Maxillary sinus wall fenestration at the lateral wall or floor of the sinus can result from many potential factors, such as the repair of oro-antral communication, Caldwell-Luc antrostomy, tooth extraction after an endodontic or periodontal infection that eroded the sinus wall, and the combination of sinus pneumatization and alveolar ridge resorption after teeth removal. When sinus wall fenestration is observed on radiographs, it usually indicates adhesion between the sinus membrane and buccal flap, which makes the reentry surgery for subsequent sinus augmentation challenging. To minimize surgical complications in these challenging scenarios, this paper presents a split-flap surgical technique for the management of soft tissue adhesion between the sinus membrane and alveolar mucosa when attempting a lateral window sinus augmentation.


Split-Thickness Flap for the Management of a Maxillary Sinus Wall Bony Fenestration During Lateral Window Sinus Augmentation: Case Reports and Technical Surgical Notes

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window open may result in adhesion between the sinus membrane and the buccal flap, which complicates future sinus augmentations.

As a result, a bony discontinuation of the maxillary sinus wall indicates the adhesion of sinus membrane to the buccal flap. This may be evident in CBCT scans. Therefore, a careful interpretation of the CBCT images and treatment planning are important, especially when a sinus augmentation is planned.

With the adhesion of the sinus soft tissue to the buccal flap, and in cases with previously attempted sinus augmentation procedures, the perforated sinus membrane area likely healed with fibrotic tissue and has minimal elasticity, often leading to flap elevation difficulties during the surgical procedure. Therefore, during flap elevation in surgical reentry or lateral window sinus augmentations, surgeons should take extra care in splitting the tissue between the alveolar mucosa and the soft tissue lining the sinus cavity; this method, a split-flap surgical technique, ensures intact tissue on both the sinus membrane and the buccal flap, without further perforation (Figs 1 and 2).

This article presents a split-flap surgical technique to manage soft tissue adhesion between the sinus membrane and alveolar mucosa when attempting a lateral window sinus augmentation.

**Fig 1** Splitting the tissue between the alveolar mucosa and the soft tissue lining the sinus cavity. (a) After healing, the periosteal layer of the sinus membrane is fused with the periosteal layer of the buccal flap. The image indicated with an asterisk shows a magnified view of the different sinus membrane layers. In a healthy situation, the sinus membrane is 50 to 500 microns thick and comprises a periosteal layer (A); a middle layer composed of basal, columnar, and goblet cells (B); and a ciliary layer (columnar cells have 100 to 150 cilia per cell) (C). The ciliary cells are covered by a dual layer of secretion: liquid sol phase touching the cilia, and viscous gel phase above it. (b) A 15c scalpel is inserted in the middle layer of the buccal flap to prevent sinus membrane perforation, as it is very difficult to find the plane of cleavage of two periosteal layers. The buccal flap comprises three layers: the periosteal layer (C), submucosa (B), and mucosa (A), with thickness varying from 2,000 to 3,000 microns. (c) Flap detachment is performed with an elevator until the adhesion of the sinus membrane to the buccal flap is visible. (d) The sinus membrane is finally elevated, leaving some of the periosteal and mucosal layers of the buccal flap attached to the periosteal layer of the sinus membrane.
Case Reports

Case 1

This patient was missing their maxillary right dentition for more than 10 years, and severe ridge absorption combined with sinus pneumatization to result in a fenestration on the right maxillary sinus wall, as seen in panoramic and CBCT images (Fig 3). The patient opted for implant placement to rehabilitate the edentulous site, and lateral window sinus augmentation was therefore indicated for proper implant placement. When elevating the flap, care was taken to access the lateral wall of the maxillary right sinus, as adhesion between the buccal flap and the sinus membrane was observed. Careful dissection (split) of the soft tissue area at the bony fenestration of the sinus wall is important to prevent the creation of a Class V sinus membrane perforation, which could be very difficult to repair and even result in the absorption of the lateral sinus augmentation. In this particular case, the surgeon (T.T.) used a 15c scalpel to (1) separate the two layers of soft tissue to maintain the sinus soft tissue integrity and (2) raise the split-thickness buccal flap (Figs 2 and 4). Because it is difficult to find a plane of cleavage between the periosteal layer of the sinus membrane and the overlying flap, the clinician left some of the flap's connective tissue on top of the sinus membrane. The blade split the flap more buccally while paying great attention to avoid perforating it. Six months after the intervention, the graft was well contained under the sinus membrane.

Fig 2  (a) At the level of adhesion of the two periosteal layers, a 15c blade is inserted in the submucosal layer of the buccal flap. (b) Split-thickness separation is performed until the apical part of the bony fenestration is reached. (c) Beyond the apical margin of the bone fenestration, the flap returns to full-thickness. (d) A piezoelectric device is then used for the initial phase of sinus elevation.

Fig 3  (a) A preoperative orthopantomography shows an edentulous ridge in the maxillary right quadrant. (b) CBCT cross-sectional views show a buccal bony wall fenestration.
Case 2

This patient lost their maxillary left premolar and molars due to periodontal disease. At 5 years postextraction, the patient was not tolerating the partial removable prosthesis and asked for a fixed rehabilitation. CBCT images indicated a bone fenestration at the maxillary sinus floor of the edentulous site, but soft tissue closure was seen clinically (Fig 5). In this particular case, the bone fenestration was at the ridge level. However, because the clinician did not notice this bone fenestration during the surgery, the scalpel blade actually went inside the sinus during the first incision. Nonetheless, the split-flap surgical technique was applied to correct this problem. Following the flap procedure, the soft tissue was sutured over the bone fenestration with 6/0 polyglycolide acid (Vicryl, Ethicon, Johnson & Johnson). After repairing the unintentional soft tissue perforation, the borders of the bony walls were identified, and a modified sinus augmentation with crestal access was performed to elevate the soft tissue and sinus membrane (Fig 6). Six months later, implants were successfully placed and left to heal for 3 months. A fixed restoration was later delivered to the patient without any problems (Fig 7), and the patient was very happy with the treatment outcome.

Case 3

The patient was referred to the authors’ department regarding a sinus infection that developed 3 weeks after a maxillary sinus augmentation and had not healed after a second regimen of antibiotics (1 g amoxicillin bid and 500 mg metronidazole tid). CBCT scans showed (1) a complete radiopacity of the sinus and (2) graft material dispersed inside the sinus but not at the level of the ostium. The treatment approach advocated for graft and implant removal via an intraoral approach without functional endoscopic sinus surgery. In fact, there were no particles inside the ostium, and there was evidence of a healthy sinus with a patent ostium in the preoperative CBCT scan taken before the first intervention. Additionally, a natural premolar with a periodontal lesion was scheduled for extraction. The molar was not extracted because it was the distal abutment of a fixed provisional prosthesis on four teeth. The molar will be extracted at the
latest stage, after graft consolidation and implant integration. The graft was removed from the previous antrostomy, and a resorbable collagen membrane (Bio-Gide, Geistlich) was placed over the antrostomy and fixed with a miniscrew. A platelet-rich fibrin membrane was used at the premolar and implant extraction sites. Two months after healing, CBCT scans showed complete resolution of the sinus pathology. At the reentry surgery 2 months later, careful dissection between the flap and the soft tissue at the sinus wall fenestration site (split-flap surgical technique) was performed with a 15c blade to prevent perforation (Figs 2 and 8). The soft tissue that was split between the flap and the sinus membrane became part of the sinus membrane, making it possible to perform a standard lateral window sinus augmentation (Fig 8). Clinical and radiologic views at the 5-month follow-up show satisfying results (Fig 9).

Discussion

Lateral window sinus augmentation is one of the most commonly performed surgeries prior to implant placement at maxillary posterior sites when the alveolar ridge height is insufficient. The sinus augmentation procedure is predictable and highly successful, and the survival rate was > 90% for implants placed in an augmented sinus via the lateral window technique. One of the most common complications encountered during lateral window sinus augmentation is sinus membrane perforation, and the risk factors associated with perforation could include sinus membrane thickness, maxillary sinus configuration, presence of sinus septa, residual bone height, the antrostomy...
A recent study summarized factors that could possibly influence the risk of sinus membrane perforation during the lateral window technique, and a scoring system was proposed to rank low-, moderate-, and high-risk factors. Bony fenestration of the maxillary sinus wall or floor is definitely another risk factor that should be taken into consideration. It has been reported that during reentry surgery following a previous sinus augmentation that was aborted for any reason, the sinus membrane is more likely to heal with scar or fibrotic tissue, therefore increasing the difficulty when performing membrane elevation.

Anatomical Assessment of the Superior Buccal Fornix

Anatomical assessment of the superior buccal fornix is essential, as it relates to the split-thickness flap for management of sinus wall bony fenestrations. A sound anatomical knowledge of the oral vestibule and anterior vestibular sulcus.
lateral wall of the sinus, and their arterial supply, is mandatory for clinicians performing surgical interventions in this area. The vestibule oral mucosa does not have a well-determined muscolaris mucosae, and it is consequently difficult to clearly identify a boundary between it and the underlying tissues.

In fact, in the area beyond the mucogingival junction (represented by the alveolar mucosa), the tissue is not firmly attached to the periosteum, is not keratinized, and provides a flexible area for movement of the cheeks and the lips, thanks to the presence of a submucosal layer of connective tissue. A connective tissue layer such as that contains major blood vessels, nerves, and muscular insertions, and it separates the oral mucosa from the underlying bone.

The thickness of mucosal and submucosal layers vary considerably (2 to 5 mm) and may relate to different facial phenotypes (dolichocephalic vs mesocephalic vs brachycephalic) and to the external stresses subjected upon a region. In a healthy situation, the sinus membrane thickness ranges from 50 to 500 microns.

All such anatomical aspects should be considered prior to elevating a split-thickness flap for a sinus reentry surgery, especially when splitting the adhering periosteal tissue between the sinus fenestration and the submucosa.

Vascularization of the maxillary oral vestibule is mainly furnished by the two branches of maxillary artery—the posterior superior alveolar artery (PSAA) and the infraorbital artery (IOA)—and may influence intraoperative bleeding, even when a split-thickness clinical approach is chosen.

As a matter of fact, anatomical dissections of cadavers confirmed that the PSAA divides into an external (gingival) branch along its course, and this branch is directed toward the superior buccal fornix and the maxillary tuberosity, anastomosing an extraosseous branch of the IOA in almost one third of the cases. It is clinically important to know the frequency of the latent presence of an extraosseous anatomic vessel between the PSAA and the IOA, as its laceration during split-thickness procedure at this level can cause local hemorrhage. Should this occur, pressure with a humidified gauze pad and the use of electrocautery may be recommended.

Conclusions

Maxillary sinus wall fenestration is a challenging clinical situation that must be properly addressed when a sinus augmentation procedure is re-attempted. This case report with technical notes presented a split-thickness flap technique to manage maxillary sinus wall fenestration. Future studies are needed to clinically and histologically validate its outcomes.

Acknowledgments

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References