

Complications of postoperative swelling of the maxillary sinus membrane after sinus floor augmentation

Abstract

Objective

The aim of this article was to investigate postoperative swelling of the maxillary sinus membrane that occurred one week after sinus floor augmentation.

Materials and methods

Maxillary sinus floor augmentations were performed by the lateral window technique in 132 sites using beta-tricalcium phosphate (β -TCP) granules. Cone beam computed tomography (CBCT) scans were taken before surgery, the day of surgery, and one week, three months and one year after surgery. The proportion of the area of the postoperative swelling of the sinus membrane in relation to the remaining sinus cavity was determined and classified into three types: Type 1, less than one-third; Type 2, one-third to two-thirds; and Type 3, more than two-thirds of the remaining sinus cavity. The sites were divided into two groups based on the extent of lateral window coverage: Group 1, not completely covered; and Group 2, completely covered. The degree of migration of the β -TCP granules was evaluated and classified into three types: Type A, limited to the lateral window; Type B, limited to the adjacent tooth; and Type C, extending beyond the adjacent tooth.

Results

One week after surgery, swelling of the maxillary sinus membrane occurred in all 132 sites (100%). The proportion of postoperative swelling was Type 1 at 24 sites (18.2%), Type 2 at 65 sites (49.2%) and Type 3 at 43 sites (32.6%). In Group 1, the extent of migration was Type A at seven sites (38.9%), Type B at eight sites (44.4%) and Type C at three sites (16.7%). In Group 2, the extent of migration was Type A at 110 sites (96.5%), Type B at one site (0.9%) and Type C at three sites (2.6%).

Conclusion

A complication of this temporary swelling of the sinus membrane was the migration of β -TCP granules toward the buccal side through the lateral window. It is recommended that the lateral window be covered tightly to avoid the migration of bone substitute materials in the lateral window technique.

Keywords

Sinus floor augmentation, cone beam computed tomography, swelling of the sinus membrane, biological reaction, complication.

Introduction

Conventional postoperative evaluation using panoramic radiographs provides only 2-D information and may not be good enough to evaluate the outcomes of sinus floor augmentation precisely. Recently, cone beam computed tomography (CBCT) was developed, and it offers the advantage of clear image quality at very low patient radiation doses. CBCT has made it possible to evaluate biological reactions of the augmented area longitudinally using images taken in the same direction. However, there remains considerable disagreement about how to reduce the patient radiation dose from CBCT. The radiation dose depends on the CBCT unit, exposure voltage, exposure current and imaging volume. Okano et al. reported that the effective dose of the 3D Accuitomo (J. Morita, Kyoto, Japan) ranged from 18 to 66 μ Sv.¹ According to data

from Li, the effective dose from 3D Accuitomo was 54 μSv , while that of CB MercuRay (Hitachi Medical Systems America, Twinsburg, Ohio, U.S.) using a panoramic field of view was 560 μSv .² Lofthag-Hansen et al. reported that the calculated effective dose of 3D Accuitomo was 52–63 μSv with a volume size of 60 mm in diameter \times 60 mm in length, tube voltage of 75 kV and tube current of 4.5–5.5 mA.³ Therefore, postoperative examination of sinus floor augmentation using CBCT appears to be safe when the appropriate CBCT device and parameters are selected.

We found that the maxillary sinus membrane swelled one week after sinus floor augmentation. This previously unknown biological reaction could not be identified on the 2-D radiographs and has not been reported before. The aims of this clinical study were to investigate this postoperative swelling of the maxillary sinus membrane using CBCT and to evaluate its complications. Furthermore, methods to prevent these complications were considered.

Materials & methods

Selection and regulation of CBCT device

In order to limit the radiation dose, 3D Accuitomo was selected and an imaging volume size of 60 mm in diameter \times 60 mm in length for the examination of maxillae was chosen. Furthermore, the tube voltage was set at 80 kV and the tube current at 2 mA for 17.5 s of exposure time. In this situation, the calculated effective dose was approximately 40 μSv .

Informed consent for CBCT scans

It was explained to all of the patients that the total radiation dose of five CBCT examinations was approximately 200 μSv and less than half of that of old-type CBCT scans. All of the patients understood the importance of CT evaluations of the sinus floor augmentation and consented to five CBCT scans over the first year after surgery.

Patients and surgery

The patient population was 112 and consisted of 35 males and 77 females who ranged in age from

25 to 77 years (mean age of 53.5 years). All patients were in good health, and 24 patients (21.4%) were smokers. The standard examination found no local or systemic contraindications to the maxillary sinus floor augmentation. In 20 patients (15.2%), the maxillary sinus floor augmentation was performed bilaterally, and the surgery was carried out in 132 sites in total.

All of the patients had been referred to our clinic by their original dentists for sinus floor augmentation owing to insufficient bone volume of the posterior maxillae. Maxillary sinus floor augmentations were performed by the lateral window technique using only beta-tricalcium phosphate (β -TCP) granules (OSferion, Olympus Terumo Biomaterials, Tokyo, Japan) over the period of March 2006 to June 2012. The surgeries were performed by the same oral surgeon under local anesthesia with intravenous sedation. After the creation of the lateral window, the maxillary sinus membrane was detached from the surface of the maxillary sinus and elevated. The empty compartment created by elevating the sinus membrane was filled with β -TCP granules as the bone substitute material.

The sites were divided into two groups based on the extent of lateral window coverage. The lateral window was not completely covered in Group 1 and was completely covered with a titanium mesh plate and microscrews or only a resorbable barrier membrane in Group 2.

CBCT evaluation

The proportion of the area of the postoperative swelling of the maxillary sinus membrane that occurred one week after surgery in relation to the remaining sinus cavity was determined and classified into three types (**Fig. 1**):

Type 1: Swelling of less than one-third of the remaining sinus cavity

Type 2: Swelling of one-third to two-thirds of the remaining sinus cavity

Type 3: Swelling of more than two-thirds of the remaining sinus cavity.

The degree of buccal migration of the β -TCP granules through the lateral window was classified into three types (**Fig. 2**):

Type A: Limited to the lateral window

Type B: Limited to the adjacent tooth

Type C: Extending beyond the adjacent tooth.

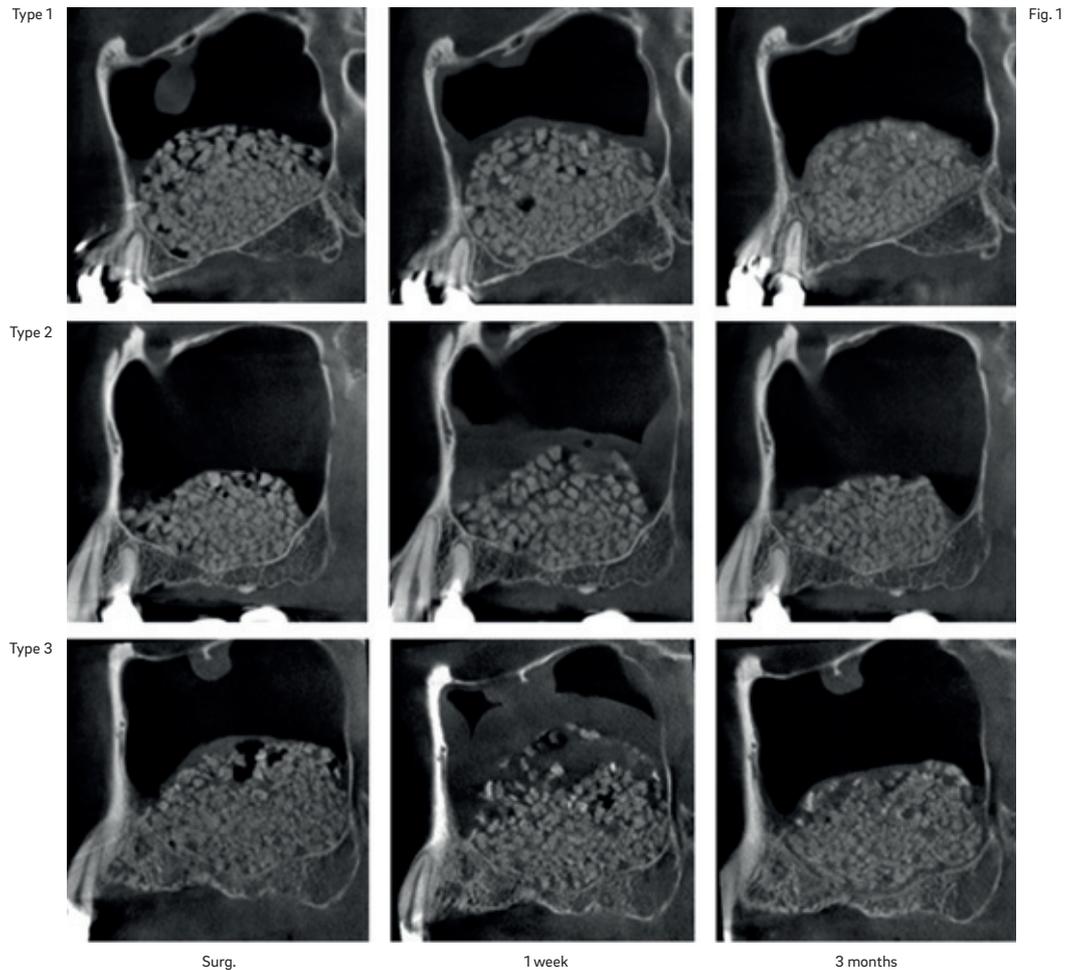


Fig. 1
Classification of the postoperative swelling of the maxillary sinus membrane that occurred one week after the sinus floor augmentation. Three months after surgery, the postoperative swelling had disappeared spontaneously in 127 sites (96.2%).

Results

CBCT evaluation

Extent of postoperative swelling

Slight swelling of the maxillary sinus membrane, of up to 4 mm, was observed in 21 sites (15.9%) before the surgery. One week after surgery, postoperative swelling of the sinus membrane was observed in 132 sites (100%). Three months after surgery, the swelling of the sinus membrane had disappeared spontaneously (**Fig. 1**) in 127 sites (96.2%).

The number of sites according to the three types of postoperative swelling is shown in **Figure 3**. In approximately 80% of the sites, the extent of the postoperative swelling constituted more than one-third of the remaining sinus cavity:

- Type 1:** 24 sites (18.2%)
- Type 2:** 65 sites (49.2%)
- Type 3:** 43 sites (32.6%).

Migration of β -TCP granules

Migration of the β -TCP granules toward the buccal side through the lateral window was observed as a complication of the postoperative swelling of the maxillary sinus membrane.

Case 1 (52-year-old female, Group 1, Type 3, Type C, nonsmoker)

The sinus floor augmentation and the guided bone regeneration technique were performed simultaneously, and a barrier membrane was placed without covering the lateral window completely (**Figs. 4a–c**). One week after surgery, Type 3 swelling of the sinus membrane was observed and some β -TCP granules at the augmented area had disappeared (**Fig. 4d, red arrows**). According to the horizontal CBCT slice images, the β -TCP granules had migrated toward the buccal side through the lateral window and moved beyond the canine (**Fig. 4e, yellow arrows**). Ten days after surgery, intra-

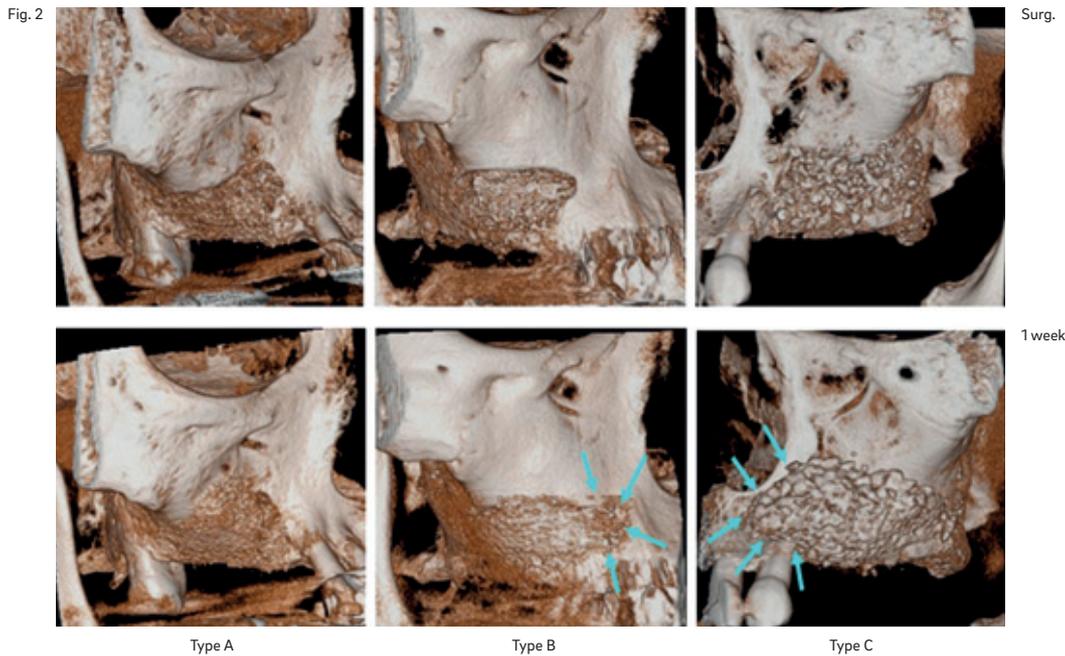


Fig. 2
Classification of the buccal migration of β -TCP granules through the lateral window.

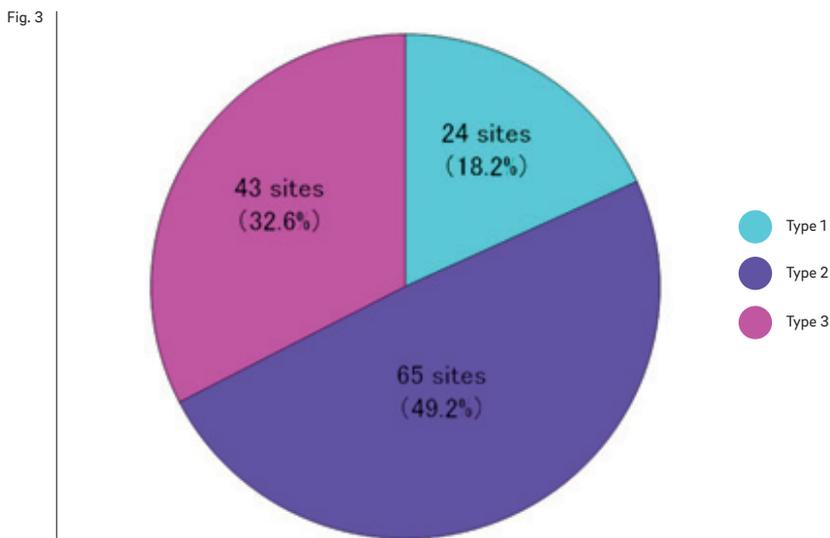
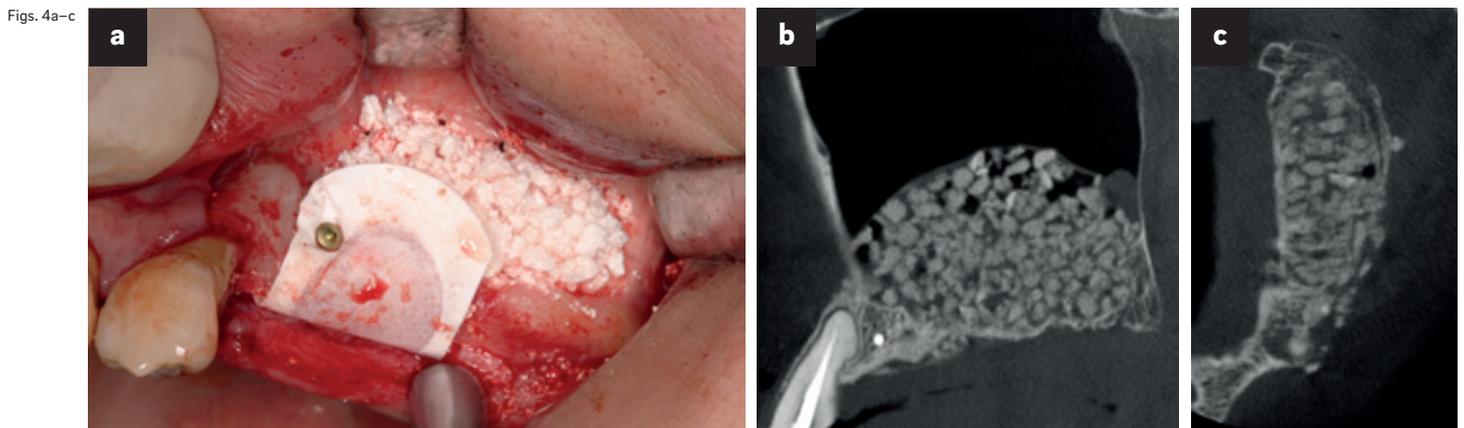
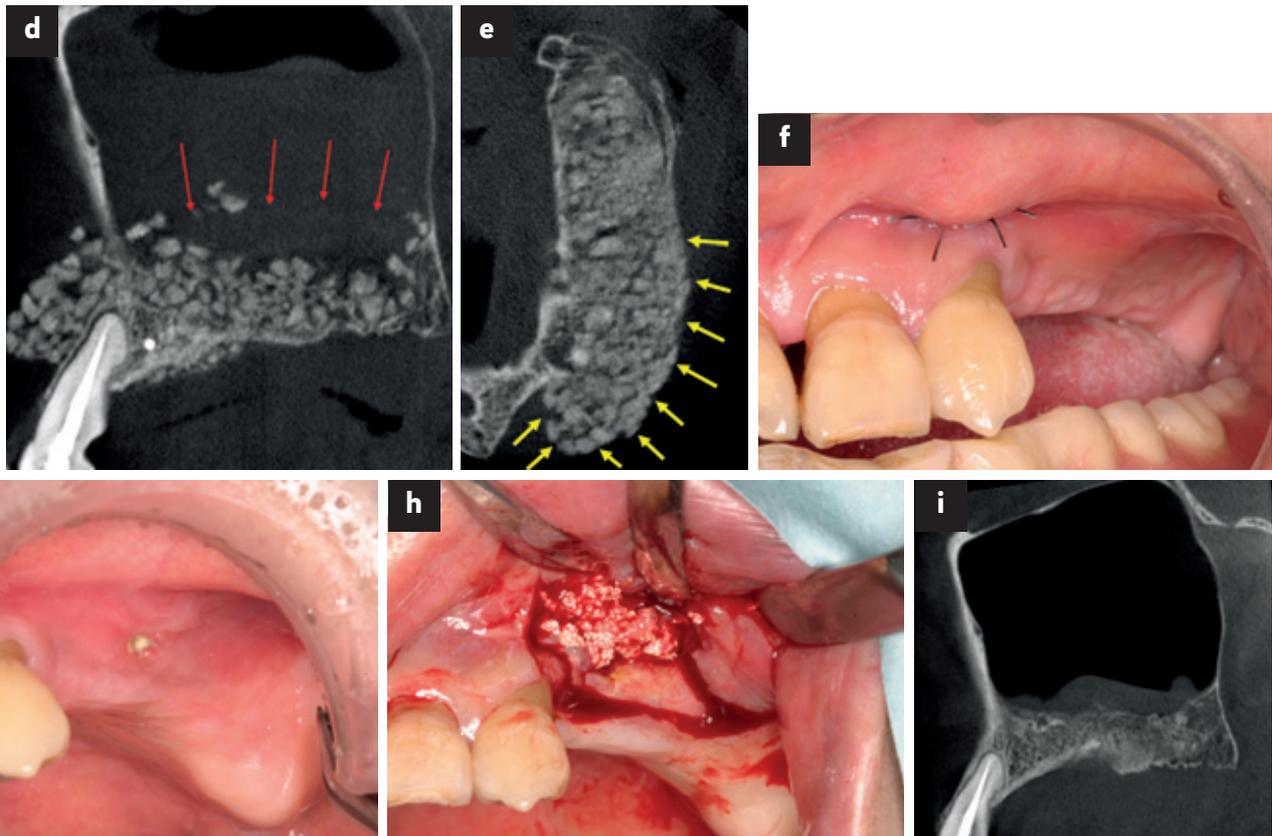


Fig. 3
Incidence of the types of postoperative swelling of the maxillary sinus membrane ($n = 132$).

Figs. 4a–c
(a) The lateral window was not completely covered by the barrier membrane.
(b) A sagittal CBCT slice image taken on the day of surgery. The area to be augmented was filled with β -TCP granules.
(c) A horizontal CBCT slice image taken on the day of surgery.





Figs. 4d–i

Figs. 4d–i

(d) A sagittal CBCT slice image taken one week after surgery. Type 3 swelling of the maxillary sinus membrane had occurred. Some β -TCP granules had disappeared from the augmented area (red arrows).

(e) A horizontal CBCT slice image taken one week after surgery. The β -TCP granules had migrated toward the buccal side through the lateral window and moved beyond the canine (yellow arrows).

(f) An intra-oral photograph taken ten days after surgery. The swelling at the sulcus remained and a hard object was palpable underneath the gingiva.

(g) Six months after surgery, a β -TCP granule became exposed through the gingiva.

(h) The migrated β -TCP granules, the barrier membrane and the microscrews were removed.

(i) A sagittal CBCT slice image taken one year after sinus floor augmentation.

oral swelling remained (**Fig. 4f**) and something hard could be felt underneath the mucosa. As one β -TCP granule had become exposed, the migrated β -TCP granules and barrier membrane were removed six months after surgery (**Figs. 4g & h**). One year after surgery, the swelling of the sinus membrane remained and the volume of the augmented area had decreased considerably compared with that on the day of surgery (**Fig. 4i**).

Lateral window coverage and migration

The relationship between the degree of migration and lateral window coverage after one week of healing is shown in **Table 1**. In Group 1, β -TCP granules had migrated through the lateral window toward the buccal side in 11 sites (61.1%), and Type C had occurred in three sites (16.7%). In Group 2, Type A was seen in 110 sites (96.5%), and Type C was observed in three sites (2.6%) in spite of the full coverage of the lateral window.

Case 2 (70-year-old female, Group 2, Type 2, Type C, nonsmoker)

In this case, since the anterior wall of the maxillary sinus was very thin, the lateral window was covered with two collagen membranes and the wound was closed without a releasing incision (**Figs. 5a–d**). One week after surgery, Type 2 swelling of the sinus membrane was observed (**Fig. 5e**) and the β -TCP granules had migrated toward the buccal side from all directions (**Fig. 5f, blue arrows**).

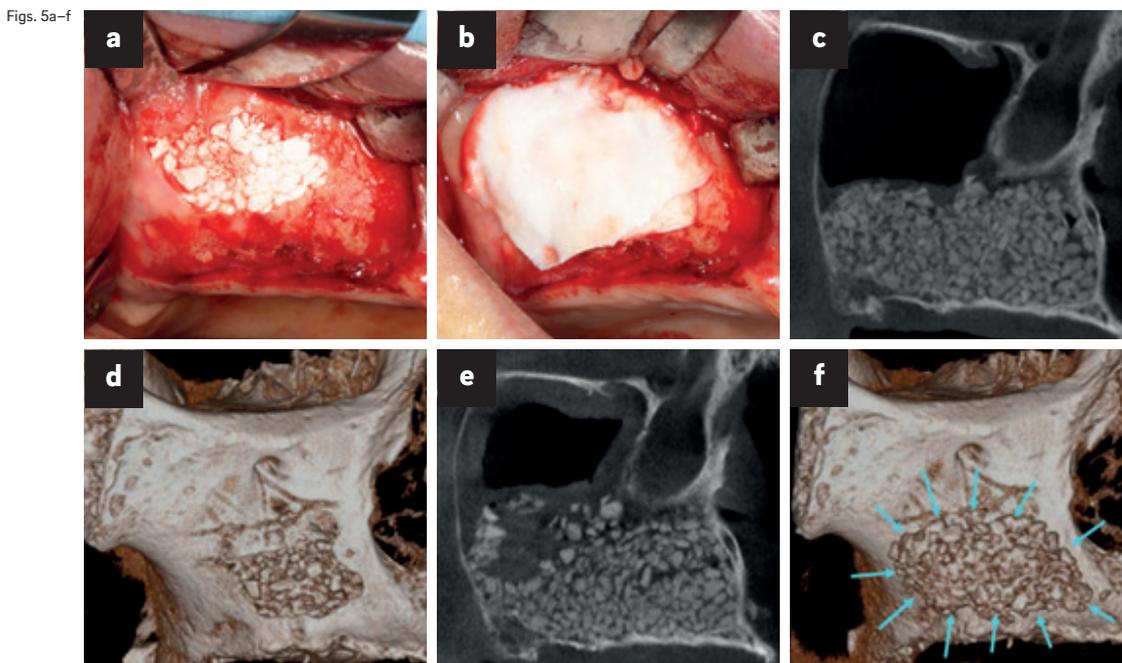
Case 3 (43-year-old female, Group 2, Type 3, Type A, nonsmoker)

The sinus floor augmentation was performed and the lateral window was completely covered with a titanium mesh plate and fixed with three titanium microscrews (**Figs. 6a–d**). One week after surgery, Type 3 swelling of the sinus membrane was observed and the trap door had lifted up due to the pressure of the swelling (**Fig. 6e, yellow arrows**). However, no β -TCP granules had migrated through the lateral window (**Fig. 6e**), and the swelling disappeared spontaneously three months after surgery (**Fig. 6f**). One year after surgery, the titanium mesh plate and screws were removed and the implants were placed successfully (**Fig. 6g**).

Table 1

	Group 1 Not completely covered	Group 2 Completely covered
Sites	18 sites	114 sites
Type A	7 sites (38.9%)	110 sites (96.5%)
Type B	8 sites (44.4%)	1 site (0.9%)
Type C	3 sites (16.7%)	3 sites (2.6%)

Table 1
Lateral window coverage and migration of β -TCP granules ($n = 132$).



Figs. 5a–f
(a) The area to be augmented was filled with β -TCP granules.
(b) The lateral window was completely covered with two pieces of resorbable membrane.
(c) A sagittal CBCT slice image taken on the day of surgery.
(d) A volume-rendered image taken on the day of surgery.
(e) A sagittal CBCT slice image taken one week after surgery. Type 2 swelling of the maxillary sinus membrane had occurred.
(f) A volume-rendered image taken one week after surgery. The β -TCP granules had migrated toward the buccal side from all directions (blue arrows).

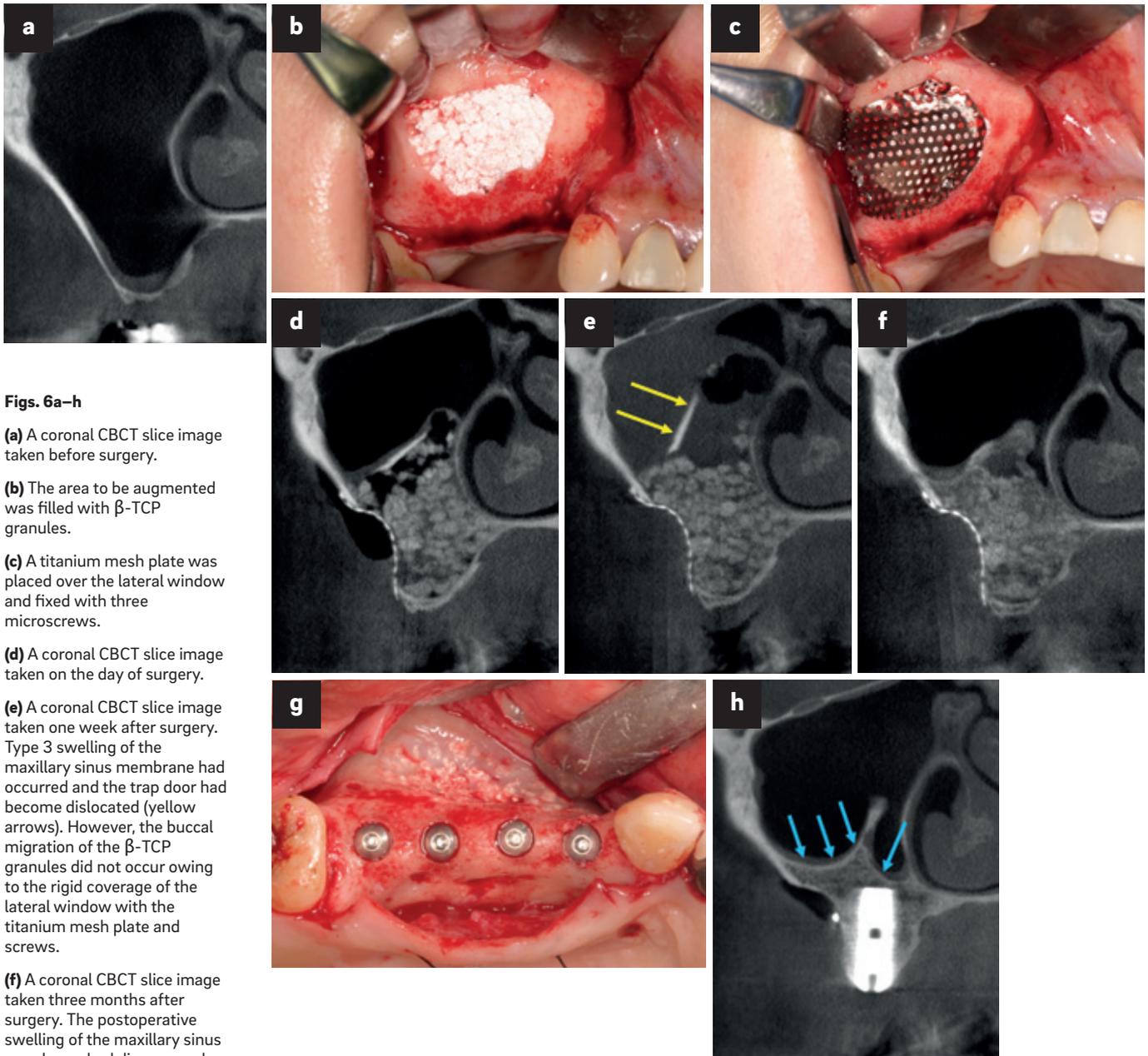
The volume of the augmented area had been retained, and a radiopaque line similar to that of cortical bone was observed at the newly formed floor of the maxillary sinus (Fig. 6h, blue arrows).

Discussion

CBCT has changed the possibilities of implant dentistry, especially in bone augmentation techniques. Its low radiation dose makes it possible to evaluate the augmented area longitudinally with images taken in the same direction. In this study, postoperative swelling of the maxillary sinus membrane was evaluated using CBCT at five stages. However, the radiation dose should be restricted even though that of CBCT is very low. Therefore, selection of the

CBCT device and the parameters to be used was very important to avoid the harmful influence of radiation on the patients' health.

The postoperative swelling of the maxillary sinus membrane, which occurred one week after the sinus floor augmentation, was an unknown biological reaction. It occurred in all 132 sites and disappeared spontaneously in 96.2% three months after surgery. In a monkey model,^{4,5} inflammatory cell infiltration was identified underneath the epithelial layer of the sinus membrane four days after sinus floor augmentation. At 20 days after surgery, the sinus mucosa presented a normal aspect with inflammatory infiltration of limited size. Thus, this temporary postoperative swelling of the sinus membrane was due to mechanical stimulation from elevation of the sinus membrane during sinus floor augmentation. Almost all of the patients reported no



Figs. 6a–h

Figs. 6a–h

(a) A coronal CBCT slice image taken before surgery.

(b) The area to be augmented was filled with β -TCP granules.

(c) A titanium mesh plate was placed over the lateral window and fixed with three microscrews.

(d) A coronal CBCT slice image taken on the day of surgery.

(e) A coronal CBCT slice image taken one week after surgery. Type 3 swelling of the maxillary sinus membrane had occurred and the trap door had become dislocated (yellow arrows). However, the buccal migration of the β -TCP granules did not occur owing to the rigid coverage of the lateral window with the titanium mesh plate and screws.

(f) A coronal CBCT slice image taken three months after surgery. The postoperative swelling of the maxillary sinus membrane had disappeared spontaneously and the trap door returned to its original position.

(g) One year after surgery, the titanium mesh plate and screws were removed. The remaining β -TCP granules were observed at the lateral window and embedded in the newly formed bone. Four implants were placed successfully.

(h) A coronal CBCT slice image taken after placement of the implants. A radiopaque line similar to that of cortical bone was observed at the newly formed floor of the maxillary sinus (blue arrows).

symptoms concerning the postoperative swelling of the sinus membrane, and we had not previously observed this phenomenon.

In approximately 80% of the 132 sites, the extent of the postoperative swelling constituted more than one-third of the remaining maxillary sinus cavity. As shown in **Figure 1**, even if the size of the augmented area was almost the same, the extent of the swelling was different. These results suggest that the extent of the postoperative swelling did not depend on the area of the detachment, and it was difficult to predict the extent of swelling before surgery.

A complication of this postoperative swelling of the sinus membrane was migration of the β -TCP granules. This migration was brought about by the pressure of swelling and the direction of pressure was difficult to determine. When the pressure was toward the lateral window, the β -TCP granules migrated toward the buccal side of the alveolar bone through the lateral window. This migration of the granules led to the loss of β -TCP granules at the augmented area and resulted in unexpected poor bone formation as in Case 1. Therefore, bone substitute materials such as β -TCP granules act as a space maker for

bone augmentation in sinus floor elevation. Ahn et al. reported that little to no new bone formation was observed at the augmented area six months after sinus floor augmentation using blood-soaked collagen sponges as a space maker.⁶ Scala et al. concluded that the void initially occupied by the coagulum after sinus membrane elevation shrank substantially during the observation period.^{4, 5} Furthermore, Schweikert et al. reported the function of a titanium device as a space maintainer in sinus floor augmentation in monkeys.⁷ They concluded that shrinkage of the newly formed tissue was observed and the space-maintaining function of the device was in doubt. The current study found that the postoperative swelling of the sinus membrane occurred in 100% sites and the pressure of swelling was strong enough to migrate the β -TCP granules toward the buccal side. Therefore, blood-soaked collagen sponges or clots would have collapsed under the pressure of postoperative swelling of the sinus membrane.

The migration of bone substitute materials posed the risk of wound dehiscence and infection. In Case 2, the buccal migration of the β -TCP granules occurred even though the lateral window had been covered with two collagen membranes. When the postoperative swelling was Type 2 or 3, the pressure of the swelling was sufficiently strong to push the membranes out of the lateral window. Therefore, we now cover the lateral window with a titanium mesh plate and screws, as was done in

Case 3. In the lateral window technique, it is recommended that the lateral window be covered tightly to avoid the migration of bone substitute materials through the lateral window.

Conclusion

One week after sinus floor augmentation, postoperative swelling of the maxillary sinus membrane occurred in all 132 sites. The swelling brought about the migration of the bone substitute materials. Furthermore, the migration of the β -TCP granules caused loss of volume at the augmented area and wound dehiscence. In order to avoid the migration of bone substitute materials, the lateral window should be covered tightly with a titanium mesh plate and screws for safety in the lateral window technique for sinus floor augmentation.

Competing interests

The authors declare that they have no competing interests.

Acknowledgments

Some photographs of Cases 1–3 were excerpted from Nosaka Y. Sinus floor elevation: avoiding pitfalls using cone-beam CT. Quintessence Publishing; 2010.

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References

- Okano T, Harata Y, Sugihara Y, Sakaino R, Tsuchida R, Iwai K, Seki K, Araki K. Absorbed and effective doses from cone beam volumetric imaging for implant planning. → Dentomaxillofac Radiol. 2009 Feb;38(2):79–85.
- Li G. Patient radiation dose and protection from cone-beam computed tomography. → Imaging Sci Dent. 2013 Jun;43(2):63–69.
- Lofthag-Hansen S, Thilander-Klang A, Ekestubbe A, Helmrot E, Gröndahl K. Calculating effective dose on a cone beam computed tomography device: 3D Accuitomo and 3D Accuitomo FPD. → Dentomaxillofac Radiol. 2008 Feb;37(2):72–9.
- Scala A, Botticelli D, Rangel IG Jr, De Oliveira JA, Okamoto R, Lang NP. Early healing after elevation of the maxillary sinus floor applying a lateral access: a histological study in monkeys. → Clin Oral Implants Res. 2010 Dec;21(12):1320–6.
- Scala A, Botticelli D, Faeda RS, Rangel IG Jr, De Oliveira JA, Lang NP. Lack of influence of the Schneiderian membrane in forming new bone apical to implants simultaneously installed with sinus floor elevation: an experimental study in monkeys. → Clin Oral Implants Res. 2012 Feb;23(2):175–81.
- Ahn JJ, Cho SA, Byrne G, Kim JH, Shin HI. New bone formation following sinus membrane elevation without bone grafting: histologic findings in humans. → Int J Oral Maxillofac Implants. 2011 Jan-Feb;26(1):83–90.
- Schweikert M, Botticelli D, De Oliveira JA, Scala A, Salata LA, Lang NP. Use of a titanium device in lateral sinus floor elevation: an experimental study in monkeys. → Clin Oral Implants Res. 2012 Jan;23(1):100–5.