Masterclass in Clinical Practice

Implant Dentistry
with
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Maxillary Sinus Anatomy: Essential knowledge for sinus floor elevation (SFE)

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Introduction

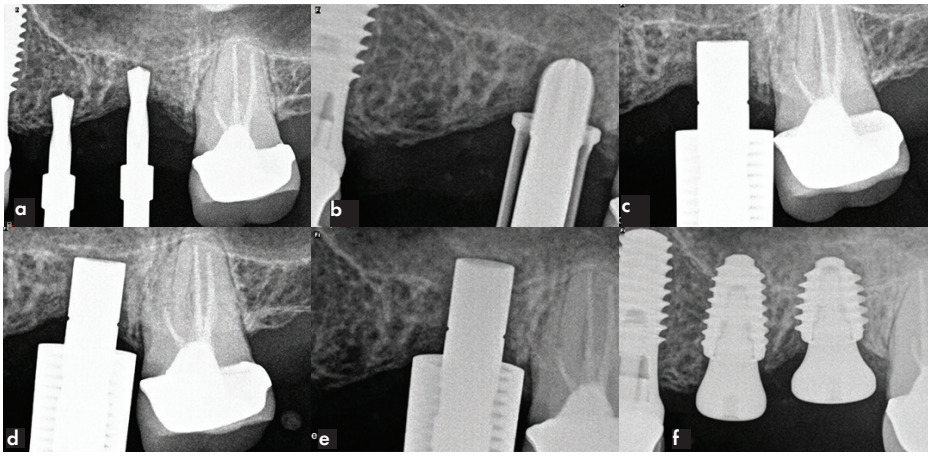
The posterior maxilla often poses a variety of complications for dental implant placement. The bone may be of poor quality, the sinus may have pneumatisized or the alveolar bone may have resorbed post extraction. In addition the maxillary sinus may have a complex anatomy which can only be assessed using 3D radiology. Pneumatization will further change the anatomy and shift the relative position of anatomical landmarks, making assessment more difficult.

SFE may be done using a transcrestal approach or a lateral window and the preference is dependent on factors such as residual bone height, anatomy of sinus, alveolar crestal width, the number of missing teeth to be replaced and most of all the surgical training and experience of the clinician. Boyne and James (1980) introduced the lateral window technique more than 40 years ago.[1] In 1994 Summers described the transcrestal technique using osteotomes to in-fracture the sinus floor without opening the sinus through a window (Figures 1a-f).[2] In our experience, the thickness of the facial/lateral wall may also be an important factor in deciding between transcrestal and lateral window techniques. A thick facial wall requires an experienced clinician and should not be attempted lightly.

This short review will cover important aspects of the maxillary sinus as it relates to SFE. It is aimed at the surgically trained and experienced technician. It requires specialised instrumentation and a thorough knowledge of GBR materials used in SFE which cannot be covered in this review. It is important to remember that we are working in the domain of Ear Nose and Throat specialists and that we need to know when to liaise with our ENT colleagues for maxillary sinus related pathology and /or complications. Any clinician performing SFE procedures should be trained in managing complications that may be associated with these procedures, both intra-operative and post-operative. A comprehensive pre-operative assessment is an essential part of avoiding complications.

Macro-anatomy:

The maxillary sinus is a paired anatomical structure that lies within maxillary bones and is filled with air. It is the largest of the paranasal sinuses, described as a pyramid with a base on the lateral border of the nose, with the apex directing towards the zygomatic process of the maxilla. The floor of the maxillary sinus is formed by the alveolar process of the maxilla, while the roof is the floor of the orbit. The posterior wall forms the anterior border of the infratemporal fossa. The lateral wall of the sinus is often composed of thin bone and provides the access point for the lateral window approach of the SFE procedure. The medial wall accommodates the sinus ostium that opens into the ethmoid infundibulum within the middle meatus of the lateral nasal wall.[3] The function of the maxillary sinus is still controversial. It is, however, assumed its role might be in warming aspirated air and reduction of the craniofacial weight.



Figures 1(a-f). Fig 1a shows initial drilling indicating insufficient bone below sinus. To avoid perforation of Schneiderian membrane, a non-cutting drill is used as shown in Fig 1b which allows drilling up to the sinus floor. A Summers-type osteotome is then used to fracture the sinus floor upward, showing the initial fracture mesial of osteotome in Fig 1d and then pushing the fractured segment slowly into the sinus as shown in Fig 1e. Implant placement in Fig 1f showing the elevated floor above the implant

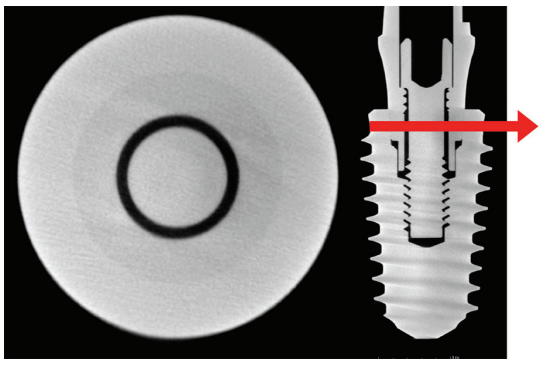


Figure 2: CBCT showing a low rounded sinus septa in 16 position (red arrow), distal to a very thin septa 13.1mm high in 15 position (yellow arrow) which would be almost impossible to overcome and two windows either side of septa would be the better option in such a case.

Sinus septa:

One of the most often seen complications of SFE is the perforation of the Schneiderian membrane. This is often caused by trying to elevate the membrane over a septum in the sinus. In a study which we published in 2009, we found septa in 66% of dentate and 71% of edentulous sinuses.[4] Septa may be wide with rounded crests, making sinus floor elevation easy with low risk of membrane tearing or it may be thin with a sharp crest, making elevation over the crest near impossible (Figure 2). Should a septum be in the middle of the proposed window preparation, two windows would need to be prepared, one either side of the septum, treating the SFE as two adjacent sinuses rather than trying to remove sinus with risk of tearing the membrane.

Micro-anatomy and drainage:

The maxillary sinus together with other paranasal sinuses and nose function as a unit and part of the upper respiratory tract. The maxillary sinuses are lined by a specialized epithelium (pseudostratified columnar ciliated epithelium) which contains numerous goblet cells and is underlined by a vascular lamina propria rich with serous and mucous glands and blood vessels. Both layers together establish the mucosa which is attached to the underlying periosteum forming a mucoperiosteum known as the Schneiderian membrane.[5] The thickness of the Schneiderian membrane is an important factor when considering SFE, as the chances of perforation increase if the thickness of the membrane is less than 0.5 mm with a thickness of more than 1-1.5mm being the safest to prevent perforation.[6,7] Variety of values for average membrane thickness has been reported in the literature, however a thickness of 0.8 – 1.99 mm is considered as physiologically healthy. Mucosa of the maxillary sinus is responsible for mucociliary clearance (drainage), a defence mechanism of the respiratory tract to protect against airborne pollutants, allergens and pathogens.[8] The drainage process includes a protective mucous layer (secreted by goblet cells and mucous glands) that traps the airborne particles and cilia which move in a synchronized manner to transfer mucous layer toward the ostium and thereafter to the nose. Drainage is crucial for the health of the maxillary sinus, especially related to SFE procedure. Any obstruction may result in complications with SFE.[5]

Blood supply

Complications in SFE may involve tearing of the Schneiderian membrane, intra-operative bleeding and post-operative infection or loss of graft. Of these the most dramatic may be if the Anterior Antral Artery (AAA) is severed, especially for the inexperienced surgeon (see video). The blood supply of the maxillary sinus is through three branches of the maxillary artery, namely the posterior superior alveolar artery (PSAA), the infra-orbital artery (IOA)and the greater palatine artery (GPA). The PSAA enters the posterior aspect of the maxilla and supplies teeth, gingiva and the Schneiderian lining posterior. The IOA gives off superior anterior alveolar

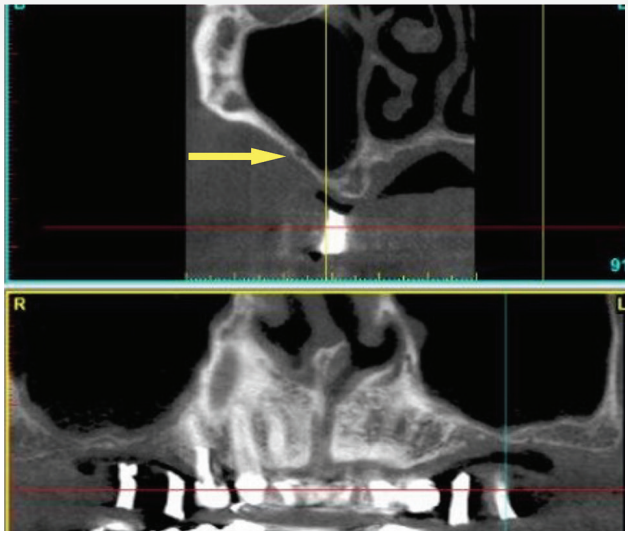


Figure 3: CT scan showing intraosseous AAA (yellow arrow) in area of planned window preparation. This case is shown in video.

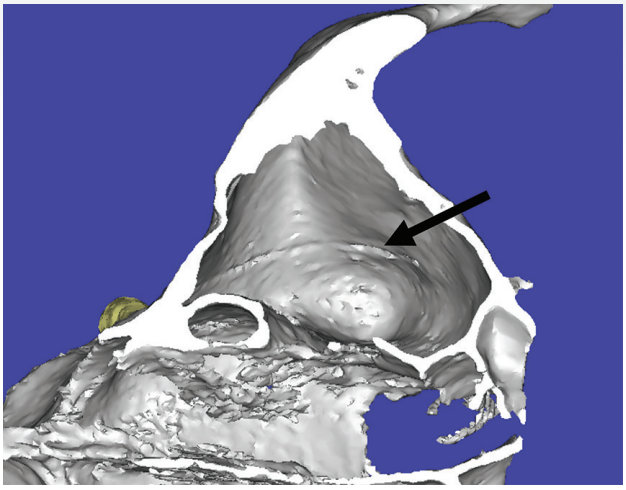


Figure 4: The AAA groove can be seen in this medical CT of a sinus. In such a case it would be possible to lift the artery with the Schneiderian membrane without the risk of severing the artery

artery branches within the infra-orbital canal to supply the anterior teeth and Schneiderian membrane. The PSAA and IOA form an intraosseous anastomosis in almost all cases, and this anastomosis forms the AAA within the lateral wall of the sinus.[9] This is where the window is prepared for the lateral window technique and it is important to identify the size and position of this artery. It can usually be seen on a CBCT (Figure 3) and care should be taken when performing the window preparation as severing the artery may lead to severe bleeding that may cause dramatic airway obstruction especially when done under local anaesthesia without throat protection and one suction tube only. It will not be life threatening bleeding but will certainly require a very experienced surgeon with specialized equipment to manage this in a conscious patient. Additional equipment such as a laser may be essential to control such bleeding. This is demonstrated in the video. In many cases the artery may be within the Schneiderian membrane which would not pose the same risk as it would be lifted with the membrane (Figure 4), but with CBCT this is not always possible to visualise accurately.

Nerve innervation and local anaesthesia:

The infraorbital and anterior, middle, and posterior superior alveolar branches of the maxillary nerve (V2) are responsible for general innervation of the maxillary sinuses. Most of the sensory innervation of the maxillary sinus is provided by the posterior superior alveolar branch, which usually has two to three branches supplying the posterior wall of the sinus.[10] The middle superior alveolar branch contributes secondary mucosal innervation, while the anterior superior alveolar branch innervates the anterior portion of the maxillary sinus. The infraorbital nerve runs anteriorly through the middle of the sinus roof and supplies the superior and part of the medial wall, while the ostium and inferior wall are innervated by the greater palatal nerve.[11] SFE is usually done under local anaesthesia, thus thorough knowledge of the maxillary sinus innervation is a necessity. When performing SFE procedure with lateral approach an Infraorbital, posterior superior alveolar and greater palatine nerve block anaesthesia should be considered.[12]

CBCT to examine 3D anatomy:

Meticulous radiological evaluation of the maxillary sinus is needed when planing SFE procedures. It is important to thoroughly assess the sinus anatomy, to recognise the presence of pathology and to develop a proper treatment approach. In recent years, due to its superiority compared to conventional 2-D radiographs and low effective radiation dose compared to medical computed tomography, CBCT has become the most preferred imaging modality for the maxillary sinus evaluation.[13] CBCT image of a healthy maxillary sinus shows its radiolucency with a thin mucosal lining and a clear ostium which reveals appropriate mucociliary clearance. However, several factors have to be considered preoperatively regarding SFE: the thickness of membrane lining the sinus, presence of sinus septa, the angle of the buccolingual maxillary sinus wall, presence of teeth/implants approximating the sinus floor, the thickness of bone on the buccal side, residual alveolar ridge height and width, width of the sinus and presence of AAA.[14] All the above-mentioned factors should be visualized and evaluated using

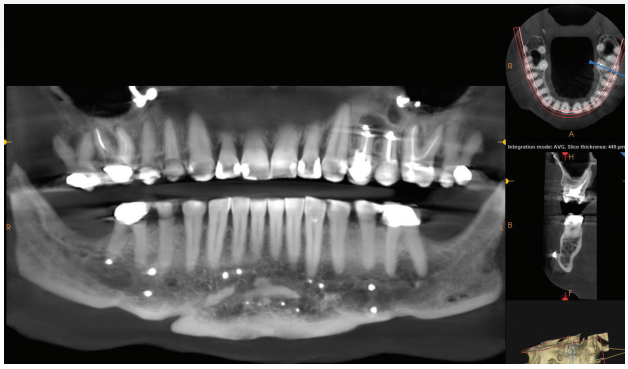


Figure 5a: Panoramic slice showing what appears to be ample vertical bone height in 2nd quadrant for implant placement after tooth removal and 4b showing pneumatization in cross section with less than 4 mm of vertical bone height between roots.

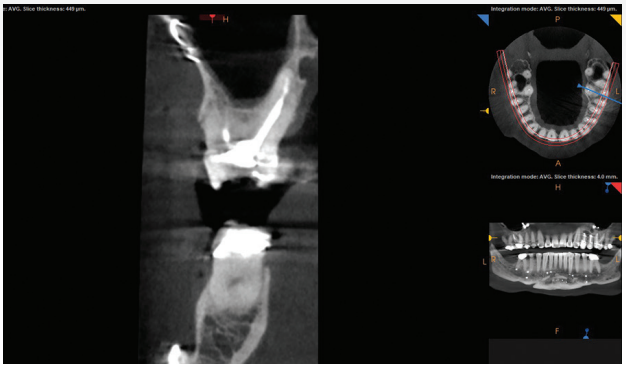


Figure 5b: Tooth 26 with pneumatization between buccal and palatal roots where implant would have to be placed

CBCT prior to deciding on the best feasible treatment option available.

Another complication often found on CBCT compared to panoramic radiographs, is the fact that a panoramic radiograph may show excellent vertical bone when deciding on an extraction of a molar, whereas the cross section on the CBCT may show complete pneumatization between the roots, making implant placement impossible without a full lateral window SFE (Figure 5 a-b).

Pathology of maxillary sinuses:

CBCT has given dentistry a very valuable tool for assessing anatomy and pathology but with it comes the responsibility to take the necessary time and care to assess for pathology. Missing pathology may impact negatively on SFE success. Implant dentistry has become the most frequent reason for CBCT requests and incidental pathological findings will be part of the assessment.

CBCT done for routine implant dentistry in asymptomatic patients may have a high percentage of mucosal thickening or mucous cysts in up to a third of cases.[15] When apical tooth pathology is found under the floor of the sinus, mucosal sinus pathology may increase to more than two thirds and in severe apical periodontitis cases up to a 100% of cases may show sinus pathology.[16] Figure 6 shows sinus floor thickening probably due to the apical periodontitis on molar. The most important aspect of assessment on CBCT is to scroll through the entire volume of the sinus to ensure that no pathology is hidden and not to look at just a few slices in site of implant position. Comparing left with right is always a good idea to determine if what is seen is abnormal, sometimes pathology can be symmetrical and missed as pathology (Figure 7).

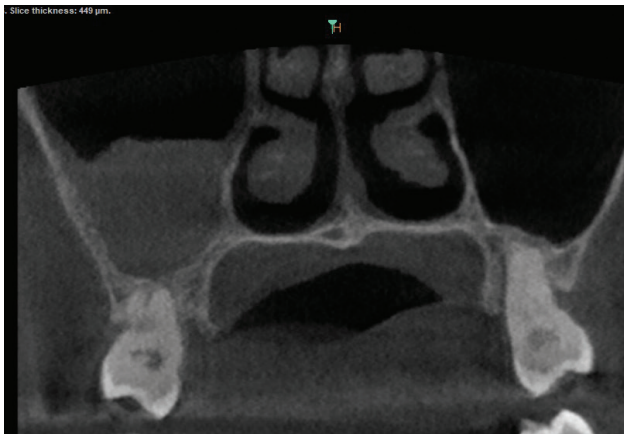


Figure 6: The molar on left showing apical periodontitis with a pronounced reaction in the sinus floor above it and the right sinus showing clear normal appearance.

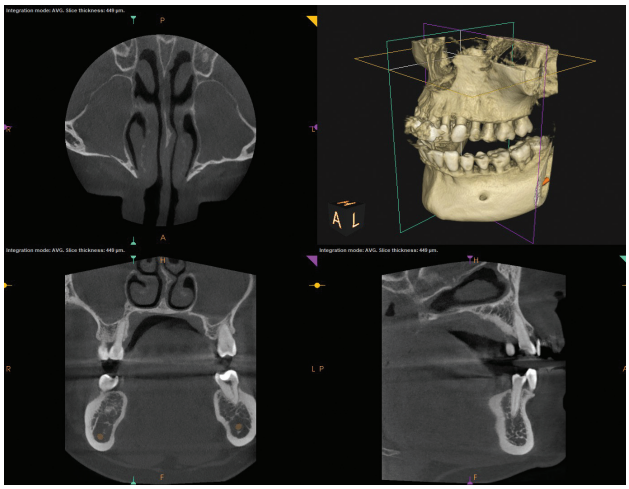


Figure 7: Complete opacification of both sinuses which could be misinterpreted by an inexperienced clinician as normal due to the symmetry.

Conclusion

Although sinus floor elevation procedures are always complex procedures with potential for anatomical complications, post-operative infections and even requiring removal of dental implants and/or bone grafts from within the maxillary sinus in severe cases- it is a procedure which many dentists are now performing. This is often done without the necessary training and great care should be taken when performing such procedures. In addition, the correct grade of medical indemnity insurance is essential when doing these procedures.

Many specialized instruments exist for the transcrestal technique of SFE and this is perhaps a safer procedure for dentists to do, especially when done without the introduction of a particle bone graft into the sinus.

References

1. Boyne PJ, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone. J Oral Surg. 1980;38(8):613-6.

2. Summers RB. A new concept in maxillary implant surgery: the osteotome technique. Compendium. 1994;15(2):152, 4-6, 8 passim; quiz 62.

3. Mohan N, Wolf J, Dym H. Maxillary sinus augmentation. Dent Clin North Am. 2015;59(2):375-88.

4. van Zyl AW, van Heerden WF. A retrospective analysis of maxillary sinus septa on reformatted computerised tomography scans. Clin Oral Implants Res. 2009;20(12):1398-401.

5. Whyte A, Boeddinghaus R. The maxillary sinus: physiology, development and imaging anatomy. Dentomaxillofac Radiol. 2019;48(8):20190205.

6. Lin YH, Yang YC, Wen SC, Wang HL. The influence of sinus membrane thickness upon membrane perforation during lateral window sinus augmentation. Clin Oral Implants Res. 2016;27(5):612-7.

7. Wen SC, Lin YH, Yang YC, Wang HL. The influence of sinus membrane thickness upon membrane perforation during transcrestal sinus lift procedure. Clin Oral Implants Res. 2015;26(10):1158-64.

8. Bustamante-Marin XM, Ostrowski LE. Cilia and Mucociliary Clearance. Cold Spring Harb Perspect Biol. 2017;9(4).

9. Valente NA. Anatomical Considerations on the Alveolar Antral Artery as Related to the Sinus Augmentation Surgical Procedure. Clin Implant Dent Relat Res. 2016;18(5):1042-50.

10. Duncavage JA BS. The Maxillary Sinus [Textbook]. New York: Thieme; 2011.

11. Danesh-Sani SA, Loomer PM, Wallace SS. A comprehensive clinical review of maxillary sinus floor elevation: anatomy, techniques, biomaterials and complications. Br J Oral Maxillofac Surg. 2016;54(7):724-30.

12. Bathla SC, Fry RR, Majumdar K. Maxillary sinus augmentation. J Indian Soc Periodontol. 2018;22(6):468-73.

13. Rahpeyma A, Khajehahmadi S. Open Sinus Lift Surgery and the Importance of Preoperative Cone-Beam Computed Tomography Scan: A Review. J Int Oral Health. 2015;7(9):127-33.

14. Tavelli L, Borgonovo AE, Re D, Maiorana C. Sinus presurgical evaluation: a literature review and a new classification proposal. Minerva Stomatol. 2017;66(3):115-31.

15. Sanaullah M, Sinha A, Srivastava S, Mishra A, Singh Y, Basu S. Hidden pathologies of maxillary sinus using CBCT scans. Journal of Indian Academy of Oral Medicine and Radiology. 2021;33(3):260-5.

16. Yeung AWK, Hung KF, Li DTS, Leung YY. The Use of CBCT in Evaluating the Health and Pathology of the Maxillary Sinus. Diagnostics. 2022;12(11):2819.