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Raising the transcrestal sinus floor in the presence of antral pseudocysts, and in sinus floors with a normal Schneiderian membrane: a retrospective cohort study

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Abstract

In this study we sought to investigate the influence of antral pseudocysts on the raising of the transcrestal sinus floor. We retrospectively studied two groups (test group: those with antral pseudocysts, and controls: those with normal Schneiderian membranes). The crestal approach with simultaneous placement of implants was used for all patients. Cone-beam computed tomography was done before, immediately afterwards, and 4-6 months postoperatively. Nineteen participants (16 male, three female, mean (SD) age 48 (10) years) were enrolled in the test group, and 73 (38 male, 35 female, 44 (11) years) in the control group. Immediately postoperatively the mean (SD) residual bone height was 5.15 (1.34) mm in the test group and 5.36 (1.28) mm in the control group ($p = 0.15$), and the raised heights of the sinus floor were 4.98 (2.01) mm and 5.47 (2.13) mm ($p = 0.35$) in the test and control groups, respectively. Four to six months postoperatively the endo-sinus bone gain values were 3.55 (2.46) mm and 4.03 (2.33) mm in the test and control groups, respectively ($p = 0.26$). All pseudocysts swelled immediately after operation. Four to six months postoperatively, two had remained unchanged, three had increased in volume, six had disappeared, and eight had decreased in volume. The survival rate of implants was 100% for both groups. Within the limitations of this study, transcrestal raising of the sinus floor in the presence of antral pseudocysts may be a viable technique, as they may not influence the clinical effects of raising the sinus floor during healing.

Keywords: antral pseudocyst; transalveolar approach; simultaneous implant placement; cone-beam computed tomography

Introduction

Placement of implants in the posterior maxilla is often limited by the lack of vertical bone height, and augmentation may be indicated when the distance from the top of the alveolar ridge to the sinus floor is less than 8–10 mm.[1] To date, two major techniques for raising the sinus floor have been used: the lateral window, and the transalveolar, approach. The transalveolar approach is less invasive, and popular clinically.[2]

Cysts are often encountered in the maxillary sinus and are primarily classified as retention cysts, mucoceles, and antral pseudocysts.[3–7] Retention cysts are caused by obstructive seromucous glands of the sinus mucosa that result in cystic dilatation of the gland by accumulated mucus.[8] They seldom become large enough to be seen on radiographs, and they are common around the ostium.[9] Mucoceles are lesions

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that develop from extravasations of mucus into the surrounding soft tissues as a result of obstruction of salivary flow or trauma. They opacify the affected sinus and expand into the adjacent structures, in which case raising the sinus floor should be avoided.[10] Antral pseudocysts are an accumulation of inflammatory exudates that are enclosed by loose connective tissue. They are found in 1.4% to 9.6% of the population when assessed by panoramic radiographs.[11] Radiologically, they are homogeneous and dome-shaped, with a smooth spherical outline along the free border. As they are located primarily on the sinus floor, they act as obstacles to the transalveolar approach.[12]

There is ongoing debate about whether antral pseudocysts affect the raising of the maxillary sinuses, and different strategies have been used to prevent possible intraoperative and postoperative complications. Three principal ones have been reported: the removal of the pseudocysts three to 12 months before the sinus floor is raised;[5] removal of them during the operation to raise the sinus floor;[12,13] and leaving them alone when the floor is raised.[3,6,7,9,14–16] The third option may be the simplest and fastest. However, a lateral approach has been widely used in previous studies[3,7,9,14] and only a few papers have reported the use of the crestal approach in the presence of pseudocysts.[6,15,16]

The aim of this retrospective study was to compare the clinical outcomes of implants placed in the presence of antral pseudocysts (experimental) and in sinuses with normal Schneiderian membranes (controls), and to evaluate their effect on the transcrestal sinus lift. We hypothesised that their presence does not affect the clinical outcome.

Patients and methods

Patients

This retrospective study was approved by the regional ethics committee of the West China Hospital of Stomatology, Sichuan University (ethics registration number WCHSIRB-D-2015141). From July 2013 to August 2015 all patients who had transcrestal surgery at the Department of Oral Implantology, West China School of Stomatology, were consecutively assessed. The inclusion criteria were: treated by the crestal approach; teeth were extracted from the implant sites at least four months before operation; and complete cone-beam computed tomographic (CT) scans, radiographs and clinical records were available.

Exclusion criteria were: compromised systemic health; alcohol misuse or smoking >20 cigarettes/day; the Schneiderian membranes damaged during operation; and uncontrolled periodontal disease.

The sample size was calculated as described by Machin et al.[17] The 80% test power and two-sided 95% CI were adopted. The differences between endo-sinus bone gain measured in the two groups were chosen as the primary outcomes. A mean (SD) value of 5.0 (1.3) mm was used for the control group[18] and as recommended by Feng et al[15] 3.40 (1.78) mm was chosen for test group. To detect a true difference of at least 1.6 (1.78) mm between the two groups, therefore, we required at least 87 participants.

Surgical and prosthetic procedures

For the operation we used a membrane elevation kit (DASK Advanced Sinus Kit; Dentium Korea, Samsung-dong). The oral cavity was disinfected and local infiltration anaesthetic injected into the surgical area. A midcrestal incision was made and a full thickness mucoperiosteal flap raised. Drills with a particular stopper were used (Fig. 1). According to preoperative cone-beam CT images, stoppers of different heights were chosen that were consistent with the different residual bone heights between the crest and the sinus floor. Once the sinus floor had been penetrated with the intact membrane, various membrane detachment instruments were used to displace the membrane from the bone. After the integrity of the membrane had been checked using the Valsalva manoeuvre, bone substitutes (Bio-Oss; Geistlich Pharma AG) were

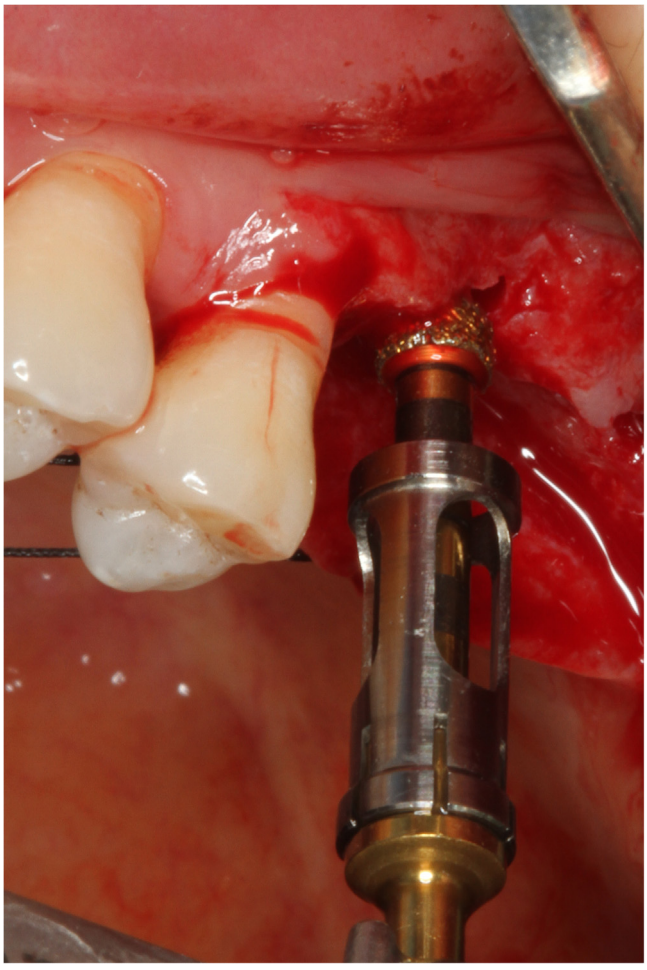

Fig. 1. We used a crestal approach drill connected to a stopper to prepare the site.

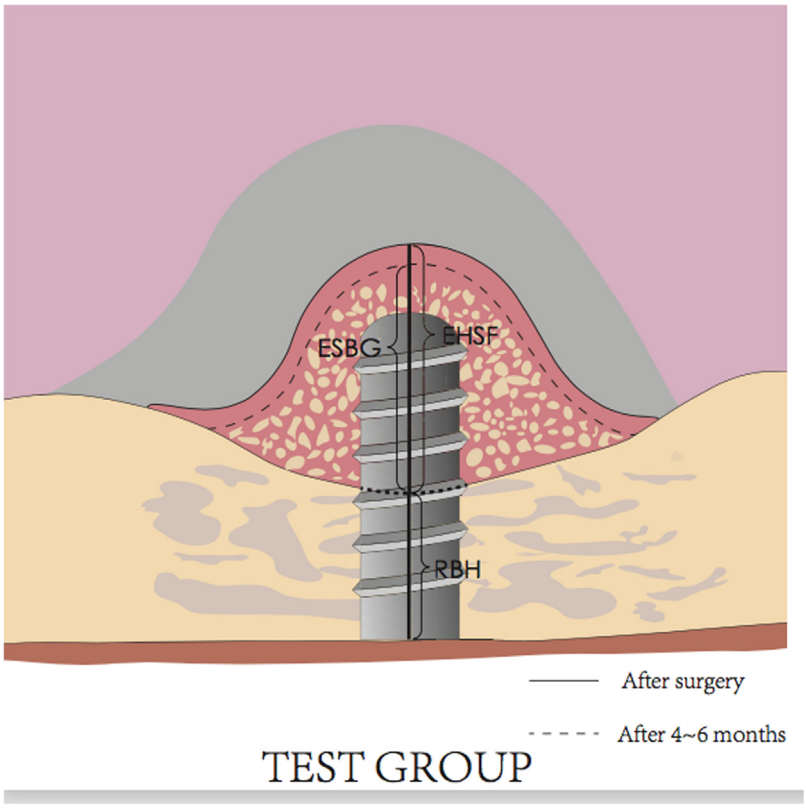

Fig. 2. Linear measurements on cone-beam computed tomography scans.
RBH = residual bone height; EHSF = the raised height of the sinus floor measured at T1; ESBG = the endo-sinus bone gain measured at T2.

inserted into the lifted sinus, the implants (Institut Straumann AG) were inserted.

All patients were given one dose of amoxicillin 1000 mg every eight hours for seven days, and analgesics as required. Patients were instructed to rinse their mouths with 0.2% chlorhexidine solution 2-3 times a day for one week. The sutures were removed seven days postoperatively.

After a healing period of 4-6 months the implant was exposed through a minimal crestal incision and impressions taken. Reconstructions were delivered two weeks later. The implant was said to have survived if the patient was free of symptoms and had stable implants without radiographic evidence of severe bone loss.

Radiographic analysis

Cone-beam CT images were obtained preoperatively (T0), immediately after operation (T1), and 4-6 months postoperatively (T2) (3D Accuitomo 170®, J. Morita Mfg Corp). All measurements were made by one independent examiner with training in making related measurements. Values were measured twice in 10 randomly-selected scans at an interval of one week, and calibrated with an intraclass correlation coefficient of 0.838.

Classification of the membrane

The condition of the sinus membrane was evaluated using the preoperative cone-beam CT data, which were reformatted and analysed using i-Dixel One Volume Viewer (J. Morita Mfg. Corp). According to the mucosal thickness and the appearance, the mucosa was classified as normal (≤2 mm thick) or as a dome-shaped antral pseudocyst.[16]

Linear variables

Cone-beam CT images taken at T1 and T2 were used to analyse the linear variables. The implant served as a reference point for adjusting the image in a i-Dixel One Volume Viewer. The following variables were evaluated on the mesial and distal sides of the implant (Fig. 2).

Residual bone height was measured from the crest to the sinus floor in the postoperative cone-beam CT images, and was calculated as the mean of the mesial and distal alveolar residual crests of the implant site.

The raised height of the sinus floor was measured using the postoperative cone-beam CT images. The distance between the floor of the maxillary sinus and the border of the graft was measured at the mesial and distal sides of each implant and then a mean was taken.

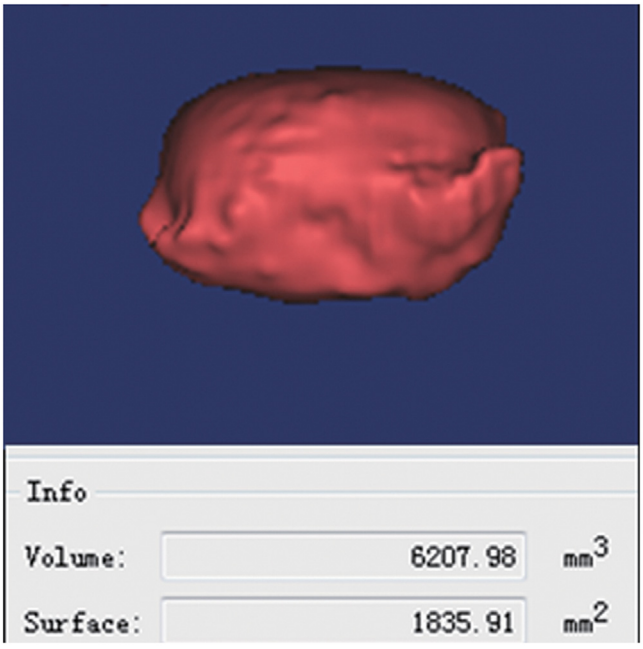

Fig. 3. Preoperative 3-dimensional image of one antral pseudocyst reconstructed from DICOM data, which indicates a dome-shaped lesion.

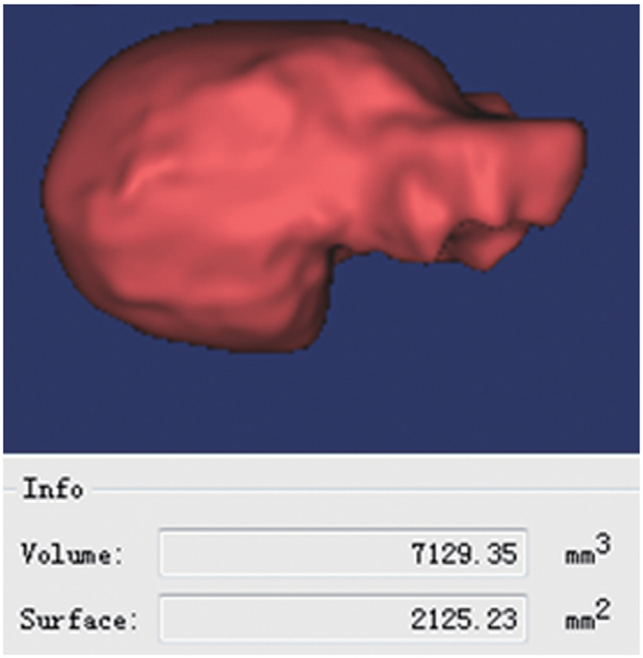

Fig. 4. Postoperative image shows that the volume increased and that part of the bottom lifted.

Endo-sinus bone gain was calculated by recording the mean distance of both sides of the implant between its platform and the floor of the maxillary sinus. An increase of the mean value on consecutive radiographs (taken at T1 and T2) indicated endo-sinus bone gain.

Volumetric changes in the antral pseudocysts

Cone-beam CT images at T0, T1, and T2 were saved as DICOM files, which were imported into Materialise Mimics 15.0. A total of 57 sinuses (19 of which were in the test group at T0, T1, and T2) were segmented, and volumetric measurements were made (Figs. 3–5). The percentage of the volumetric change was calculated by subtracting the volume of the pseudocyst at T1 or T2 from the volume at T0. The difference was then divided by the volume of the pseudocyst at T0, and multiplied by 100%. To take account of errors in measurement, a volume change within 5% was defined as "no change".

Statistical analyses

We used SPSS Statistics for Windows software (version 17.0, SPSS Inc) to analyse the data. Independent-samples *t* tests were used to calculate the significance of differences between the groups in the measurements of residual bone height, raised height of the sinus floor, and endo-sinus bone gain. The chi-squared test was used to assess the significance of differences in categorical variables. The significance threshold for all analyses was set at $p < 0.05$.

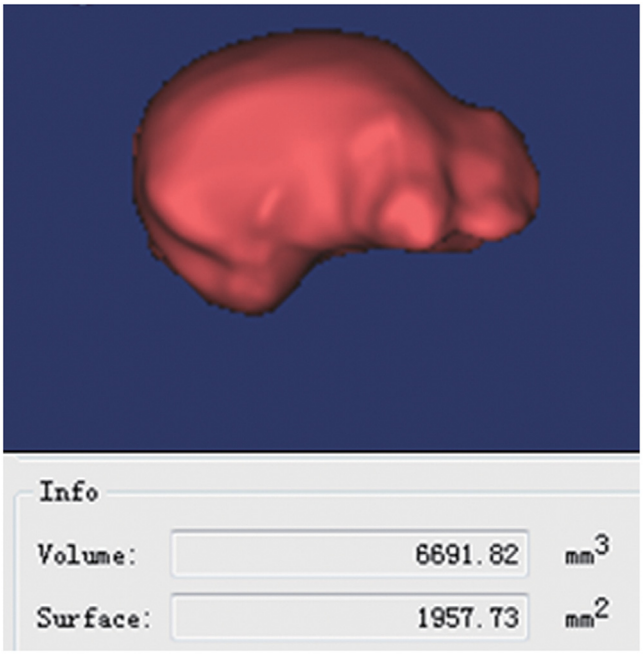

Fig. 5. Six-month 3-dimensional image shows that the volume of the image decreased, and the lifted part collapsed to some degree.

Results

Demographic details

Consecutive patients who fulfilled the inclusion criteria were entered into the study. Six patients who were treated by the lateral window approach because the sinus membrane was perforated during the transalveolar approach were excluded

Table 1
Measured bone data from the sinus floor postoperatively.

Variable	Experimental group (n = 19)	Control group (n = 73)	p value*
Residual bone height (mm):			
Mean (SD)	5.15 (1.34)	5.36 (1.28)	0.15
Range	2.02–8.07	2–7.5	
Raised height of sinus floor (mm):			
Mean (SD)	4.98 (2.01)	5.47 (2.13)	0.35
Range	1.45–9.55	1.75–9.36	
Endo-sinus bone gain (mm):			
Mean (SD)	3.55 (2.46)	4.03 (2.33)	0.26
Range	0.71–7.95	0.87–8.52	

* From the independent *t* test.

from the analysis. As a result, a total of 19 participants (16 male and 3 female, mean (SD) age 48 (10) years) were enrolled in the test group, and 73 (38 male and 35 female, mean (SD) age 44 (11) years) in the control group. All implants remained successfully functional after a follow-up period of 4-6 months, resulting in a 100% survival rate for both groups.

Linear measurements

The mean (SD) residual bone height (p = 0.15), raised height of the sinus floor (p = 0.35), and endo-sinus bone gain (p = 0.26) are shown in Table 1. There were no significant differences between the two groups.

Surgical complications

During operation, rifts of the Schneiderian membrane were noted in one case with antral pseudocysts, and in five cases with normal Schneiderian membranes after the Valsalva manoeuvre. These six cases were excluded from the study. A buccal window was created in the lateral wall of the maxillary sinus, the sinus membrane was raised gently, and all six perforations were repaired and covered using a collagen membrane (Bio-Gide, Geistlich Pharma AG). Bone substitutes (Bio-Oss; Geistlich Pharma AG) were applied to graft the sinus. There were no disturbances in the healing process among the six cases.

Volumetric changes in the antral pseudocysts

The mean (SD) volume of an antral pseudocyst preoperatively was 3.02 (2.44) ml (0.56-9.33 ml), 3.90 (2.76) ml (0.65-10.6 ml) immediately poatoperatively, and 2.30 (2.57) (0-7.75 ml) after 4-6 months follow-up. Immediately postoperatively the volumes of all antral pseudocysts increased. After four to six months, two remained unchanged, three had increased in volume, six had disappeared, and eight had decreased in volume.

Discussion

Our results have shown that the presence of antral pseudocysts did not influence the raised height of the sinus floor after the transalveolar approach, nor did their presence affect the endo-sinus after 4-6 months of healing. Most pseudocysts (14/19) either decreased or disappeared after a short healing period, which showed that the crestal approach in the presence of such cysts does not pose additional risks for aggravation of the original lesions in most cases.

After 4-6 months there was no significant difference in the endo-sinus bone gain between the two groups, which is similar to that reported by Qin et al.[16] They evaluated 15 patients with antral pseudocysts and 72 patients with normal Schneiderian membranes, and found that the bone gain was 3.45 mm for the cyst group and 3.34 mm for the normal group, with no significant differences in bone gain during the healing period.

The Schneiderian membrane is organised in three layers: a thin band of periosteum that loosely adheres to the internal aspect of the sinus bony walls; a respiratory ciliated pseudostratified columnar epithelium facing the sinus lumen; and a fine layer of connective tissue interposed between the periosteum and the epithelium.[19] The deepest layer of the Schneiderian membrane is related to the regeneration of bone that occurs after sinus lifting procedures.[20] Because antral pseudocysts develop as a result of the accumulation of inflammatory exudates that are surrounded by loose connective tissue, we hypothesised that the pseudocysts do not affect the deepest periosteum-like lining of the membrane, and therefore do not affect the bone-inductive function. However, more studies with longer follow-up periods are required to confirm these findings.

The perforation of the sinus membrane is the most common surgical complication during augmentation of the maxillary sinus.[21] The low perforation rate in our study for patients with antral pseudocysts is similar to that reported by Kara et al[14] and Feng et al[15] both of whom reported that they had used the crestal approach in the presence of pseudocysts, and found no penetration of the membrane during operation. They inferred that, as the Schneiderian membrane is generally thickened in the presence of pseudocysts, tearing of the sinus membrane would be unusual.

To investigate the changes in the antral pseudocysts during the follow-up of 4-6 months, we made a volumetric analysis of the DICOM data. To the best of our knowledge, it is the first time that the volume of antral pseudocysts has been evaluated in procedures to raise the sinus floor. The result showed that, immediately postoperatively, the volumes in all cysts increased, and this result confirms the findings of Guo et al.[22] They had evaluated 11 patients with pseudocysts who had had the lateral approach, and found that the thickness of the Schneiderian membrane increased from 1.19 (0.47) mm preoperatively to 7.05 (5.85) mm immediately postoperatively.

The sample sizes differed between the two groups. First, the incidence of antral pseudocysts is low (ranging from 1.4% to 9.6% when assessed on panoramic radiographs),[11] while the incidence of normal sinus membranes is higher than that of pseuodcysts, which is 55.1% as viewed by cone-beam CT.[23] Secondly, the difference in sample size has also been shown by other authors. Qin et al[16] evaluated 15 patients with pseudocysts and 72 patients with normal Schneiderian membranes, and Guo et al[22] reported 11 patients with pseudocysts and 30 patients with normal sinus membranes.

However, these findings should be interpreted with caution because of the limitations of the study design. The small number of cases in the pseudocyst group, together with the brief follow-up period, might affect the findings. Prospective studies with larger samples and longer follow-up periods are required to confirm these findings.

Conclusions

Within the limitations of the study, transcrestal raising of the sinus floor in the presence of antral pseudocysts may be a viable technique, and the pseudocysts may not influence the clinical effects of transcrestal raising of the sinus floor during the healing period.

Conflicts of interest

We have no conflicts of interest.

Ethics approval and patients' consent

This retrospective cohort study was approved by the regional ethics committee of the West China Hospital of Stomatology, Sichuan University (ethical registration number WCHSIRB-D-2015141). We have obtained the permission of the patients.

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