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ORIGINAL ARTICLE

Histological and clinical outcomes of lateral sinus floor elevation with simultaneous removal of a maxillary sinus pseudocyst

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Abstract

Background: Maxillary sinus pathologies are a potential risk for failure of implant and bone augmentation. Management of lateral sinus floor elevation in the presence of a pseudocyst remains controversial, and reports on histological outcomes of endo-sinus bone augmentation with maxillary cysts are scarce.

Purpose: To present a modified surgical technique for removal of maxillary pseudocyst with simultaneous sinus floor elevation, and to evaluate clinical and histological outcomes of the bone grafting.

Materials and Methods: Patients with a radiographic dome-shaped opacity in the posterior maxillary sinus were included to receive lateral sinus floor elevation with simultaneous pseudocyst removal. Bone core specimens harvested from the lateral aspect of the augmentation sites were histomorphometrically analyzed. Data were recorded and evaluated in terms of survival rates and complications.

Results: A total of 15 patients were included who underwent 17 maxillary sinus augmentation surgeries. Implant survival rate was 97.0%. Bone biopsy specimens were obtained at 6 months after surgery. Histomorphometric analysis revealed that mean percentages of mineralized bone, bone substitute, and nonmineralized tissue were 24.9% ± 18.1%, 14.4% ± 12.5%, and 60.1% ± 12.44%, respectively. No recurrence of the pseudocyst was detected on radiographic examination.

Conclusions: The described technique could be successfully applied in clinical practice to perform sinus augmentation in the presence of pseudocysts.

KEYWORDS

antral pseudocyst, bone regeneration, sinus floor elevation

1 | INTRODUCTION

Although sinus elevation is typically viewed as a routinely performed surgical procedure to increase bone volume in posterior maxilla, maxillary sinus pathologies are a potential risk for failure of implant and bone augmentation.[1,2] Among pathologies of the maxillary sinus, pseudocysts, with a relatively high incidence ranging 1% to 24% (depending on the type of radiograph taken), are mostly encountered in cases of sinus floor augmentation.[3,4] On radiographs, pseudocysts appear as faintly dome-shaped soft tissue on the floor of the maxillary sinus.[5] Thus, careful clinical and radiographic examinations are required before any sinus elevation surgery.[6]

Management of lateral sinus floor elevation in the presence of a pseudocyst remains controversial in terms of cyst removal.[5] Lin stated that the existence of an antral pseudocyst is an absolute contraindication to sinus floor augmentation.[7] On the other hand, according to a prospective study by Timmenga et al., the effect of maxillary sinus surgery does not appear to have clinical consequences in patients without signs of preexisting maxillary sinusitis.[8,9] Several recent studies have considered the presence of a large cyst without signs of sinusitis as a reversible contraindication for sinus floor elevation, one that does not affect the prognosis of bone grafts.[10,11] Complete cyst removal is the gold standard to manage cystic lesions[3]; however, these techniques are limited by higher rates of injury and complications.

Moreover, certain studies have shown that an ordinary course of sinus elevation can be performed with no apparent clinical consequences in patients without signs of preexisting maxillary lesions.[5,12] In cases of a large cyst, elevation of the cyst has a potential risk of ostium blockage.[13] Lin et al. proposed a technique that allowed removal of a pseudocyst followed by sinus augmentation after a short healing period[7]; nevertheless, this modified technique is still a two-staged surgery that requires an additional healing period of 3 months.

So far, management of cysts through maxillary sinus elevation remains controversial. Techniques involving removal of cysts are basically two-staged procedures, wherein a maxillary sinus floor surgery is performed, which is followed by removal of the pseudocyst after a specific healing period. Reports on histological outcomes of endo-sinus bone augmentation in cases of presence of a cyst are scarce. A procedure that combines efficacy and minimal invasiveness is still lacking.

The purpose of this clinical study was to present a modified surgical technique for removal of maxillary pseudocysts with simultaneous sinus floor elevation, evaluating clinical and histological outcomes of bone grafting.

2 | MATERIALS AND METHODS

2.1 | Patient selection

In total, 17 patients who were referred to the Fourth Division of Peking University School of Stomatology, Beijing, China, between February 1, 2013 and June 1, 2017, for implant rehabilitation were consecutively recruited in this study. Inclusion criteria were (a) residual alveolar ridge height <5 mm; (b) spherical or dome-shaped radiopacity in the sinus; (c) buccolingual bone width >6.5 mm; and (d) absence of bony septa in the area of the augmented sinus. Patients were excluded if they had uncontrolled systemic diseases that could impair implant surgery.

The institutional ethics committee of the Peking University School of Stomatology approved this study (reference number: PKUSSIRB-201631115) before patient selection.

2.2 | Clinical procedures

2.2.1 | Preoperative procedures

Following selection, patients were evaluated and treated for periodontal health until a clinically acceptable oral environment was achieved. Cone-beam computed tomography (CBCT) was performed for further identification of the position of the pseudocyst (Figure 1).

2.3 | Surgical procedures

2.3.1 | Maxillary pseudocyst removal and sinus augmentation

All patients received prophylactic antibiotic therapy with 2 g of amoxicillin (500 mg of clarithromycin if allergic to penicillin) 1 hour before treatment. After surgery, amoxicillin (750 mg three times a day), ibuprofen (600 mg three times a day), and chlorhexidine mouthwash (0.2% three times a day) were prescribed for 7 days. Surgery was performed under local anesthesia with 4% articaine according to standard operating procedures. In brief, a crestal incision and vertical releasing incisions were made, followed by full-thickness flap elevation (Figure 2A). After the lateral maxillary wall was exposed, a smaller lateral bony window was first formed using a low-speed bone bur (Figure 2B). The sinus membrane was intentionally perforated, and aspiration of the fluid was performed using a fine needle to reduce the pseudocyst volume and to simplify its removal (Figure 2C). Removal of the lesion was performed through the small additional bony access with tissue pliers (Figure 2D). After irrigation with saline solution, an additional standard bony window was created, and sinus elevation could be performed according to a standardized protocol (Figure 2E). The sinus membrane was gently reflected without increasing membrane perforation and then covered with absorbable collagen membrane (Figure 2F). All sinuses received a graft consisting of large-particle Bio-Oss (Geistlich Pharma AG, Wolhusen, Switzerland) along. At the end of the procedure, the flap was closed. Specimens of the lesion were sent for histopathologic examination.

2.3.2 | Harvesting of bone biopsy and implant placement

Six months after surgery, bone biopsy specimens were obtained by performing a second-stage surgery before implant placement (Figure 3). Bone cores were obtained from the lateral aspect of the former augmentation site. The biopsy core was obtained under external irrigation with sterile saline, and the implant (Thommen Medical AG, Grenchen, Switzerland) was placed according to standard surgical protocols. Healing abutment connection and soft-tissue adjustments were achieved at the same time.

2.4 | Postoperative management

After all surgical interventions, patients were instructed to continue with 0.2% chlorhexidine rinse for 20 seconds and 500 mg of amoxicillin three times per day for 1 week. They were advised to consume a soft diet during the first postoperative week, and their healing outcomes were evaluated after 2 weeks.

2.5 | Preparation of bone biopsy samples

Immediately after harvesting, bone biopsy samples were fixed in 4% paraformaldehyde, demineralized in 15% ethylenediaminetetraacetic acid, and embedded in paraffin. Consecutive horizontal sections (4-μm thick) were obtained along the central axis of the biopsy core. Four to six sections were obtained from the central section of each biopsy specimen and subjected to hematoxylin and eosin staining.

The central region of the biopsy, which was situated at the augmented tissue within the sinus, was analyzed. Histomorphometric analysis was performed to calculate the percentages of mineralized bone (MB), nonmineralized tissue (NMT), and bone substitute (BS).

2.6 | Follow-up procedures and clinical assessments

Standardized panoramic radiographs were recorded immediately after surgery and 12 months after implant placement. All radiographs were obtained by the same operator with the same device (Planmeca

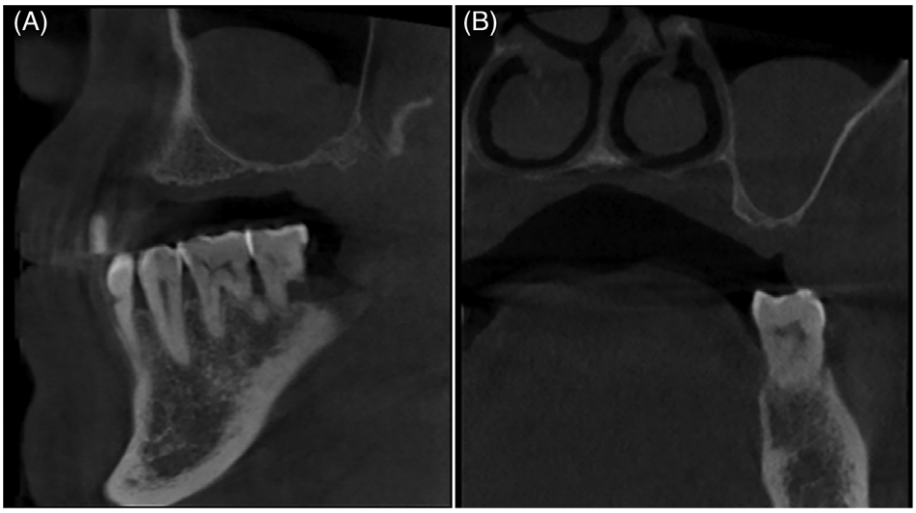

FIGURE 1 Dome-shaped radiopacity observed in the right maxillary sinus

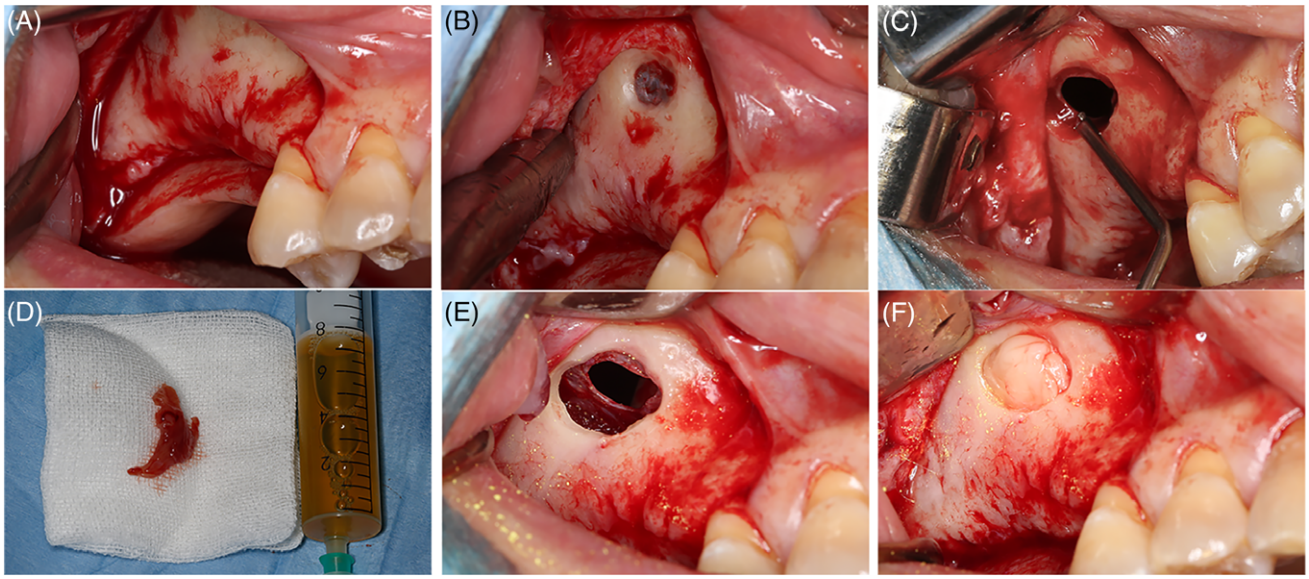

FIGURE 2 A, Elevation of a full-thickness flap to expose the lateral wall of the maxillary sinus. B, Creation of a smaller round-shaped bony window for pseudocyst removal. C, The sinus membrane was perforated and mucous fluid was aspirated using a fine needle. D, The aspirated mucous fluid and the pseudocyst removed with tissue pliers. E, An additional bony window larger than the former one was created to elevate the sinus. F, The sinus membrane was reflected and then covered with absorbable collagen membrane

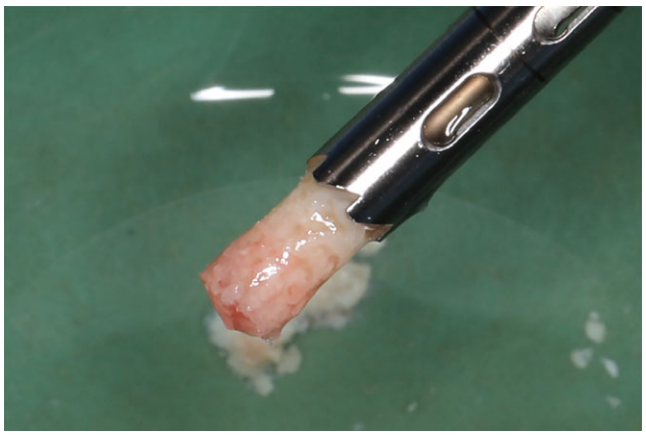

FIGURE 3 Bone specimen obtained from the lateral aspect of the augmentation site

ProMax Dimax3 Ceph; Planmeca, Helsinki, Finland) set at 60 to 62 kV and 8 to 12 mA with a 16-second exposure time and standardized positioning of the head and body. Clinical follow-up was scheduled at 2 weeks, 3 months, and 6 months after surgery and annually thereafter. Primary and secondary outcome measurements were as follows.

2.7 | Primary parameters

2.7.1 | Implant survival rates

Implant survival was assessed on the basis of the following criteria: absence of clinically detectable implant mobility, absence of pain or any subjective sensation, absence of recurrent periimplant infection, absence of continuous radiolucency around the implant, and absence of progressive marginal bone loss.

2.8 | Secondary parameters

2.8.1 | Histomorphometric outcomes

Percentages of MB, BS, and NMT were measured. Each section was examined using light microscopy (Leitz Laborlux 12, Leitz, Germany) at 4× magnification, superimposing a 100-square graticule (1.23 × 1.23 mm, Leica microscope systems, Leica, Germany) at the ocular level. Analysis of percentages of MB, BS, and NMT was performed using Image Pro Plus 6.0 software (Media Cybernetics, Silver Spring, Maryland). The area fraction percentage of each component was determined. Counting was performed three times per bone core and per patient.

2.8.2 | All complications

Postoperative complications such as hematoma, sinusitis, cyst recurrence, and infection were recorded.

All clinical assessments were performed by a clinician who was not involved in treatment of the patients.

2.9 | Statistical analysis

All data were analyzed using the Statistical Package for Social Sciences (SPSS software, version 14.0, IBM, Armonk, New York). Continuous and discrete variables were described using mean (±SD) and frequency, respectively.

The contents were in accordance with the checklist.

3 | RESULTS

Overall, 19 pseudocysts were removed from sinuses of 17 patients. One patient dropped out at 6 months after loading; he was contacted by phone and reported no issues in relation to the implants. In another patient, because no cystic fluid could be obtained through aspiration with a needle, the wound was primarily closed without removing the lesion. After a 3-month healing period, the pesudocyst was slightly reduced in size, and the sinus membrane was lifted by avoiding perforation of the sinus. Eventually, these two patients were excluded, and only 15 patients with 17 sinuses completed the study. Primary baseline characteristics of patients are presented in Table 1.

3.1 | Primary outcome measure

Only one implant (#27) failed before loading, probably because of lower primary stability. Accordingly, the implant survival rate was 97.0%. This implant was removed and placed again after a 3-month healing period. All other implants remained stable, with no complications reported till the end of the study.

3.2 | Secondary outcomes measures

3.2.1 | Histomorphometric outcomes

A total of 17 bone biopsy specimens were obtained at 6 months after grafting, of which, three were too deteriorated to undergo histomorphometric analysis and were thus discarded. Histomorphometric analysis revealed that the mean percentages of MB, BS, and NMT were 24.9% ± 18.1%, 14.4% ± 12.5%, and 60.1% ± 12.4%, respectively (Figure 4). The proportions of each component are presented in Table 2.

TABLE 1 Patient and intervention characteristics

Characteristic	No.
Number of patients (female)	15 (5)
Mean age at implant insertion (years)	53.8
Number of elevated maxillary sinus	17
Total number of inserted implants	33

3.2.2 | Complications

Until the last recall, no pseudocyst recurrence was detected on radiographic examinations. One patient developed acute sinusitis 2 weeks after surgery, which was treated with oral antibiotics. Other surgical complications were minor inflammation at the implant site and minor discomfort owing to the surgical procedure (Table 3).

Prosthetic analysis revealed that two crowns were replaced because of veneer and restoration fracture (Table 3).

4 | DISCUSSION

The present study evaluated outcomes of pseudocyst removal with simultaneous sinus floor elevation performed for rehabilitation of missing posterior teeth. Results suggested that the technique performed in the present study provided favorable clinical and histological outcomes.

To our knowledge, this is the first study to perform histological analysis of endo-sinus bone augmentation in the presence of pseudocysts. Histologically, maturation of the endo-sinus bone (24.9%) observed with the method used in the present study was comparable to results of similar cases without pseudocyst reported in previous relevant studies, in which Bio-Oss was used along.[14,15] Available literature shows a wide range of results when ABBM mixed with autogenous bone was used, with vital bone concentration ranging 15.7% to 32.2%,[16,17] which is comparable to the results of the present study. According to certain articles, sinus bone graft has been contraindicated in the presence of a cyst in the maxillary sinus.[7,18] The present study showed that presence of a cyst in the maxillary sinus does not affect prognosis of the sinus bone graft. In this study, the total implant survival rate was 97.0%, which is similar to rates reported in previous studies, in which Bio-Oss was used along or as a composite graft with amounts of autogenous bone.[1,10]

Although Caldwell-Lec surgery and endoscopic sinus surgery can be performed for complete cyst removal and to avoid recurrences, studies have proposed a period of 6 to 12 months for sinus augmentation after removal of an antral pseudocyst to allow for regeneration of new respiratory ciliated epithelium.[19,20] However, high complication rates and operative trauma can create challenges in terms of patient cooperation. Before sinus floor elevation, aspiration of mucus is performed to reduce the size of the cyst and decompress the pressure.[21] Although the reported survival rate of implants is as high as 91.8% (61.7%-100%), there is a potential risk of recurrence owing to connective tissue remnants.[22] A previous study reported spontaneous

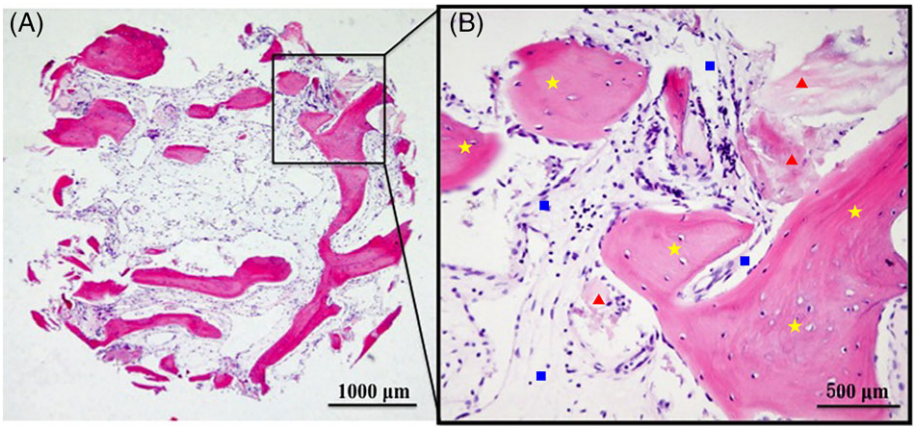

FIGURE 4 A, Histological section of a bone core biopsy providing an overview at 4-fold magnification (solo-window group). B, Image at a higher magnification showing details of the same sample. Note the newly formed bone (yellow stars) over remaining allograft particles (red triangles) embedded in a nonmineralized matrix (blue squares; H&E 20*)

regression of lesions in approximately 30% of patients.[23] On the other hand, a recent study reported successful sinus augmentation without removal of cyst.[4] However, the shortcoming of this technique is that histological evaluation cannot be performed, and if the cyst occupies most of the space (75%) in the sinus the ostium may be blocked or compromised because of sinus elevation.[6] Accordingly, to safeguard sinus drainage, sinus floor elevation must preserve the patency of the ostium.[24] A study by Wang et al. showed that 29.4% of sinus cysts were found to increase in size after 38-102 months of follow-up, indicating increasing obstruction of the ostium[25] Therefore, removal of a large pseudocyst before or during a sinus grafting procedure may be recommended, although most of them are not evident clinically. Lin et al. proposed a modified technique, in which the maxillary sinus was elevated following removal of a maxillary sinus pseudocyst after a short healing period.[7] However, this technique has several limitations. An additional postoperative healing period of 3 months was still needed, and patients were required to undergo a second surgical procedure, in which sinus floor elevation was performed in the presence of scar tissues derived from the first surgical access, thus increasing the technical difficulty.[7]

TABLE 2 Histomorphometric data

MB%	24.9 ± 18.1
BS%	14.4 ± 12.5
NMT%	60.1 ± 12.4

Abbreviations: BS, bone substitute materials; MB, mineralized bone; NMT, nonmineralized tissue.

TABLE 3 Incidence of surgical complication

	n	%
Sinus complications	1	5.9
Acute sinusitis	1	5.9
Recurrence of pseudocyst	0	0.0
Prosthetic complications	...	...
Restoration fracture	1	3.0
Implant loss	1	3.0

The technique used in the present study was performed through intentional perforation of the sinus membrane with simultaneous sinus floor elevation after closure of the membrane tear with absorbable collagen membranes. The smaller bony window is created to allow removal of the cyst without excessive damage of surrounding sinus mucosa or increasing the size of the perforation. The bony window is then enlarged, encircling the former window, and by avoiding elevation of the sinus membrane close to a laceration, thus increasing the size of the tear. A larger opening is also facilitated to obtain easier access to complete the membrane elevation and perform the repair. Membrane perforation, which is encountered in 10% to 56% of cases, should not be regarded as a contraindication for sinus augmentation.[26] It has proven to be a safe and highly effective surgical procedure with predictable results.[26] The mini-bony window was first created for removal of a lesion so as to avoid excessive damage of the sinus membrane. The conventional bony window was performed to allow sinus elevation around the perforation. The mucus of the maxillary sinus was aspirated before sinus membrane elevation, which could decompress pressure, reduce the size of the cyst, and decrease the possibility of laceration of the Schneiderian membrane.[27] Because increased membrane thickness generally occurs in the presence of a pseudocyst, sinus membrane separation and elevation is easier to perform in such a situation. Accordingly, sinus augmentation could be successfully performed with intentional sinus perforation.

In the present study, 12.5% to 15% of patients developed fluid leakage and sinusitis during the postoperative phase. The rates of obstruction of ostium, hemorrhage, and infection were low in the present study. Based on available literature, the prevalence of sinusitis after sinus augmentation in the absence of any pathology is approximately 3% to 20%.[28,29] Mardinger et al. reported six patients from 129 maxillary sinus floor augmentation cases who developed postoperative sinusitis.[4] Until the end of the follow-up, no recurrence of pseudocyst was detected on radiographic examination.

On the other hand, there is a potential risk of implant and bone augmentation failure if a lesion is histologically verified as an invasive or malignant lesion. Hence, preoperative radiographic evaluation must be performed. Pseudocysts typically appear in hemispheric and

homogeneously opaque and well delineated in panoramic and CBCT images, without aggressive and destructive characteristics.[13]

The present study has certain limitations. The number of cases was limited and the follow-up duration was relatively short. Additional randomized controlled trials are warranted to compare clinical outcomes of the presented technique and removal of pseudocysts 3 months before maxillary sinus floor elevation. Future follow-up studies should evaluate long-term recurrence of cysts.

5 | CONCLUSION

Based on the findings of this study, the described modified surgical procedure could be successfully performed to remove maxillary pseudocysts immediately after sinus augmentation. However, detailed clinical and radiographic evaluation should be performed before sinus floor elevation.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to report.

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