How to Prevent and Manage Postoperative Complications in Maxillary Sinus Augmentation Using the Lateral Approach: A Review

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Maxillary sinus augmentation with a lateral approach is known to present more postoperative complications than other atrophic posterior maxilla treatment modalities because it is more invasive. These complications include infections that occur in the form of chronic or acute sinusitis. According to the literature, the frequency of these complications ranges from 3% to 5%. They can result from an inadequate management of intraoperative complications or from a poor evaluation of maxillary sinus particularities and pathology before the surgery. Therefore, the prevention of postoperative complications lies in the selection of cases that will allow for the identification and evaluation of infectious risk. Only a multidisciplinary approach that includes an implantologist, a rhinologist, and the treating physician will allow this. On the other hand, in infectious complication cases, the intervention of the otorhinolaryngologist (ENT) specialist is necessary. Based on the available literature and the author's experience, the methodology described in this article will allow for the prevention and management of postoperative complications related to this surgical technique. *Int J Oral Maxillofac Implants 2023;38:1005–1013. doi: 10.11607/jomi.10145*

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The prevalence of sinus augmentation surgery complications is relatively low, averaging from 3% to 5%,[1–3] though there have also been reports of up to a 14.9% prevalence.[4] These complications may be classified as chronic or acute sinusitis.[5] Early complications are those that appear within 21 days postoperation, while late complications occur after that point, sometimes many years later.[6–8] Risk assessment is important for identifying the risk factors and indicators that predispose a situation to complications.[9] To that end, the present article seeks to outline some of the risk factors and indicators in an effort to prevent and more effectively treat complications when they occur. To begin, the surgeon may ask two basic questions.[10]

MAXILLARY SINUS HEALTH

The first question a surgeon may ask is "Is the maxillary sinus healthy or not?" This is because the sinus cavity must be healthy before attempting the sinus augmentation surgery. Sinus pathologies—such as rhinosinusitis, polyposis, and sinus tumors—may favor the occurrence of complications after maxillary sinus augmentation.[11,12] The diagnosis of those pathologies, which are detected as opacities on CBCT, and their management make examination of the sinus cavity mandatory.[13] Sinus pathology can be detected in more than 60% of patients planned for sinus augmentation.[14,15]

Not all sinus pathologies require treatment, but it is necessary to identify those that require further assessment and intervention.[16] For example, a minor (2 mm) thickening of the sinus lining does not require consultation by an otorhinolaryngologist (ENT) as long as it does not interfere with the drainage of the sinus. Therefore, the risk is minimal as soon as the osteomeatal complex (OMC) is patent and the mucociliary clearance is preserved (Fig 1).[10] However, the question of treatment arises for cases of thickening that reach 5 mm.[17,18] In that situation, an ENT who can make decisions based on review of the CBCT scans, patient medical history

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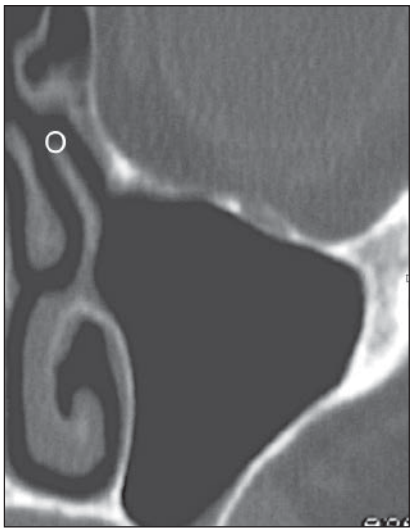
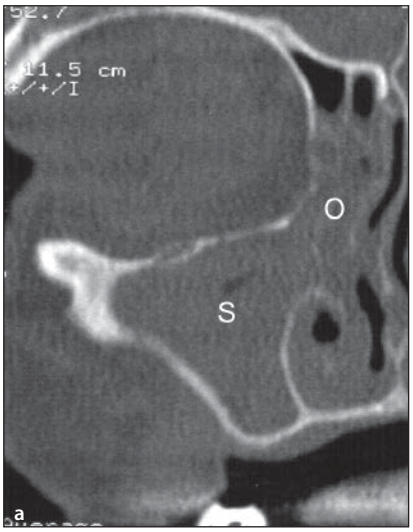


Fig 1 The patency of the OMC (O).



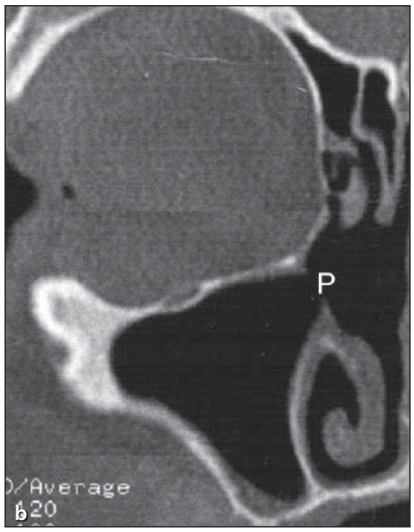


Fig 2 *(a)* The OMC (O) is blocked because of the sinusitis (S). *(b)* After the antrostomy, there is no more sinusitis and the OMC is now patent (P).

symptoms, and other risk factors may be consulted to perform an endoscopic examination.[17,19] After evaluation and risk assessment, the ENT will decide on the best strategy to restore drainage, especially if drainage is obstructed because of, for instance, sinusitis (Fig 2a).[12,20] The treatment may consist of steroids and/or antibiotics or a surgical approach, such as an antrostomy (Fig 2b).[21] The same strategy may be adopted for polyposis. Such reversible pathologies are considered relative contraindications.

Another situation worth considering is that of an inverted papilloma sinus tumor, which can obstruct the OMC. Although this tumor is benign and rare, its surgical removal is associated with high risk of recurrence, which may be as high as 34.1% within 2 years.[22] There is also the possibility of malignant transformation, which has a risk of 13.6%.[23,24] This implies that this type of pathology must be considered an absolute contraindication, as are other pathologies with ciliary dyskinesia, such as Kartagener syndrome.[25]

Additionally, caution has to be exercised in cases of odontogenic bacterial and OMC blockage (Fig 3). According to recent literature, 20% to 50% of maxillary sinusitis has an odontogenic origin.[26,27] Extraction of the causal tooth in the presence of an occluded OMC may result in drainage of the sinus through the alveolar socket, leading to oroantral communication. In such cases, antrostomy may be undertaken by an ENT prior to extraction to avoid the occurrence of oroantral communication.

POSTPROCEDURE INFECTION RISKS

If the sinus is healthy, the second question a surgeon may ask is "Are there any risks of infections after the grafting procedure?" To answer this question, one must be able to predict the impact of surgery on the physiology of the sinus, knowing that several local or systemic factors can modify the physiology and lead to postoperative complications.

Anatomical Factors

In cases of stenosis of the OMC in combination with the transient postoperative sinus membrane edema,[28,29] sinus drainage and mucociliary clearance may be impaired, causing acute sinusitis (Fig 4).[30] All factors causing stenosis are anatomic variants detectable at the OMC level and may contribute to sinus infection. In their study, Sandhu et al[31] reported the presence of these variants in 73.2% of cases. The most common variants are deviation of nasal septum,[32] middle turbinate variants,[33] enlarged ethmoid bulla,[34] hypertrophy of Haller cells,[35] and uncinate process variants.[36] Some of these factors can be related. For example, the association of two variations of the middle turbinate (concha bullosa and inverted convexity of the middle turbinate) with membrane thickening was highly significant for the obliteration of OMC.[30] As a result, it would be necessary to reduce the transient edema of the membrane by using local steroids pre- and postsurgically.[10,37] In an effort to avoid complications, consultation with an ENT may be advisable when these variants are detected regarding whether they should be surgically removed or modified preoperatively.

It is also important to look for large mucosal cysts that may obstruct the OMC during the elevation of

the sinus membrane. They are radiographically recognizable on the CBCT as dome-shaped opacities. The options of simultaneous surgical removal[38] or aspiration of the contents of the cyst with a syringe may be considered.[39]

In cases of a narrow alveolar ridge crest, simultaneous widening of the crest along with sinus augmentation may be considered. However, according to Barone et al,[40] the infection rate for this simultaneous approach is 15.4% compared to 3% for sinus augmentation alone. This may be due to wound dehiscence, the frequency of which may be reduced by appropriate flap management.

Management of Complications

In case of perforation, the granules of the graft can migrate in the sinus cavity and remain trapped in the OMC, particularly in cases of OMC stenosis (Fig 5a). As a result, when the graft is not contained and sinus drainage is obstructed, a surgical approach must be implemented to maintain the graft and the implants (Figs 5b and 5c).[2,41] Early diagnosis is essential for identifying the complication causes. This is accomplished through risk assessment using clinical and 3D radiographic (CBCT) examination, as well as ENT consultation for appropriate intervention when needed. In cases of OMC occlusion and sinusitis, the ENT may perform a functional endoscopic surgery to restore sinus drainage.[2] Prescribing antibiotics without any additional assessment and treatment is not a reliable solution.

Odontogenic Factors

Odontogenic factors, which may be considered a major etiology of acute and chronic sinusitis, are also likely to modify postoperative sinus physiology. Neighboring teeth with apical lesions or periodontal involvement can be the source of inflammatory sinus membrane thickening and further graft contamination.[42] To prevent this type of complication, the surgeon must be able to identify the at-risk teeth and to provide them with adequate and predictable treatment. However, if the prognosis is questionable, extraction may be advisable prior to sinus augmentation.

The presence of endodontic paste remnants inside the sinus cavity may be particularly dangerous because they can induce aspergillosis.[43] Thus, it becomes imperative to have it removed endoscopically by the ENT[10,16] prior to the graft surgery.

EFFECTS OF PERI-IMPLANTITIS

A common cause of late implant failure in grafted sinuses is antitis (PI).[44–46] This pathology is very common in patients with a history of periodontitis.[47,48] Those patients must be appropriately screened before

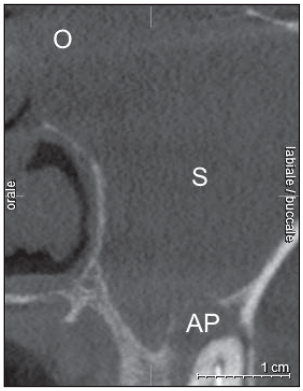


Fig 3 The apical lesion (AP) has caused sinusitis (S) and the OMC (O) is blocked.

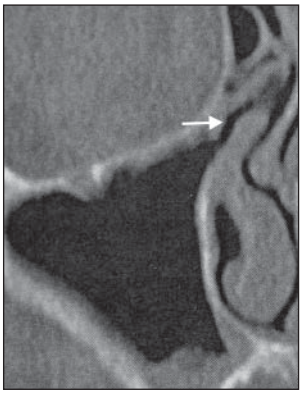


Fig 4 The OMC is very narrow *(arrow)*.

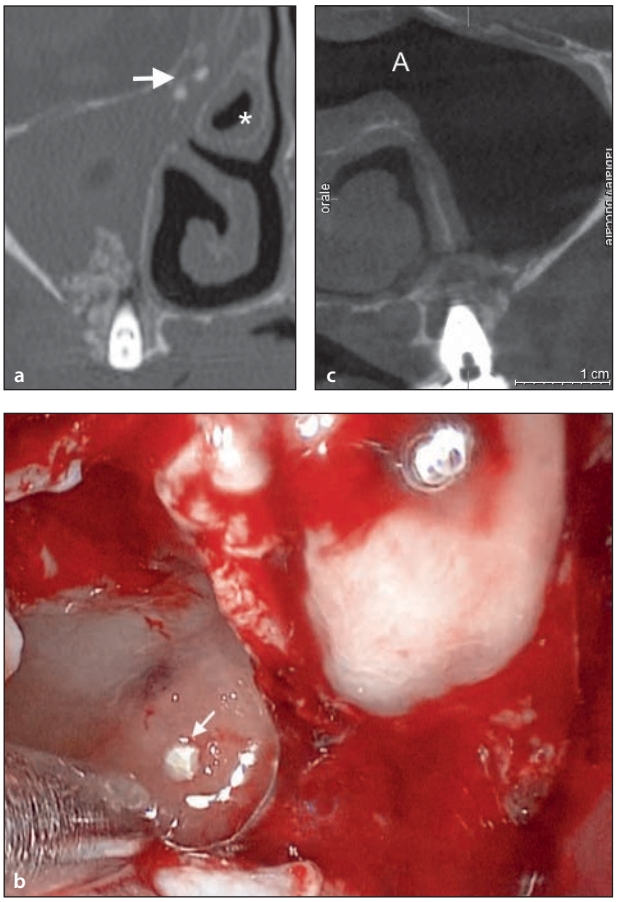


Fig 5 (a) The granules are blocked in the OMC *(arrow)* because of the stenosis created by the concha bullosa *(*)*. *(b)* The emergency antrostomy revealed the granules lost through the perforation *(arrow)*. *(c)* Thanks to the antrostomy (A), the graft and the implants were able to be preserved (CBCT at 5 years).

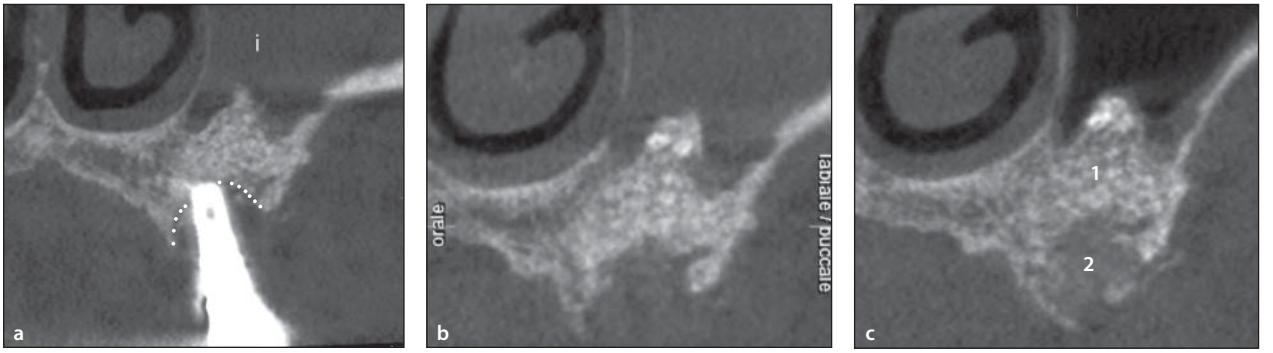


Fig 6 *(a)* The bone defect (dotted line) extends up to 2 or 3 mm from the implant apex with significant inflammation (i) of the sinus membrane, but the OMC is patent (not visible on this cut). *(b)* CBCT immediately after implant removal. *(c)* CBCT taken 8 months after implant removal. Residual graft is present (1). The defect is completely healed (2), and the sinus membrane shows no more thickening.

surgery using, for example, the Implant Disease Risk Assessment (IDRA) proposed by Heitz-Mayfield et al,[49] and any periodontitis must be stabilized prior to sinus augmentation. Recently, Stacchi et al[50] considered both the lateral window technique and one-stage sinus floor elevation to be significant risk factors for PI, finding a prevalence of 7.6% at the patient level. On the other hand, Cho-Lee et al[51] concluded the opposite: that PI is a risk factor for maxillary sinus augmentation. Similarly, Krennmair et al[47] do not consider sinus augmentation as a risk factor for PI, but it should be noted that the study follow-up only goes to 5 years and PI usually occurs later than that.[46] The available literature does not provide any clear answer regarding the prevalence of PI in native bone compared to augmented areas. For some authors,[52,53] the prevalence is identical. In a long-term retrospective study, Urban et al[54] did not find any differences in the prevalence even when considering residual bone height, which stood in contrast to Valentini et al,[46] who found a tendency for higher prevalence when the residual bone height was < 3 mm. However, in those two studies, the main difference was the grafting material, which was autogenous bone plus inorganic bovine bone for the former[54] and solely inorganic bovine bone for the latter.[46] For others,[55] marginal bone loss is more important in grafted sites, but the term "peri-implantitis" is not mentioned as a possible etiology for the reported bone loss and sinus graft is not specifically mentioned, as in the report from Galindo-Moreno et al.[56] However, in both studies, the use of biomaterials as a potential cause is clearly mentioned,[55,56] which could be interpreted as showing that inner grafting material remnants could reduce the ability of the graft to defend itself against infections.

In a recent animal study,[57] it was concluded that PI does not appear to be more frequent in native bone compared to grafted sites, but the bone lesions are more extensive in the grafted sites. This could be balanced by the fact that in this specific animal study,[57] only bone dehiscences treated with guided bone regeneration were assessed. In a 10-year evaluation, Valentini et al[46] reported an implant-related PI prevalence of 16.8% in nongrafted sites, which is less than that reported by Derks and Tomasi.[58] However, recent reports[59,60] confirm that PI in a grafted sinus may lead to sinusitis.

Management

In case of limited bone defects, although not mentioned in the literature, it is conceivable to treat PI in the same way as in native bone.[61] According to Scarano et al,[62] when PI leads to grafted bone destruction, it is usually recommended to remove the entire graft. Valentini et al[63] reported cases of large bone defects and whether they were associated with sinusitis (Figs 6a and 6b). The treatment consisted of granulation tissue and implant removal only in the cases where associated sinusitis was absent, and in cases where associated sinusitis was present, an antrostomy followed by granulation tissue and implant removal was performed. Complete bone reconstruction was observed after 1 year (Fig 6c). This was confirmed histologically.[63] The cause behind the bone defect healing remains unclear. It was suggested that the residual graft includes both living bone and biomaterial remnants, meaning that the upper part of the graft would be much more rigid and would withstand the pressure within the sinus, thus preventing the defect from flattening.[64] This rigidity may be due to the presence of slowly resorbing biomaterial. The three-wall structure would then be preserved, and regeneration may start from the residual bone contained in the remaining graft. This spontaneous healing process would render any attempt to surgically reconstruct the bone defect useless. It would also be necessary to verify the process subject to the nature of the grafting material and other factors to be determined. As a prevention, follow-up indeed allows for the detection and treatment of mucositis, which is the only reversible

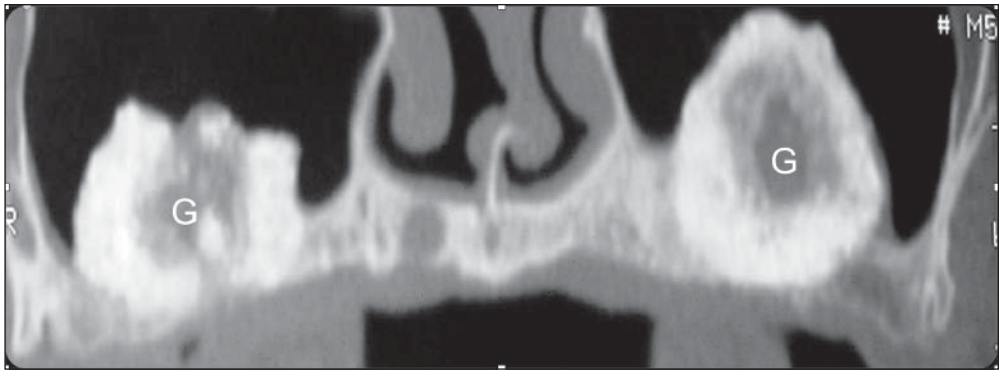


Fig 7 There are bone lacunae (G) in the center of the grafts. The patient had been taking alendronate orally for 9 years.

stage of peri-implant diseases. In a study with a 1-year follow-up, mucositis was detected in 69% of the included patients, while no case of PI was diagnosed over the same period.[65]

As reported by Stacchi et al,[50] PI occurs an average of 7 years after loading or more.[45] Therefore, the implementation of a strict maintenance program[60] to detect and treat mucositis is essential. For this purpose, a screw-retained prosthesis is preferable with the presence of > 2 mm of keratinized mucosa.[66,67] The lack of patient compliance with attending control visits should be considered as an additional risk factor.[52] As already mentioned, it might be useful to use IDRA to accurately understand the risk of PI and minimize it with an appropriate prevention.[49]

PATIENT MEDICAL HISTORY FACTOR

Even though it is not well documented in the literature, the last factor that can disturb the physiology of the sinus is the patient's medical history.[68] This issue must be considered with the patient's physician.

Diabetes Mellitus

Diabetic patients are more susceptible to developing infections.[69] Huynh-Ba et al[70] reported that the implants placed in the sinus augmentation group showed more failures than those in the native bone group, but the difference was not statistically significant. Regarding the complication rate, the sinus augmentation group had more complications than the native bone group, and the difference was statistically significant. Moreno Vazquez et al[4] reported an infection rate of 20% with diabetic patients. It is therefore essential for these patients to have a well-controlled glycemia with HbA1c < 7% before the surgery.[71,72]

Antiresorptive Drugs

The risk of medication-related osteonecrosis of the jaw is a reality, and an assessment must be performed for each patient because the risk increases with the dose and the duration of antiresorptive drug use (Fig 7).[73] Zhang et al[74] recommend the utmost caution, while others[75,76] are strongly opposed to the use of antiresorptive drugs at all. The solution of a drug holiday has been proposed, and though it may be worth considering, its validity remains uncertain.[73] Consultation with the treating physician for an individual evaluation and a risk assessment remains the best option.

Smokers

Cigarette smoking has been established as a risk factor for sinus augmentation.[77,78] In a 6- to 20-year retrospective study, the implant survival rate was 77.1% in the smoking group and 90% for the control.[60] Among smokers, the complication rate increases when the sinus augmentation is carried out at the same time as a lateral augmentation.[40]

As mentioned earlier, PI can put the graft at risk,[59,60] and smoking is known to be an important PI risk factor.[49] As a rule, candidates for sinus augmentation must stop smoking.[79]

Allergies

One implantology risk factor is an allergy to penicillin.[80,81] For patients with this allergy, clindamycin is often recommended as a replacement.[54] In 2018, Khoury et al[82] reported several postoperative infections for some patients who received clindamycin, and they concluded that a prophylactic treatment with clindamycin seems to be a risk factor for sinus graft infection. The explanation for this result could be explained by the findings of Carreño Carreño et al,[83] who took samples of the sinus membrane after it was exposed by the lateral osteotomy and found streptococci in 18.1% of the cases. These streptococci were sensitive to ampicillin, amoxicillin-clavulanate, and ciprofloxacin, which could explain the lack of efficacy of clindamycin. The proposed alternative (ciprofloxacin) belongs to the fluoroquinolone family, which is well known to have side effects such as the rupture of the Achilles tendon.[84,85]

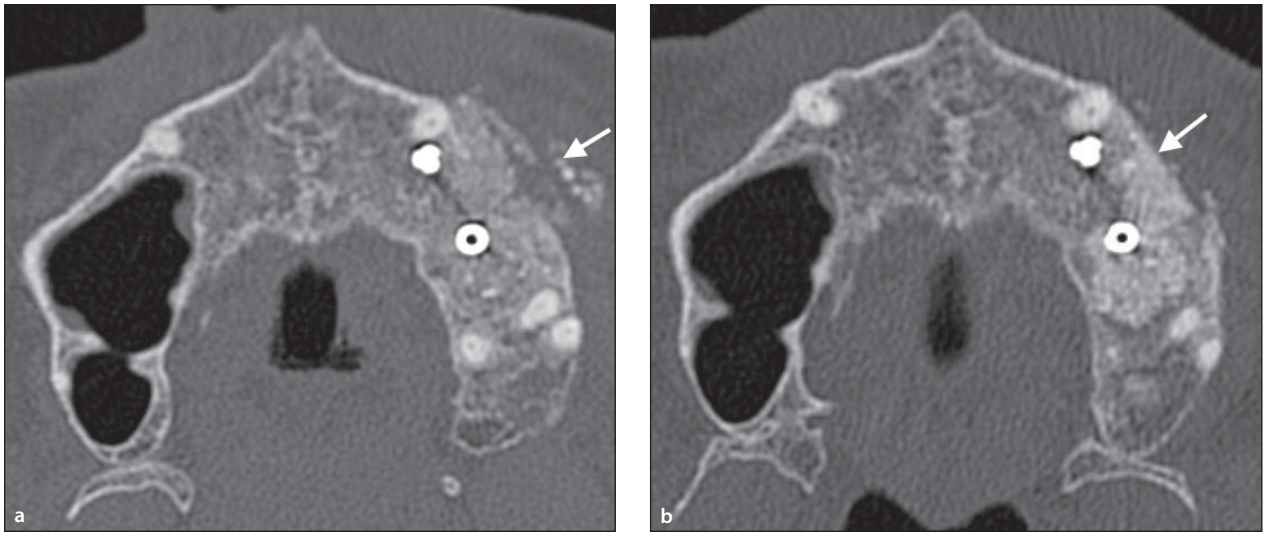


Fig 8 *(a)* Because of repeated sneezing after the operation due to a pollen allergy, the graft material was moved to the vestibular area outside the sinus *(arrow)*. *(b)* The defect was regrafted *(arrow)*.

According to Khasawneh et al,[86] many patients say they are allergic to penicillin, but most of them are not, as can be verified by using specific tests.[87,88] In cases of a real allergy, clarithromycin[89] or azithromycin[90] in combination with metronidazole can be used. In case of severe infection, fluoroquinolone is the antibiotic of choice and the decision to use it must be discussed with the ENT and the treating physician.

Another allergy-related complication is the possibility of seasonal allergies (eg, pollen) creating a barotrauma. Those patients may sneeze several times a day, and the resulting intrasinus pressure may displace the graft outside the sinus cavity, which may or may not lead to infection.[10] The diagnosis is made with axial section of a CBCT scan, which shows the displacement of the graft towards the outside and allows the OMC patency to be checked (Fig 8a). The dislodged part of the graft can be removed and eventually replaced with a new partial graft (Fig 8b).

If an infection is detected within the graft after removal of the dislodged part, a local antibiotic (doxycycline) is used,[91] then removed after few minutes. After that, the graft is reevaluated 8 months later to decide if completion of the graft is necessary for implant placement.

For patients with this type of allergy, it is preferable to perform the procedure outside the seasonal allergy period or to use antihistamines. The patient is advised not to blow their nose or sneeze opening the mouth for 2 weeks after the procedure to prevent barotrauma. Diving and air travel are also prohibited for 1 month. Barotrauma may also be caused by wearing a positive pressure mask to treat sleep apnea.[92] In this case, the patient should be advised not to wear it for at least 3 weeks.

To improve the lateral graft stability, it is recommended to create a reduced-size window and cover the graft with a collagen membrane inserted between the graft and the internal surface of the buccal plate,[93] or to pin it if the buccal plate is thick enough.

CONCLUSION

Maxillary sinus floor augmentation via the lateral window technique (LWT) remains a safe and predictable surgery in cases of atrophic posterior maxilla with associated pneumatized sinus. It is advisable to select an ENT familiar with the LWT to collaborate with in cases requiring consultation and/or intervention. The most important tool for clinicians to avoid and manage complications is careful risk assessment and decision-making. For this reason, this technique should only be performed by surgeons who are prepared and able to prevent and manage complications through evidence-based decision-making.

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