinones CR, Kirsh A, et al. Maxillary sinus augmentation using different grafting materials and dental implants in monkey. Part I. Evaluation of anorganic bovine-derived bone matrix. Clin Oral Implants Res 1997; 8:476–486.
14. Lundgren S, Andersson S, Gualini F, Sennerby L. Bone reformation with sinus membrane elevation: a new surgical technique for maxillary sinus floor augmentation. Clin Implant Dent Relat Res 2004; 6:165–173.
15. Simion M, Dahlin C, Trisi P, Piattelli A. Qualitative and quantitative comparative study on different filling materials used in bone tissue regeneration: a controlled clinical study. Int J Periodontics Restor Dent 1994; 14:198–215.
16. Simion M, Trisi P, Piattelli A. Vertical ridge augmentation using a membrane technique associated with osseointegrated implants. Int J Periodontics Restor Dent 1994; 14:496–511.
17. Simion M, Jovanovic SA, Trisi P, Scarano A, Piattelli A. Vertical ridge augmentation around dental implants using a membrane technique and autogenous bone or allografts in humans. Int J Periodontics Restor Dent 1998; 18:8–23.
18. Simion M, Jovanovic SA, Tinti C, Benfenati SP. Long-term evaluation of osseointegrated implants inserted at the time or after vertical ridge augmentation. A retrospective study on 123 implants with 1–5 year follow-up. Clin Oral Implants Res 2001; 12:35–45.
19. Simion M, Fontana F, Rasperini G, Maiorana C. Long-term evaluation of osseointegrated implants placed in sites augmented with sinus floor elevation associated with vertical ridge augmentation: a retrospective study of 38 consecutive implants with 1- to 7-year follow-up. Int J Periodontics Restor Dent 2004; 24:208–221.
20. Palma V, Magro-Filho O, Americo de Olivera J, Lundgren S, Salata L, Sennerby L. Bone reformation and implant integration following maxillary sinus membrane elevation: an experimental study in primates. Clin Implant Dent Relat Res 2006; 8:11–24.
21. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. Int J Oral Maxillofac Implants 1985; 1:11–25.
22. Steigmann M, Garg AK. A comparative study of bilateral sinus lifts performed with platelet-rich plasma alone versus alloplastic graft material reconstituted with blood. Implant Dent 2005; 14:261–266.
23. Hatano N, Shimizu Y, Ooya K. A clinical long-term radiographic evaluation of graft height changes after maxillary sinus floor augmentation with a 2:1 autogenous bone/xenograft mixture and simultaneous placement of dental implants. Clin Oral Implants Res 2004; 15:339–345.
24. Nevins M, Fiorellini JP. The maxillary sinus floor augmentation procedure to support implant prostheses. In: Nvisn M, Mellonig JT, eds. Implant therapy: clinical approaches and evidence of success. Chicago, IL: Quintessence, 1998: 171–195.
25. Ferrigno N, Laureti M, Fanali S. Dental implants placement in conjunction with osteotome sinus floor elevation: a 12-year life-table analysis from a prospective study on 585 ITI implants. Clin Oral Implants Res 2006; 17:194–205.
26. Klongnoi B, Rupprecht S, Kessler P, Thorwarth M, Wiltfang J, Schlegel KA. Influence of platelet-rich plasma on a bioglass and autogenous bone in sinus augmentation. Clin Oral Implants Res 2006; 17:312–320.