Various sinus augmentation procedures have been introduced to overcome maxillary sinus pneumatization.1–3 Despite the predictability of those, some complications such as sinusitis, hemorrhage, and swelling were reported.2 Among those, postoperative sinusitis is the most detrimental because it sometimes leads to complete failure of the augmentation and the spread of infection to other anatomical structures,4 even though the incidence was reported as not particularly high (0% to 7.4%).2 Factors related to postoperative sinusitis include perforation of the sinus membrane, infected bone substitute material, and displacement of the dental implant.2,5

Traditional protocols for managing these factors are as follows: (1) a pharmacologic approach, and then (2) radical surgical treatment, ie, the curettage of bone substitute particles, granulation tissue, and sinus membrane in the sinus cavity and/or removal of the placed implant.6 Recently, it was demonstrated that some cases require correction of the disrupted sinus clearance function by means of functional endoscopic sinus surgery (FESS).6,7 However, a limitation of the above protocols is based on the empirical decision,8 possibly due to the low frequency of occurrence. Moreover, there was no clear discrimination between various clinical scenarios regarding postoperative sinusitis, such as a superficial graft infection, and infection primarily related to partial or total obstruction of the ostium.

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The aim of the present study was to report the clinical and histologic results of three patients who developed maxillary sinusitis following lateral sinus augmentation and subsequently underwent FESS without the removal of graft material.

**MATERIALS AND METHODS**

The present study was approved by the Institutional Review Board of the Veterans Health Service Medical Center in Seoul, Korea (BOHUN IRB No. 2016-10-002). This study was prepared in accordance with the guidelines of the CARE checklist. The detailed information regarding surgery and medication is presented in Table 1.

**Case 1**
A man 50 years of age required dental implant placement in the left posterior maxilla with a residual ridge height < 2 mm (Fig 1a). On a preoperative computed tomography (CT) scan, approximately 10 mm of mucosal thickening was observed (Fig 1b). The patient was referred to an otorhinolaryngologist to evaluate the eligibility for lateral sinus augmentation.

Upon permission by the otorhinolaryngologist, lateral sinus augmentation was performed. A surgical access window was made, the sinus membrane was elevated, and a mixture of bone substitute materials was grafted (Fig 1c, Table 1). Because of ridge atrophy in the crestal area, lateral ridge augmentation was performed simultaneously. No membrane perforation or tearing was detected during the procedure.

After 3 weeks, the patient developed the following symptoms: swelling, tenderness, headache, nasal obstruction, nasal discharge, and fistula formation in the buccal vestibule. A CT scan revealed severe mucosal thickening with obstruction of the ostium (Fig 1d). Intraoral drainage and medication were performed (Table 1), but the patient’s symptoms were not alleviated. The patient was referred to an otorhinolaryngologist. A CT scan demonstrated reduced but persistent mucosal thickening (Fig 1e), but the grafted bone substitute particles were relatively well consolidated without dispersion or scattering. The patient underwent FESS. Using uncinectomy, the ostium was enlarged in order to regain the function of drainage. The grafted bone substitute material was not removed (Fig 1f). The complete disappearance of symptoms was reported at the 3-month follow-up visit after FESS.

After 6 months, two implants were placed (BioHorizons), and a core biopsy specimen was obtained. Following the use of a provisional prosthesis, the definitive prosthesis was delivered (Fig 1g). The surgical site showed no further biologic complication (Figs 1h and 1i) and no functional problem over 7 years of follow-up.

**Case 2**
Lateral sinus augmentation was performed for a man 41 years of age in the left posterior maxilla with a residual ridge height < 3 mm. No specific pathology was observed in the clinical or radiologic examinations (Fig 2a). During sinus membrane elevation, the membrane was perforated (approximate length: 15 mm) (Fig 2b). After the repair of the perforation, a mixture of bone substitute materials was grafted (Fig 2c, Table 1).

The patient developed swelling, tenderness, and nasal obstruction and postnasal drip 4 weeks after surgery. The symptoms were not resolved despite medication (Table 1). Severe mucosal thickening with obstruction of the ostium was observed on a CT scan (Fig 2d). The patient was referred to an otorhinolaryngologist and underwent FESS under local anesthesia (Fig 2e). Two weeks later, the patient’s symptoms were improved markedly. The patient reported the complete disappearance of symptoms at the 4-month follow-up visit after FESS. Two implants (TSIII, Osstem)
were placed, and a core biopsy specimen was obtained 6.5 months later. After 7 months of healing, the definitive prosthesis was delivered (Fig 2f). No biologic or functional complication was reported over 2 years of follow-up (Figs 2g and 2h).

**Case 3**
A man 70 years of age required dental implant placement in the right posterior maxilla with a residual ridge height of 3 to 4 mm (Fig 3a). During the lateral sinus augmentation procedure, approximately 10 mm of

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<td>Same as patient 1</td>
<td>Same as patient 2</td>
<td>Placement of multi-layers of collagen tape (CollaTape, Zimmer)</td>
<td>Amoxicillin clavulanate (Maxicran, Boryung) and pseudoephedrine-triprolidine (Actifed, Samil) for 14 days</td>
</tr>
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sinus membrane perforation occurred (Fig 3b). This perforation was repaired using a resorbable collagen barrier, and a mixture of bone substitute materials was grafted (Table 1). Then, two dental implants (TSIII, Osstem) were placed, and submerged healing was provided (Fig 3c).

The patient complained of bad smell and feverish sensation around the nose at 3 weeks. A cone beam computed tomography (CBCT) scan revealed scattered bone substitute particles and severe sinus mucosal thickening. A pharmacologic intervention for 14 days did not resolve the symptoms (Fig 3d, Table 1), and thus, FESS was performed under local anesthesia. During FESS, the scattered bone substitute particles with some inflamed tissue around the particles were removed (Fig 4). The patient reported the complete resolution of symptoms at the 4-month follow-up visit after FESS.

Six months later, the healing abutments were connected (Fig 3e). A bone core biopsy specimen was obtained from the previous bony window area from the lateral sinus augmentation. The definitive prosthesis was delivered after 2 months (Fig 3f). No pathologic event has been observed to date (4 months after the definitive prosthesis delivery) (Fig 3g).

**Histologic Processing**

The core biopsy specimens consisting of tissues harvested with a trephine bur were fixed in 4% formalin. The tissue was carefully removed from the trephine bur, decalcified, trimmed, and embedded in paraffin. The blocks were sectioned serially at 5-μm intervals along the longitudinal axis. The most central section of the sinus was chosen for histologic analysis. The slides were double-stained with hematoxylin/eosin.

**RESULTS**

**Clinical Observations**

The symptoms of the three patients resolved completely after FESS. During the clinical examinations, all implants placed in the augmented sinuses demonstrated sufficient stability measured using Periotest M (Medizintechnik Gulden e. K.) (∆4 at the maxillary left second
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premolar site and –6 at the maxillary left first molar site in case 1; –6 at the maxillary left first molar site and –8 at the maxillary left second molar site in case 2; and –6 at the maxillary right first molar site and –7 at the maxillary right second molar site in case 3). No further sinusitis-related symptoms have been reported to date.

Radiologic Observations
After FESS, a substantially enlarged ostium and markedly reduced mucosal thickening were observed on CT scans. Moreover, no further pathologic findings such as haziness or graft material displacement were observed on radiologic examinations.

Histologic Observations
Case 1. The specimen mainly comprised loose connective tissue and bone particles. Blood vessels of varying sizes and some fibrosis were found around the bone particles. A limited amount of newly formed bone was observed around bone substitute particles (Fig 5a).

Case 2. A greater amount of newly formed bone was observed in this specimen compared with those in cases 1 and 3. In the middle of the specimen, severe fibrotic tissue was interspersed between the bone tissues. In the coronal area of the specimen, loose connective tissue was observed mixed with a small amount of new bone (Fig 5b).

Case 3. The specimen exhibited loose connective tissue and sparsely located bone tissues. Newly formed bone was observed along with bone substitute particles; several multinucleated giant cells were found. In several parts of the specimen, fibrotic tissue formation was observed (Fig 5c).

DISCUSSION
The present case report describes the clinical, radiologic, and histologic findings obtained after FESS for the management of sinus infection after lateral sinus augmentation. Medication was not sufficient to eliminate the infection, and CT scans revealed severe mucosal swelling obstructing the ostium. All underwent FESS without removing bone substitute material, which...
resulted in the complete resolution of symptoms, and
no further biologic complication was found during
the follow-ups. Core biopsy specimens revealed some
new bone formation with varying degrees of fibrotic
change and tissue density.

The management for sinus infection following sinus
augmentation includes medication, intraoral curettage
of infected graft material and tissues, and endoscopic
sinus surgery.\textsuperscript{4,6,7} However, the treatment regimens in
the literature are generally based on clinical experience.

In previous reports regarding sinus infection, intraoral surgeries were generally performed to remove
infected graft materials and inflamed tissues. However,
in the present study, intraoral surgery was not per-
formed based on the assumption that the sinus infec-
tion could be resolved by improving the drainage and
clearance functions of the sinus, ie, by FESS. During
FESS, ostium is enlarged by means of removing unci-
nate process, but sinus membrane is not generally re-
moved except for large polyps deteriorating drainage
function. In the present cases, FESS led to complete
resolution of the patients’ symptoms and substantial
reduction of sinus mucosal thickening on CT scans.
Moreover, during the follow-up period of the present

\textbf{Fig 4} Clinical photograph taken during functional endoscopic
sinus surgery for patient 3. Scattered bone substitute particles
were removed.

\textbf{Fig 5} (Below) Histologic views of the bone core biopsy speci-
mens. Varying degrees of new bone formation with degenerative
changes are observed. (a) Case 1. (b) Case 2. (c) Case 3.
study, no further biologic complication was noted, and all implants functioned successfully.

The inconsistency between the clinical/radiologic and histologic findings is particularly noteworthy. Despite clinically and radiographically successful results, varying degrees of fibrosis were accompanied by some newly formed bone in the histology. FESS salvaged the grafted materials and dental implants in the present cases, but this may not indicate a fully normal healing response. In the case of no sinus membrane perforation, a large amount of newly formed bone in close contact with bone substitute particles and well vascularized was observed, and fibrotic change was rarely reported.6–11 The sufficient stability of the implants in the present study might be derived from the residual bone, some new bone formed near the preexisting sinus bone wall, and splinting of two adjacent implants. Interestingly, no patient developed a further biologic complication such as infection only in the part above the sinus membrane, it is conceivable to use FESS alone, but there is no definitive way to confirm this. The long-term performance of the placed implants in the present study should be monitored.

CONCLUSIONS

FESS without removing bone substitute material may be sufficient to resolve postoperative sinusitis after lateral sinus augmentation. However, the low predictability of new bone formation after the augmentation makes it questionable to validate this approach even though favorable clinical and radiologic findings were obtained in all cases in this study.

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REFERENCES


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