Flapless Transcrestal Sinus Augmentation Using Hydrodynamic Piezoelectric Internal Sinus Elevation With Autologous Concentrated Growth Factors Alone

Ji-Min Kim, DDS, MSD,* Dong-Seok Sohn, DDS, PhD,† Min-Su Bae, DDS,* Jee-Won Moon, DDS, MSD,‡ Ju-Hyoung Lee, DDS, MSD,‡ and In-Sook Park, DDS, PhD‡

Purpose: *The purpose of this retrospective study was to evaluate the success rate of implants and the amount of sinus augmentation using the flapless hydrodynamic piezoelectric internal sinus elevation (HPISE) technique with autologous concentrated growth factors (CGF) alone.*

Materials and Methods: *A total of 11 maxillary sinuses were augmented using the HPISE technique through the flapless transcrestal approach. Sixteen implants (average 11.38 mm in length and 4.83 mm in diameter), with 2 different surfaces, were placed simultaneously with CGF alone. Plain panoramic radiograms and cone-beam computed tomograms (CBCT) were taken in all patients to evaluate the sinus augmentation preoperatively and postoperatively.*

Results: *The sinus membranes were successfully elevated, averaging 13.95 ± 6.61 mm in immediate postoperative CBCT without any iatrogenic perforation. After an average 23.8 weeks, the average bone gain above the sinus floor was 8.23 ± 2.88 mm in the axial aspect of CBCT. No complications were recorded in any patients during the follow-up period.*

Conclusion: *The flapless transcrestal approach to the sinus augmentation using the HPISE technique with autologous CGF alone could be an alternative to the lateral approach, even at severely resorbed edentulous posterior maxilla with insufficient bone height. (Implant Dent 2014;23:168–174)*

Key Words: internal sinus elevation, flapless surgery, transcrestal approach, piezoelectric bone surgery, hydrodynamics

In the edentulous posterior maxilla, the presence of the maxillary sinus often limits the available bone height for dental implant placement. To overcome vertical deficiency of atrophic posterior maxilla, sinus floor elevation either through a transcrestal approach or a lateral approach has been used for several decades.[1,2] The transcrestal approach is considered to be a less invasive procedure than the lateral approach.[3,4] However, the transcrestal approach with traditional flap surgery is associated with several drawbacks, such as postoperative discomfort, unexpected gingival recession, and alveolar crestal resorption due to diminished supraperiosteal blood supply by intraoperative flap reflection.[5–8] Thus, to overcome the drawbacks of the flap transrectal approach, various flapless transcrestal approaches, such as the use of osteotomes, gel pressure, hydraulic pressure, and balloon elevation have been reported.[9–13] In most of these techniques, numerous pieces of equipment were needed to elevate the sinus membrane. Unlike other transcrestal approaches to sinus augmentation methods, the hydrodynamic piezoelectric internal sinus elevation (HPISE) technique does not require osteotomes or the sinus membrane elevation equipment. Furthermore, it does not rely on bone compaction to elevate the sinus membrane.[14,15] The HPISE technique can break the sinus floor with ultrasonic vibration and elevate the sinus membrane using the hydraulic pressure of

*Clinical Instructor, Department of Dentistry and Oral and Maxillofacial Surgery, Daegu Catholic University Hospital, Daegu, Korea.
†Professor, Department of Dentistry and Oral and Maxillofacial Surgery, Daegu Catholic University Hospital, Daegu, Korea.
‡Assistant Professor, Department of Dentistry and Oral and Maxillofacial Surgery, Daegu Catholic University Hospital, Daegu, Korea.

Reprint requests and correspondence to: Dong-Seok Sohn, DDS, PhD, Department of Dentistry and Oral and Maxillofacial Surgery, Daegu Catholic University Hospital, 3056-6 Daemyung-4 Dong, Namgu, Daegu 705-718, Korea, Phone: 82-53-6504288, Fax: 82-53-6227067, E-mail: dssohn@cu.ac.kr

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internal irrigation concurrently, using only 1 insert.[14,15]

Numerous experimental and clinical studies showing bone regeneration in the sinus without bone graft materials have been reported. Patients' venous blood, absorbable collagen sponge, or fibrin-rich blocks were grafted alone to accelerate new bone formation in the widely accepted new paradigm.[16–22] The aim of this study was to evaluate, retrospectively, the predictability of flapless transcrestal sinus augmentations through use of the HPISE technique with concentrated growth factors (CGF) alone, by clinical and radiographic analysis.

Materials and Methods

Patient Selection

This study consisted of 10 partially edentulous patients who were treated at the Department of Oral and Maxillofacial Surgery, Catholic University Medical Center of Daegu, from February 2010 to November 2012. Before surgery, patients' medical histories were evaluated to exclude the patients with diseases known to affect bone metabolism, such as uncontrolled diabetes mellitus, hyperthyroidism and hypothyroidism, hyperparathyroidism and hypoparathyroidism, rheumatoid arthritis, Paget's disease, osteogenesis imperfect, multiple myeloma, bisphosphonate-related osteonecrosis of the jaw, and others. Plain panoramic radiographs and cone-beam computed tomograms (CBCT, Combi; PointNix Co., Ltd, Seoul, Korea) were taken to assess preoperative sinus conditions and exact residual bone heights and widths. The patients were sorted according to Sclars guideline for flapless surgery.[23,24] The quantity of good keratinized attached gingiva was checked (more than 3–4 mm width of keratinized gingiva had to remain after soft tissue preparation with a tissue punch around the implant placement site). Minimum residual bone width was at least 6 mm. All patients were informed about the treatment procedure and provided oral and written consent. The retrospective data were collected from patients' medical record and radiographic findings.

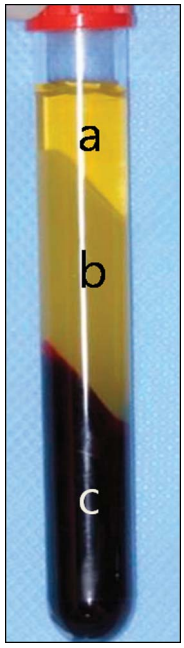

Fig. 1. Prepared CGF; the blood divided into 3 layers after centrifugation. a—Poor platelet plasma layer (blood plasma without fibrinogen and coagulant factors). b—Fibrin buffy coat layer (containing growth factors, white line cells, and stem cells) was used for the sinus augmentation. c—Red blood cell layer (containing red and white blood cells, platelets, and clotting factors).

Surgical and Prosthetic Procedure

The surgical procedures were performed according to the authors' articles published in 2010 and 2012.[15,25] Patients were given prophylactic oral antibiotics, amoxicillin, potassium clavulanate (Augmentin; Ilsung Pharmaceutical Co., Seoul, Korea), 625 mg thrice daily, beginning the day before surgery, and for 7 days postoperatively. Flomoxef sodium (Flumarin; Ildong Pharmaceutical Co., Korea, 500 mg iv) was injected 1 hour before the surgery. All surgical procedures were performed under local anesthesia using 68 mg/1.7 mL of hydrochloride articaine with 1/100,000 adrenaline for a maxillary quadrant (Septanest; Septodont, Saint-Maur-des-Fossés, France).

CGF were prepared according to Sacco's protocol, using the patients' own venous blood to accelerate new bone formation in the sinus[26] (40–60 mL of blood was drawn from patients' radial forearm). The venous blood was collected in silica-coated vacutainer tubes without anticoagulant. The blood in the vacutainer tubes was centrifuged using a special centrifuge (Medifuge; Silfradent srl, Sofia, Italy) with a rotor turning at altered and controlled speed (2400–2700 rpm) for 12 minutes. The collected blood was characterized by 3 layers. The uppermost layer was represented by the poor platelet plasma layer (blood plasma without fibrinogen and coagulant). The middle layer was the fibrin buffy coat layer (fibrin blocks containing concentrated growth factors, white line cells, and stem cells) and was named CGF. Finally, the lowest red layer represented the red blood cell layer (containing concentrated red and white blood cells, platelets, and clotting factors). The middle layers were used for sinus augmentation in this study (Fig. 1).

The flapless surgery was performed when the width of the alveolar ridge was adequate (≥6 mm), as confirmed by preoperative CBCT (Fig. 2, A–C). As a first step, soft tissue preparation was performed with a 4-mm wide motor-driven tissue punch at the center of the future implant placement site

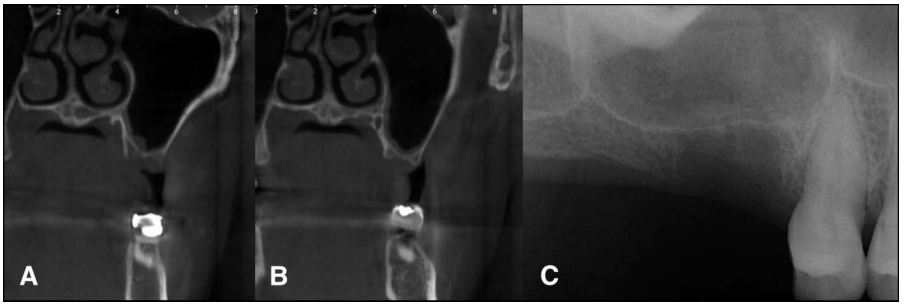

Fig. 2. The axial aspect of preoperative CBCT and periapical radiogram. **A**, Right first molar showing approximately 0.5-mm residual bone height. **B**, Right second molar showing approximately 1-mm residual bone height. **C**, Periapical radiogram displays a septa on the right maxillary sinus.

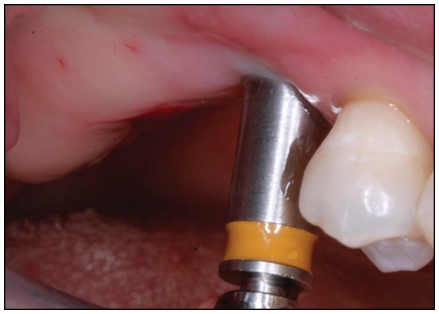

Fig. 3. Soft tissue prepared using a 4-mm-wide motor-driven tissue punch at the future implant site.

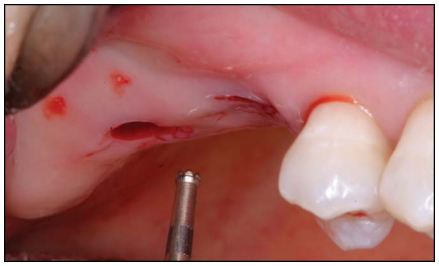

Fig. 4. The sinus floor was penetrated with the S016 insert connected to the ultrasonic piezoelectric device.

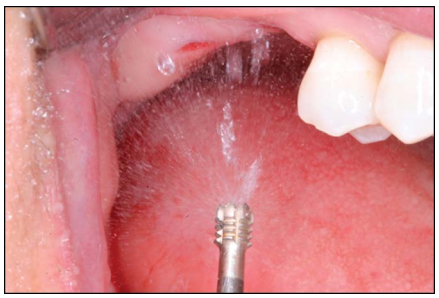

Fig. 5. The HPISE insert was inserted into the osteotomy site to enlarge the implant site and elevate the sinus membrane using hydraulic pressure by internal irrigation.

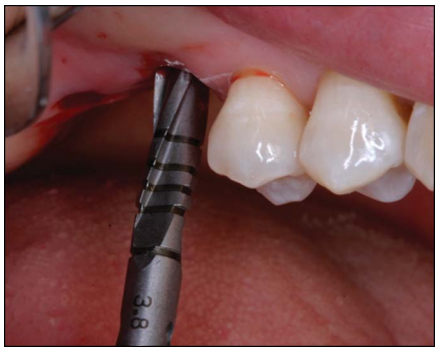

Fig. 6. The 3.8 mm wide intermittent drill was used to accommodate a 4.7-mm-wide implant for initial stability.

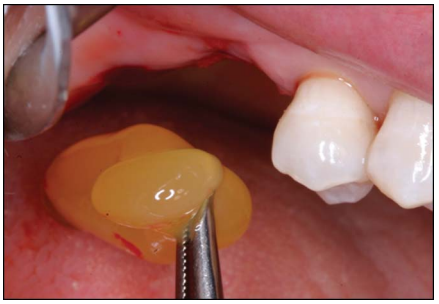

Fig. 7. CGF was inserted through the osteotomy site.

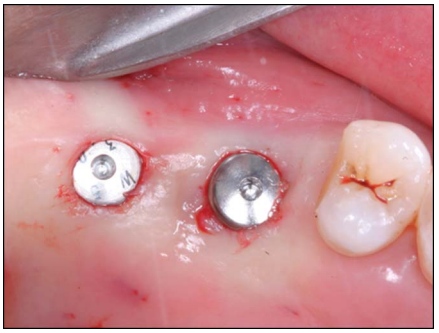

Fig. 8. Implants (Tapered Screw Vent; Zimmer Dental Inc., Carlsbad, CA) were placed by a 1-stage procedure, with 3.0-mm high healing abutment.

(Fig. 3). After exposure of the alveolar bone crest, a 1.6-mm wide round carbide insert (S016; S-Dental Co., Daegu, Korea) connected to an ultrasonic piezoelectric device (Surgybone; Silfradent srl) was used to break the sinus floor directly (Fig. 4). After breaking the sinus floor with the round insert, a 2.8 mm wide HPISE insert (S028I; S-Dental Co.) was used to enlarge the osteotomy site and elevate the sinus membrane using hydraulic pressure by internal irrigation concurrently. The HPISE insert has a 4-mm working tip height, and depth-indicating lines marked at 2-mm intervals. Thus, it measured the exact residual bone height at each implant placement site. The insert was pushed a few millimeters over the sinus floor to confirm the detachment of the sinus membrane from sinus floor. Then, hydraulic pressure was applied again for 10–20 seconds to elevate the sinus membrane at each implant site (Fig. 5). Membrane perforation was confirmed by the Valsalva maneuver or direct visualization of the sinus membrane. The backflow of saline from the sinus cavity during the application of hydraulic pressure also confirmed the integrity of sinus membrane. The HPISE tip was usually used for a final osteotomy to procure initial stability for accommodating 3.7- to 4.2-mm–wide tapered implants at the site. When wide implants (more than 4.7 mm) were placed, an intermittent drilling procedure was required. The diameter of the intermediate drill was approximately 1 mm narrower than the diameter of the implant that was placed to obtain initial stability of the implant (Fig. 6). Two to 6 pieces of CGF, as an alternative to bone graft materials, were inserted in the new compartment under the elevated sinus membrane (Fig. 7). The implant was placed simultaneously. The 3-mm-high healing abutment was connected to the placed implants as a 1-stage procedure (Fig. 8). A periapical radiograph and CBCT were taken to verify sinus elevation immediately postoperatively (Fig. 9, A–C).

Patients were instructed not to blow their noses or to cough or sneeze with an open mouth for 2 weeks after surgery. After an average 23.8 weeks, CBCT were taken to assess vertical bone gain around the implants (Fig. 10, A and B). A porcelain implant fused to a metal crown was cemented after 4–8 weeks use of provisionals, and all patients were examined, on average, 34 weeks after loading (Fig. 11, A and B).

Radiographic Evaluation and Analysis

Consecutive CBCT were taken preoperatively, immediately postoperatively, and on the day when the patient was taken an impression for provisionals, in all cases. One examiner evaluated all radiographic information. Preoperative residual bone height, the amount of the membrane elevation, and vertical bone gain above the original sinus floor were assessed on consecutive CBCT. The data were analyzed using a 3-dimensional CT scan software (RealScan 2.0; PointNix Co., Ltd). Mean values and SDs were calculated.

RESULTS

Eleven sinus elevations (9 unilateral and 1 bilateral sinuses) were

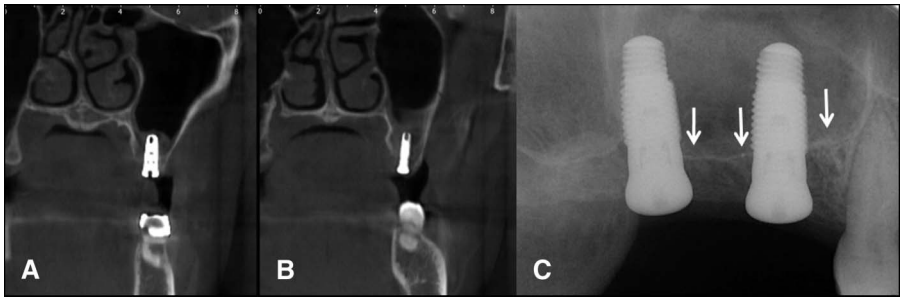

Fig. 9. Immediate postoperative CBCT and periapical radiogram demonstrating the elevated sinus membrane. All axial aspect of CBCT showing the sinus membrane elevation in the lateral approach. **A**, Approximately 10 mm of membrane elevation on the right first molar area. **B**, Approximately 13 mm of membrane elevation on the right second molar area. **C**, The original sinus floor was observed on periapical radiogram (arrow).

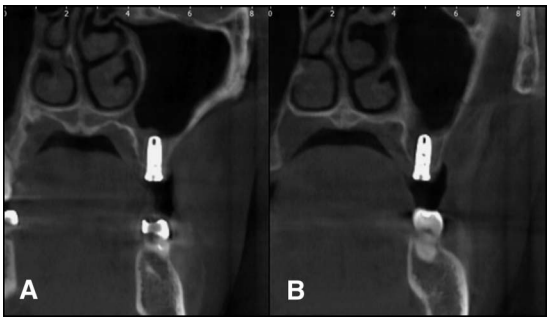

Fig. 10. CBCT was taken at impression taking for provisionals, demonstrating newly formed bone above the implant apices. Bone consolidation was observed on (**A**) the right first molar area and (**B**) the right second molar area.

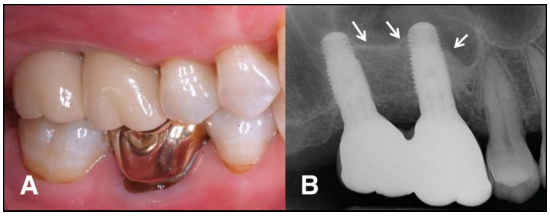

Fig. 11. Intraoral photo and periapical radiogram. **A**, A porcelain-fused metal crown bridge was connected with the implants. **B**, A periapical radiogram was taken at the prosthesis connection. Newly formed sinus floor was observed (arrow).

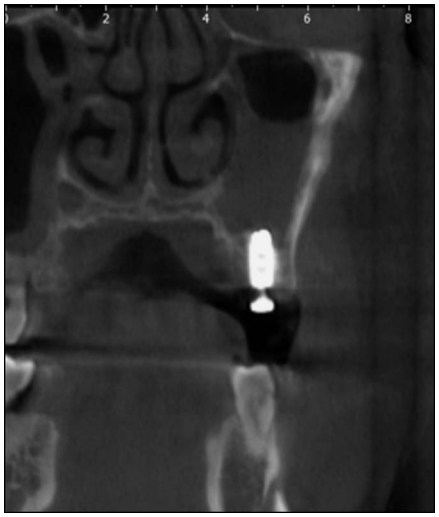

Fig. 12. Case 1, patient's immediate postoperative CBCT showing approximately 28-mm height maximum sinus membrane elevation on the right first molar area.

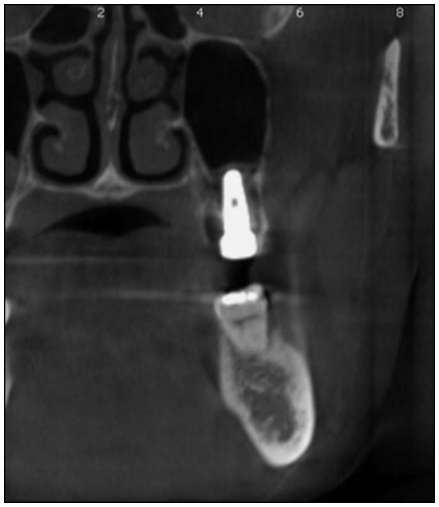

Fig. 13. Case 9, patient's immediate postoperative CBCT showing approximately 5-mm height minimum sinus membrane elevation on the right first molar area.

performed on 10 patients. A total of 16 implants with 2 different surfaces (14 hydroxyapatite-coated implants and 2 sandblasted large grit acid-etched surface) were placed. Five patients were men and 5 were women, with a mean age of 50.7 years, varying from 31 to 61 years. The mean residual bone height of the alveolar crest was 4.98 ± 2.8 mm, varying 0.5 mm–8.6 mm at the implant site. Six patients (60%) had a residual bone height of 0.5 mm to 5 mm. Four patients (40%) had more than 5 mm of residual bone height. The maximum amount of the sinus membrane elevation was 27.9 mm; the minimum was 5.5 mm (Figs. 12 and 13). Mean amount of sinus membrane elevation was 13.95 ± 6.2 mm. No membrane perforation was recorded at any implant site. Several pieces of CGF were grafted alone into all of the sinuses to accelerate new bone formation. All implants were placed by the 1-stage procedure. Most implants displayed greater than 20 N·cm insertion torque, except 2 implants that had poor initial stability, despite higher than 5-mm residual bone height. One 52-year-old female patient, whose residual bone height was 8.6 mm, displayed poor implant initial stability because of type IV bone quality. The other implant was placed within 3 months after extraction in a 52-year-old male patient with 6.4-mm residual bone height.

After sinus elevation using the flapless HPISE technique, no patient had significant postoperative complications (such as swelling, pain, or bleeding) during the healing period. After an

Table 1. Baseline Data Assessment

Sex	Age	Site	Diameter	Length	Residual Bone Height	Membrane Elevation	Vertical Bone Gain	Membrane Perforation
M	44	Right first premolar	4.5	11	3	27.9	12.7	No
		Right first molar	5.5	11	4.4	20.5	10.8	No
F	49	Right first molar	4.7	11.5	1	10.6	10.8	No
		Right second molar	4.7	11.5	0.5	13.4	13	No
M	61	Right first molar	4.8	12	2.2	24.5	10.6	No
F	52	Right first molar	6	11.5	8.4	9.6	5.8	No
F	36	Left first molar	4.7	10	5.4	17.6	6	No
		Left second molar	4.7	10	4.6	17.5	7	No
M	31	Left second molar	4.7	11.5	1.2	13.1	10.6	No
F	55	Left first molar	4.7	10	4.6	12.6	5.8	No
M	69	Left first molar	4.7	11.5	8.46	13.4	6.64	No
		Left second molar	4.7	11.5	6.64	10.6	6.26	No
F	58	Right second molar	4.7	11.5	8.6	5.5	5.1	No
		Left second molar	4.7	11.5	5.6	10.8	6.4	No
M	52	Right first molar	4.7	13	8.6	7	4.2	No
		Right second molar	4.7	13	6.4	8.6	10	No
Mean ± SD			4.83 ± 0.38	11.38 ± 0.89	4.98 ± 2.8	13.95 ± 6.2	8.23 ± 2.88	0%

Measurements in millimeters.

average 23.8 weeks healing period, plain panoramic radiograms and CBCT showed newly formed bone along the implants in all cases. Total vertical bone gain was 8.23 ± 2.88 mm, varying from 4.2 to 12.7 mm. The success rate of implantation was 100% after an average 34 weeks after loading (Table 1).

DISCUSSION

The traditional flap transcrestal approach, despite high success rates, causes inevitable postoperative complications, such as bleeding, swelling and pain, and long edentulous healing periods.[27] Because of soft tissue flap reflection, supraperiosteal blood supply is diminished. Thus, alveolar crestal bone was resorbed during the initial healing phase,[28] resulting in a potential decisive effect on implant prognosis. Accordingly, in-office CBCT and developed dental diagnostic tools have been coming into wider use, so a minimally invasive sinus augmentation through the flapless transcrestal approach has been presented.[29] Sclar[23] have presented guidelines for flapless surgery that requires approximately 3-mm width and depth of keratinized attached gingival. The keratinized tissue surrounding an implant restoration is able to withstand the masticatory force and to maintain normal oral hygiene.[23] The flapless approach without soft tissue flap reflection includes less alveolar crestal resorption and better blood supply to graft material, which results in minimal postoperative pain and bleeding. It also allows the maintenance of normal oral hygiene procedures immediately postoperatively.[30,31] The optimal tissue punch size for flapless implant surgery is slightly narrower than the future implant size.[32,33] In this study, because implants usually placed were more than 4.7 mm in diameter, 4-mm-wide tissue punches were used to expose the alveolar crest.

In 2005, Emmanouil et al presented a method using flapless maxillary sinus augmentation with hydraulic pressure.[9] They used Summers' osteotome-mediated sinus elevation technique without bone graft materials. Pommer and Watzek reported 10.6 ± 1.6 mm height of the sinus membrane elevation by means of surgical templates, using gel pressure without membrane perforation.[10] Mazor et al[12] presented the invasive antral membrane balloon elevation technique that used an ultrasonic piezoelectric insert to create the osteotome. A balloon-harboring device was used to inflate the balloon for membrane elevation. Bensaha[11] presented a method using the ultrasonic piezoelectric device for osteotomy, with an injectable hydraulic device used for membrane elevation of 7 to 15 mm height. Many of these published studies using the flapless transcrestal approach require complicated equipment for the sinus augmentation, whereas the HPISE insert is apt to break the sinus floor and to elevate the sinus membrane concurrently. Furthermore, its hydraulic pressure from internal irrigation is used to elevate the sinus membrane even mediolaterally of the sinus cavity and can prevent potential thermal damage during osteotomy. Unlike a rotary cutting device, the ultrasonic piezoelectric device provides highly controlled osteotomy because of the selective bone-cutting effect, inducing minimal trauma

to soft tissue, which allows a very low rate of sinus membrane perforation, compared with conventional techniques using a surgical mallet or osteotomes.[34–36] In all cases, even elevation of the sinus membrane from the medial and lateral walls of the sinus cavity, above the implant apices, was revealed by immediate postoperative CBCT. Intraoperative membrane perforation after sinus floor elevation frequently causes sinusitis, which directly affects the prognosis of implants.[37,38] No iatrogenic membrane perforation was noted in this study.

Several complications related to sinus bone grafting procedures in the maxillary sinus have been reported.[39–41] Whereas various studies have reported competent new bone formation in the maxillary sinus without bone grafting in humans and animals.[42–44] Sohn et al reported many cases, with clinical histological evidence, in which there is favorable new bone formation in the maxillary sinus without bone grafting materials.[17–22] In this study, CGF were used alone for sinus augmentation through the flapless transcrestal approach using the HPISE technique without any bone graft materials. CGF were made from the patients' own venous blood without any synthetics or biomaterials, such as calcium chloride or bovine thrombin, making it free from cross-contamination. Also, CGF are known to gradually release growth factors, such as transforming growth factor-β1, platelet-delivered growth factors, insulin-like growth factors, and vascular endothelial growth factors.[45] CGF have been used to accelerate new bone formation associated with guided bone regeneration in sinus grafts.[46,47] Sohn et al[48] reported that the CGF induced fast new bone formation in sinus augmentation. Furthermore, Sohn et al reported clinical and histological evaluation that CGF, as a sole material, when inserted alone in the sinus augmentation, induced rapid new bone formation in the new compartment under the elevated sinus membrane through the transcrestal and the lateral approaches.[15,16] As the result, bone regeneration along the implant body was evident radiographically.

CONCLUSION

Because the results of this study demonstrate that the amount of the elevation of the sinus membrane is similar to the one achieved through lateral approach sinus augmentation, the flapless HPISE technique could be applied to augment severely resorbed maxillary sinuses regardless of the vertical bone height, as an alternative to the lateral approach. Indeed, this study showed that flapless HPISE was a predictable method with decreased postoperative morbidity.

DISCLOSURE

Professor Dong-Seok Sohn is an inventor of the HPISE technique. The remaining authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

REFERENCES

1. Summers RB. A new concept in maxillary implant surgery: The osteotome technique. *Compendium.* 1994;15:152–162.

2. Aghaloo TL, Moy PK. Which hard tissue augmentation techniques are the most successful in furnishing bony support for implant placement? *Int J Oral Maxillofac Implants.* 2007;22:49–70.

3. Woo I, Le BT. Maxillary sinus floor elevation: Review of anatomy and two techniques. *Implant Dent.* 2004;13:28–32.

4. Toffler M. Minimally invasive sinus floor elevation procedures for simultaneous and staged implant placement. *N Y State Dent J.* 2004;70:38–44.

5. Campelo LD, Camara JR. Flapless implant surgery: A 10-year clinical retrospective analysis. *Int J Oral Maxillofac Implants.* 2002;17:271–276.

6. Widmann G, Bale RJ. Accuracy in computer-aided implant surgery—A review. *Int J Oral Maxillofac Implants.* 2006;21:305–313.

7. Rocci A, Rocci M, Scoccia A, et al. Immediate loading of maxillary prostheses using flapless surgery, implant placement in predetermined positions, and prefabricated provisional restorations. Part 2: A retrospective 10-year clinical study. *Int J Oral Maxillofac Implants.* 2012;27:1199–1204.

8. Fornell J, Johansson LÅ, Bolin A, et al. Flapless, CBCT-guided osteotome sinus floor elevation with simultaneous implant installation. I: Radiographic examination and surgical technique. A prospective 1-year follow-up. *Clin Oral Implants Res.* 2012;23:28–34.

9. Sotirakis EG, Gonshor A. Elevation of the maxillary sinus floor with hydraulic pressure. *J Oral Implantol.* 2005;31:197–204.

10. Pommer B, Watzek G. Gel-pressure technique for flapless transcrestal maxillary sinus floor elevation: A preliminary cadaveric study of a new surgical technique. *Int J Oral Maxillofac Implants.* 2009;24:817–822.

11. Bensaha T. Outcomes of flapless crestal maxillary sinus elevation under hydraulic pressure. *Int J Oral Maxillofac Implants.* 2012;27:1223–1229.

12. Mazor Z, Kfir E, Lorean A, et al. Flapless approach to maxillary sinus augmentation using minimally invasive antral membrane balloon elevation. *Implant Dent.* 2011;20:434–438.

13. Pozzi A, De Vico G, Sannino G, et al. Flapless transcrestal maxillary sinus floor elevation: Computer guided implant surgery combined with expanding-condensing osteotomes protocol. *Oral Implantol (Rome).* 2011;4:4–9.

14. Sohn DS. Minimal invasive sinus augmentation—Hydrodynamic piezoelectric internal sinus elevation (HPISE). *Korean Dental Association Newspaper.* 2008;1696:18–19.

15. Kim JM, Sohn DS, Heo JU, et al. Minimally invasive sinus augmentation using ultrasonic piezoelectric vibration and hydraulic pressure: A multicenter retrospective study. *Implant Dent.* 2012;21:536–542.

16. Sohn DS, Heo JU, Kwak DH, et al. Bone regeneration in the maxillary sinus using an autologous fibrin-rich block with concentrated growth factors alone. *Implant Dent.* 2011;20:389–395.

17. Sohn DS, Lee JS, Ahn MR, et al. New bone formation in the maxillary sinus without bone grafts. *Implant Dent.* 2008;17:321–331.

18. Mazor Z, Horowitz RA, Del Corso M, et al. Sinus floor augmentation with simultaneous implant placement using Choukroun's platelet-rich fibrin as the sole grafting material: A radiologic and histologic study at 6 months. *J Periodontol.* 2009;80:2056–2064.

19. Sohn DS, Kim WS, An KM, et al. Comparative histomorphometric analysis of maxillary sinus augmentation with and without bone grafting in rabbit. *Implant Dent.* 2010;19:259–270.

20. Sohn DS, Moon JW, Moon KN, et al. New bone formation in the maxillary sinus using only absorbable gelatin sponge. *J Oral Maxillofac Surg.* 2010;68:1327–1333.

21. Moon JW, Sohn DS, Heo JU, et al. New bone formation in the maxillary sinus

using peripheral venous blood alone. *J Oral Maxillofac Surg.* 2011;69:2357–2367.

22. Sohn DS, Moon JW, Lee WH, et al. Comparison of new bone formation in the maxillary sinus with and without bone grafts: Immunochemical rabbit study. *Int J Oral Maxillofac Implants.* 2011;26:1033–1042.

23. Sclar AG. Guidelines for flapless surgery. *J Oral Maxillofac Surg.* 2007;65:20–32.

24. Sclar AG. Surgical techniques for management of peri-implant soft tissues. In: Bywaters LC, ed. *Soft Tissue and Esthetic Considerations in Implant Therapy*. Chicago, IL: Quintessence; 2003:43.

25. Sohn DS, Maupin P, Fayos RP, et al. Minimally invasive sinus augmentation using ultrasonic piezoelectric vibration and hydraulic pressure. *J Implant Adv Clin Dent.* 2010;2:27–40.

26. Rodella LF, Favero G, Boninsegna R, et al. Growth factors, CD34 positive cells, and fibrin network analysis in concentrated growth factors fraction. *Microsc Res Tech.* 2011;74:772–777.

27. Wood DL, Hoag PM, Donnenfeld OW, et al. Alveolar crest reduction following full and partial thickness flaps. *J Periodontol.* 1972;43:141–144.

28. Nikzad S, Azari A. Custom-made radiographic template, computed tomography, and computer-assisted flapless surgery for treatment planning in partial edentulous patients: A prospective 12-month study. *J Oral Maxillofac Surg.* 2010;68:1353–1359.

29. Casap N, Tarazi E, Wexler A, et al. Intraoperative computerized navigation for flapless implant surgery and immediate loading in the edentulous mandible. *Int J Oral Maxillofac Implants.* 2005;20:92–98.

30. Becker W, Goldstein M, Becker BE, et al. Minimally invasive flapless implant surgery: A prospective multicenter study. *Clin Implant Dent Relat Res.* 2005;7:S21–S27.

31. Fortin T, Bosson JL, Isidori M, et al. Effect of flapless surgery on pain experienced in implant placement using an image-guided system. *Int J Oral Maxillofac Implants.* 2006;21:298–304.

32. Lee DH, Choi BH, Jeong SM, et al. Effects of soft tissue punch size on the healing of peri-implant tissue in flapless implant surgery. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2010;109:525–530.

33. Bayounis AM, Alzoman HA, Jansen JA, et al. Healing of peri-implant tissues after flapless and flapped implant installation. *J Clin Periodontol.* 2011;38:754–761.

34. Vercellotti T, De Paoli S. The piezoelectric bony window osteotomy and sinus membrane elevation: Introduction of a new technique for simplification of the sinus augmentation procedure. *Int J Periodontics Restorative Dent.* 2001;21:561–567.

35. Sohn DS, Ahn MR, Jang BY. Sinus bone graft using piezoelectric surgery. *Implantology*. 2003;9:48–55.

36. Sohn DS, Moon JW, Lee HW, et al. Comparison of two piezoelectric cutting inserts for lateral bony window osteotomy: A retrospective study of 127 consecutive sites. *Int J Oral Maxillofac Implants.* 2010;25:571–576.

37. Garbacea A, Lozada JL, Church CA, et al. The incidence of maxillary sinus membrane perforation during endoscopically assessed crestal sinus floor elevation: A pilot study. *J Oral Implantol.* 2012;38:345–359.

38. Kim YK, Hwang JY, Yun PY. Relationship between prognosis of dental implants and maxillary sinusitis associated with the sinus elevation procedure. *Int J Oral Maxillofac Implants.* 2013;28:178–183.

39. Maksoud MA. Complications after maxillary sinus augmentation: A case report. *Implant Dent.* 2001;10:168–171.

40. Garg AK, Mugnolo GM, Sasken H. Maxillary antral mucocele and its relevance for maxillary sinus augmentation grafting: A case report. *Int J Oral Maxillofac Implants.* 2000;15:287–290.

41. Misch CE. The maxillary sinus lift and sinus graft surgery. In: Misch CE, ed. *Contemporary Implant Dentistry*. Chicago, IL: Mosby; 1999:469–495.

42. Palma VC, Magro-Filho O, de Oliveria JA, et al. Bone reformation and implant integration following maxillary sinus membrane elevation: An experimental study in primates. *Clin Implant Dent Relat Res.* 2006;8:11–24.

43. Lundgren S, Andersson S, Gualini F, et al. Bone reformation with sinus membrane elevation: A new surgical technique for maxillary sinus floor augmentation. *Clin Implant Dent Relat Res.* 2004;6:165–173.

44. Hatano N, Sennerby L, Lundgren S. Maxillary sinus augmentation using sinus membrane elevation and peripheral venous blood for implant-supported rehabilitation of the atrophic posterior maxilla: Case series. *Clin Implant Dent Relat Res.* 2007;9:150–155.

45. Choukroun J, Diss A, Simonpieri A, et al. Platelet-rich fibrin (PRF): A second-generation platelet concentrate. Part V: Histologic evaluations of PRF effects on bone allograft maturation in sinus lift. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2006;101:299–303.

46. Dohan DM, Choukroun J, Diss A, et al. Platelet-rich fibrin (PRF): A second-generation platelet concentrate. Part I: Technological concepts and evolution. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2006;101:e37–e44.

47. Choukroun J, Diss A, Simonpieri A, et al. Platelet-rich fibrin (PRF): A second-generation platelet concentrate. Part IV: Clinical effects on tissue healing. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2006;101:e56–e60.

48. Sohn DS, Moon JW, Moon YS, et al. The use of concentrated growth factor (CGF) for sinus augmentation. *J Oral Implant.* 2009;38:25–38.