Subantral Augmentation Utilizing the Zimmer® Sinus Lift Balloon Technique

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The edentulous posterior maxilla is frequently characterized by post-extraction ridge atrophy, pneumatization of the sinuses, low bone density and the highest occlusal loads of the dental arch. All of these factors can create significant clinical challenges to successful rehabilitation with dental implants. Although placing longer (i.e. ≥ 10 mm) and wider diameter (i.e. > 3.75mm) implants can improve long-term results, preliminary sinus grafting is generally required to provide sufficient vertical bone volume for implant support.

For decades, clinicians believed that alteration of the sinus floor morphology was unfeasible, but in 1975 Tatum[1] introduced a technique for increasing maxillary bone height by placing bone graft material between the bony sinus floor and the elevated Schneiderian membrane.[2] In 1980, Boyne and James[3] published the first report on the use of bone grafting in the maxillary sinus to allow the placement of dental implants, and Misch[4] proposed that sinus lift and implant placement could be performed in a single surgery. By the 1990s, a modification[5] of Tatum's1 original technique for subantral augmentation – *or sinus lift* – had become a standard clinical procedure.[2]

The maxillary sinus anatomy usually presents as a single chamber with 5 walls forming a quadrilateral pyramid shape with its apex pointing laterally in the zygomatic process.[2] Adult anatomical dimensions are approximately 2.5 cm wide, 3.75 cm high, 3 cm deep, bounded by the orbital roof superiorly, hard palate, alveolus and dental portion of the maxilla inferiorly, zygomatic process laterally, and a thin plate of bone separating the cavity from the infratemporal and pterygopalatine fossa posteriorly.[1] Its large, flat, quadrangular base supports both the median and lateral walls of the nasal cavity.[1, 3] The Schneiderian membrane covering the bony sinus floor is a multi-layered columnar epithelium that consists of a superficial layer of ciliated columnar cells, basal cells, muciparous beaker cells, an underlying basal membrane and the tunica propria.[6]

Today, entry into the maxillary sinus is generally performed via the lateral access window (modified Caldwell-Luc technique), or a less-invasive approach through the crest of the alveolar ridge utilizing osteotomes or a combination of osteotomes and spade or trephine drill. In both cases, the Schneiderian membrane must be gently separated from the sinus floor and elevated to contain graft material that is placed inferiorly. In the crestal approach, when the sinus floor is resistant to fracture by the implant itself, a surgical instrument, such as an osteotome, must be used to fracture the sinus floor. This technique is often difficult to control and harbors a high risk of tearing the Schneiderian membrane. In the lateral approach, a sharp, broad-based surgical instrument, such as a Freer elevator or other specially designed instrument, is placed against the inferior edge of the Schneiderian membrane and moved along the bone, allowing part of the instrument to strip and elevate the Schneiderian membrane away from the floor and anterior and posterior sinus walls, thus exposing the medial nasal wall.[4] The use of sharp instruments and the presence of the sinus septa can hinder Schneiderian membrane elevation and greatly increase the likelihood of perforation.

The *Zimmer* Sinus Lift Balloon was developed to gently elevate the Schneiderian membrane with minimum trauma and without the use of sharp instruments. The apparatus is a pneumatic device consisting of a 5 ml syringe, polyvinyl chloride (pvc) tubing, and a metal shaft with a tip connected to a latex mini balloon with an inflation capacity of approximately 5 cm^3 **(Fig. 1)**. This article reports on a clinical evaluation of the new *Zimmer* Sinus Lift Balloon.

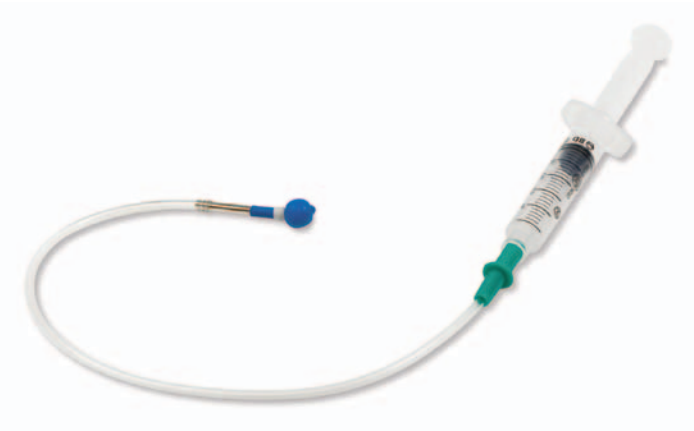


Fig 1. Zimmer *Sinus Lift Balloon*

Materials and Methods

The study was conducted by the author (GNR) from August 1997 to May 2001 in the department of Oral Implantology of the Esçola de Aperfeiçoamento Profissional, Associação dos Cirurgiões Dentistas de Campinas (EAP/ACDC), and in the Dr. Sèrgio J. Jayme Professional Training Institute (IAP), Sao Paulo, Brazil. Study candidates were patients at both institutions with atrophic edentulous posterior maxillary ridges who needed oral rehabilitation with dental implants to restore occlusal function. Preliminary patient examinations included a thorough evaluation of the sinus cavity through periapical radiographs and computerized tomography. The presence of any pathology, such as sinusitis, retention cysts, polyps, root tips, etc., was an absolute contraindication for sinus augmentation. Based on the

quantity of available bone, a decision was made whether to immediately place the implants at the time of the grafting procedure, or delay implantation until after graft healing. If primary implant stability can be achieved, simultaneous subantral augmentation and implant placement is possible. This may be accomplished if (1) the residual sinus floor bone measures at least 4 mm to 5 mm in height **(Figs. 2a and 2b)**,

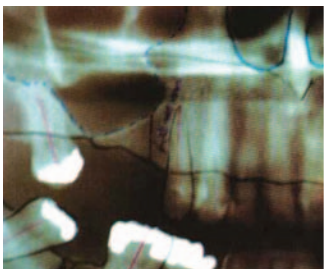


Fig 2a. *Preoperative radiograph* **Fig 2b.** *Preoperative clinical view*

(2) bicortical implant anchorage can be achieved utilizing the residual sinus floor bone with the lateral nasal wall, pyriform rim or sinus buttress, or if the implants can be stabilized with a combination of residual sinus floor bone and bone graft material condensed around the implants.

A total of 66 patients were admitted into the study. Prophylactic broad spectrum antibiotics for anaerobic and aerobic bacteria were prescribed preoperatively and maintained for 7 days postoperatively. Both the lateral maxillary window approach and crestal surgical approach were used in this study according to the needs of the individual patient. Immediately prior to surgery, the *Zimmer* Sinus Lift Balloon was twice inflated with air, and then deflated, to achieve preliminary stretching. The balloon was removed from the apparatus, the syringe was filled with the desired amount of sterile saline for balloon expansion during the surgical procedure, and the balloon was reattached for surgery. The amount of saline placed in the Luer syringe was determined by the number of millimeters that the sinus membrane would need to be elevated, and also corresponded to the amount of bone graft material in cubic centimeters that was necessary to fill the elevated area: 1 cc of saline solution corresponds to 6 mm (+/- 0.5mm) of membrane elevation and 1 cc of bone graft material needed to fill the void **(Fig. 3)**.

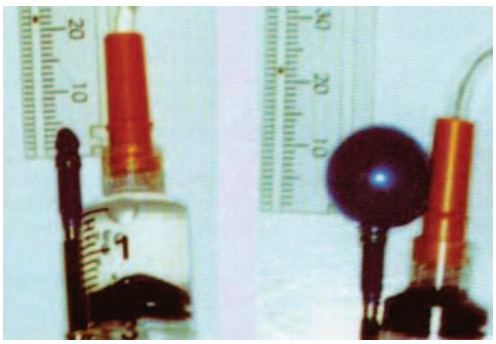


Fig 3. *The syringe indicates (a) how many cubic centimeters the Schneiderian membrane will be elevated, (b) how many millimeters of linear height the membrane will be elevated, and how many cubic centimeters of bone graft material will be needed to fill the elevated area.*

In the alveolar ridge approach, crestal and vertical releasing incisions with mucoperiosteal flaps were used to expose the surgical area. A series of osteotomes in graduated diameters were sequentially used with a mallet to laterally condense the low-density maxillary bone. Care was taken to gently penetrate the sinus floor and slightly elevate the Schneiderian membrane to allow 3 mm of access for the deflated *Zimmer* Sinus Lift Balloon. In cases of higher bone density or when sinus floor thickness was resistant to osteotome pressure alone, the osteotomy was prepared with a combination of trephine or spade drills, followed by gentle sinus floor elevation with the osteotome.

In the lateral window approach, a crestal incision, slightly oriented toward the palatine aspect, was extended beyond the osteotomy area. Vertical releasing incisions were made to provide optimal visualization of the operating field **(Fig. 4)**.

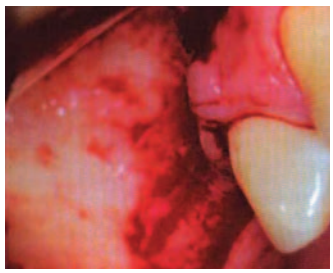
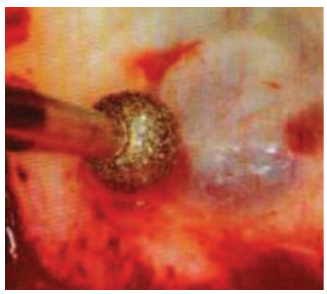


Fig 4. *Surgical Access through the lateral wall of sinus cavity*

An oval-shaped osteotomy was performed on the lateral wall of the sinus with rotary instruments used under copious saline irrigation. The instruments penetrated to the point that the surgeon was able to visualize the dark inner lining of the sinus membrane. It was not necessary to create an osteotomy larger than 6 mm for use with the *Zimmer* Sinus Lift Balloon **(Fig. 5a and 5b)**. After complete release, the



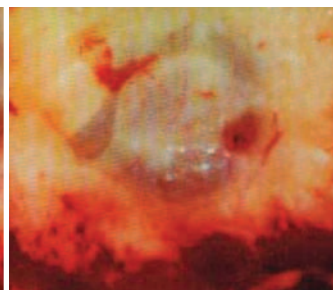
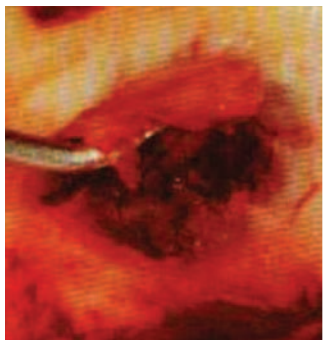


Fig 5a. *Osteotomy cut is made in lateral wall of the sinus with a diamond bur.*

Fig 5b. *Oval shaped osteotomy with 6 mm diameter.*

osteotomy wall was fractured inwardly or removed **(Fig.6)**, which allowed total visualization of the membrane and thereby decreased risks of perforations **(Fig. 7)**.



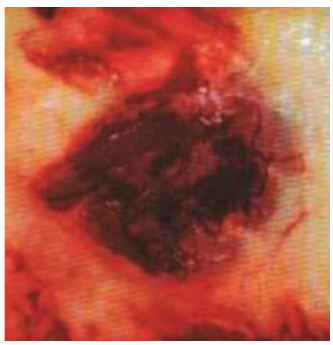


Fig 6. *Detachment of the lateral plate with a curette.*

Fig 7. *Open maxillary window shows an intact Schneiderian membrane.*

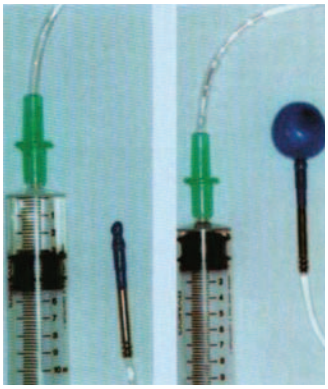


Fig 8. *Balloon is stretched by inflating it twice before surgery. Note its 3 mm size when deflated.*

With the *Zimmer* Sinus Lift Balloon, an extensive approach to the sinus was not needed because the deflated balloon only measured 3 mm in diameter for entry into the sinus cavity, but then could be expanded up to 6 cc when fully inflated inside the patient **(Fig. 8)**.

A curete was used to detach a small portion of the membrane base from the sinus floor **(Fig. 9)** to enable insertion of the deflated balloon **(Fig. 10)**. With the balloon in place, the Luer syringe was held in a digital-palm position and **(Fig. 11)** the syringe plunger was slowly pressed with the thumb to expand the balloon with saline and elevate the sinus membrane to the predetermined amount **(Fig. 12)**.

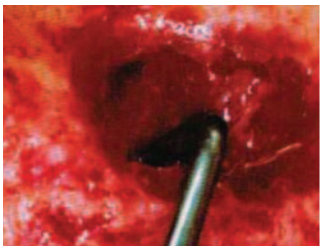


Fig 9. *Curette is used to detach the base of the membrane so that the deflated balloon can be inserted.*

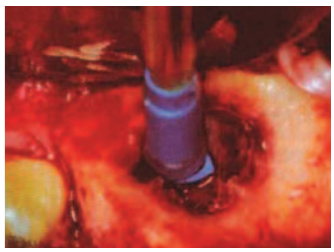


Fig 10. Zimmer *Sinus Lift Balloon is gently placed under the Schneiderian membrane.*

Fig 11. *Syringe is grasped in a digit-palm position to facilitate control of the syringe plunger.*

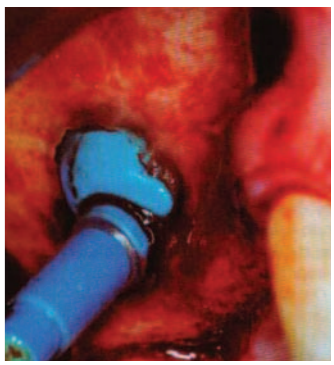


Fig 12. *Inflated* Zimmer *Sinus Lift Balloon gently elevates the Schneiderian membrane.*

Once the membrane was fully elevated, the balloon was deflated by reversing the syringe plunger, and then removed from the sinus cavity **(Fig.13)**.

Fig 13. *After the Schneiderian membrane has been elevated and the* Zimmer *Sinus Lift Balloon removed, the membrane can be observed rising and falling with the patient's respirations.*

Once the *Zimmer* Sinus Lift Balloon was removed, the Schneiderian membrane moved with the patient's respirations, elevating on inspiration and dropping upon expiration. This oscillating movement revealed that there was no mucosal perforation and that the site was ready for augmentation with or without simultaneous implant placement. In cases of Schneiderian membrane perforation, a bioabsorbable collagen membrane was placed under the laceration to create a temporary interface between the sinus cavity and the bone graft. In other cases, the collagen dressing was moistened in saline solution, placed on the deflated *Zimmer* Sinus Lift Balloon, and inserted under the perforated area of the Schneiderian membrane. The balloon was then inflated to attach the collagen to the damaged tissue. When the balloon was deflated, the collagen membrane remained attached to the underside of the sinus mucosa and covered the perforated area **(Fig. 14)**.

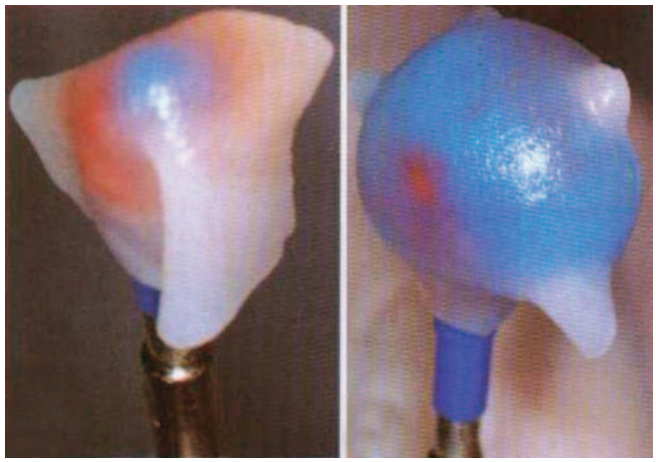


Fig 14. *To repair a tear in the Schneiderian membrane, a collagen membrane is hydrated in saline and placed onto the* Zimmer *Sinus Lift Balloon for delivery to the sinus cavity.*

All sinuses were augmented with a composite graft material **(Figs. 15a, 15b and 16)** that was introduced into

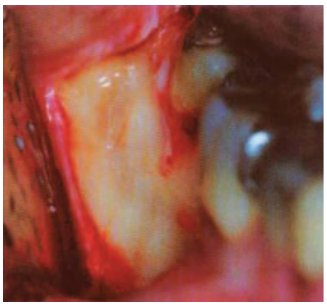


Fig 15a. *Retromolar region is selected as a donor site for an autograft.*

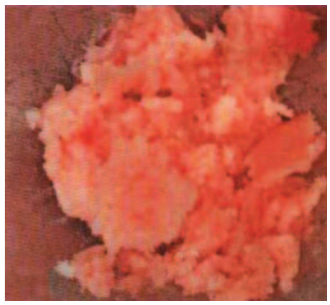


Fig 15b. *Autogenous bone harvested from the retromolar area.*

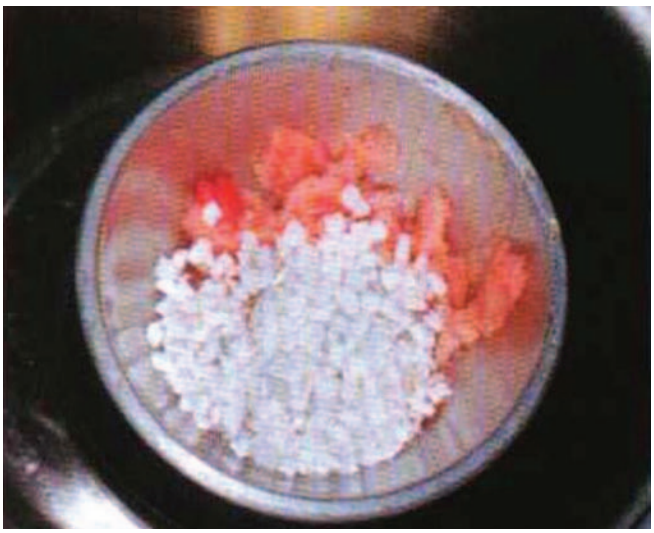


Fig 16. *Composite graft materials are mixed in a 1:1 proportion.*

the prepared site **(Fig. 17a)** and gently condensed **(Fig. 17b)** with a sterile instrument. In some cases, platelet-rich plasma (PRP) **(Fig. 18)** was added to the bone graft material **(Fig. 19a)** and used to hydrate collagen membranes **(Fig. 19b)**.

Fig 17a. *Bone graft material is delivered placed between the elevated Schneiderian membrane and the sinus floor.*

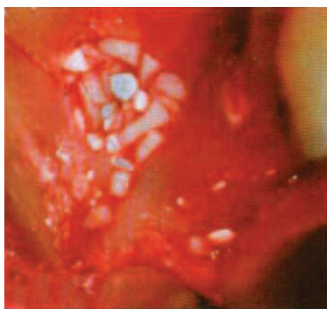


Fig 17b. *Bone graft material is condensed in place.*

After augmentation, the graft site was generally covered with a collagen membrane to prevent soft tissue invasion into the graft and sinus cavity. In cases where the removed bone plate was still intact after the lateral window approach, the graft site was closed with the maxillary bone plate **(Fig. 20)**. In all cases, primary soft tissue closure was achieved with sutures **(Fig. 21)**. Patients were evaluated for three or more years **(Figs. 22a and 22b)**.

Fig 18. *Platelet-rich plasma is concentrated in a vial for use.*

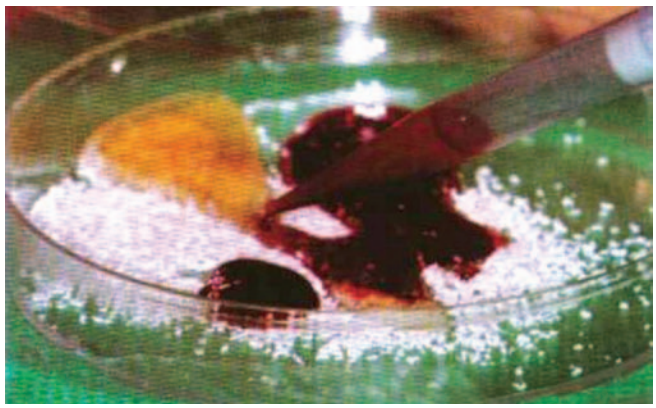


Fig 19a. *Platelet-rich plasma is used to hydrate the composite graft materials.*

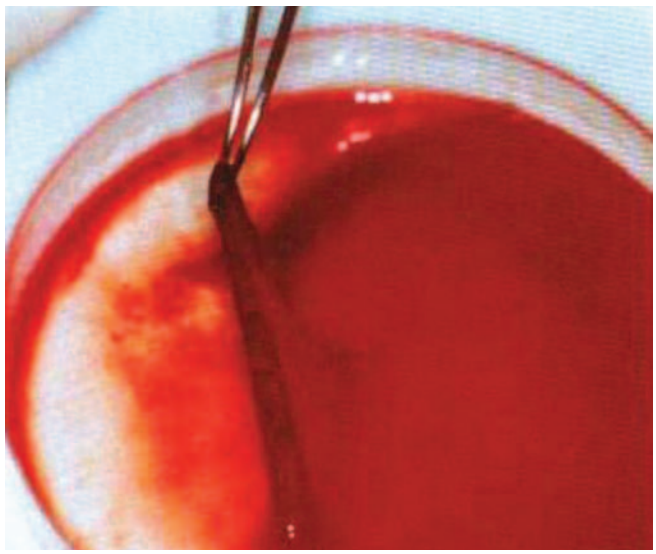


Fig 19b. *In some cases, collagen membranes were saturated in platelet-rich plasma.*

Fig 20. *A collagen membrane was placed over the osteotomy windows prior to primary soft-tissue closure.*

Fig 21. *Sutures achieve primary closure of the surgical site.*

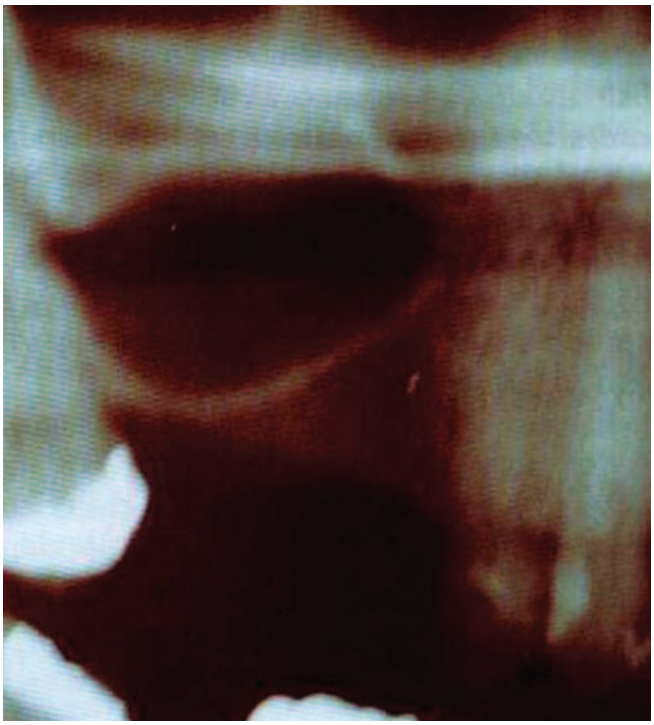


Fig 22a. *Radiographic aspect before the surgery.*

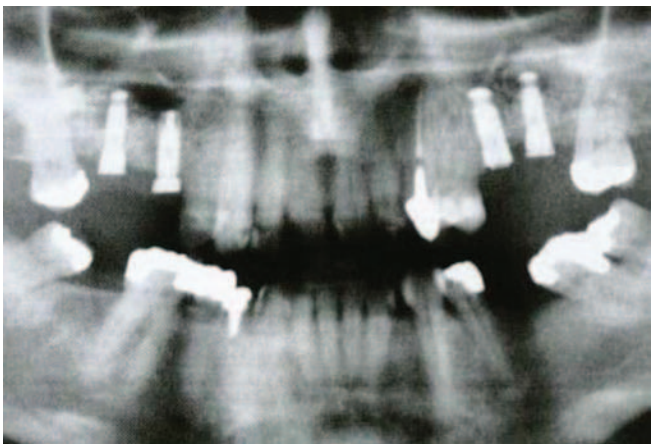


Fig 22b. *Radiographic control 11 months after the sinus floor augmentation procedure using the* Zimmer *Sinus Lift Balloon.*

Results

A total of 96 sinus floor augmentations were preformed in the study: 30 patients were treated with bilateral and 36 patients were treated with unilateral procedures. The alveolar ridge approach (osteotome procedure + *Zimmer* Sinus Lift Balloon) was used in 40.6% (n = 39/96) of the cases, and the lateral window approach (modified Caldwell-Luc technique + *Zimmer* Sinus Lift Balloon) was used in 59.4% (n = 57/96) of the cases. A total of 259 implants were placed and patients were evaluated for mean follow-up time of 45 months. During this period, 12 implants (3.1%) failed to maintain osseointegration after prosthesis placement, which left a cumulative implant survival rate of 95.4%. Schneiderian membrane perforations occurred in 11 (11.5%) of the 96 study cases. In the 57 cases where the lateral window approach was used, Schneiderian membrane perforation was 8.7% (n = 5 cases), which were caused by injury to the sinus mucous when the lateral window osteotomy was performed. In the 39 cases where the alveolar ridge approach was used, Schneiderian membrane perforation was 15.4% (n = 6 cases): 4 cases were caused by fracture of the sinus floor during the osteotome procedures, and 2 cases were caused by the surgeon inflating the balloon too rapidly. Sinus augmentations were 100% successful and there were no other complications.

Discussion

The smooth surface of the *Zimmer* Sinus Lift Balloon gently elevated the Schneiderian membrane in both surgical approaches used in this study. In the lateral wall approach, the small size of the osteotomy also facilitated retention of the bone graft material. While there is currently no clinical consensus as to which augmentation materials are optimal for sinus grafting, a variety of different materials may be effectively used, including mineralized Allograft bone.

Conclusion

The *Zimmer* Sinus Lift Balloon minimally invasive technique gently elevated the Schneiderian membrane in both the alveolar ridge and lateral maxillary window surgical approaches.

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Notes