Received: 23 March 2021 | Accepted: 22 June 2021

DOI: 10.1111/ors.12649

ORAL SURGERY

REVIEW ARTICLE

Lateral window technique: A focus review

Francisco Correia[1] | **Sónia Gouveia**[2] | **Daniel H. Pozza**[3,4,5] | **António Campos Felino**[1] | **Ricardo Faria-Almeida**[1]

[1]Faculty of Dental Medicine, Department of Oral Surgery and Periodontology, University of Porto, Porto, Portugal

[2]Department of Electronics, Telecommunications and Informatics (DETI), Institute of Electronics and Informatics Engineering of Aveiro (IEETA), University of Aveiro, Aveiro, Portugal

[3]Faculty of Medicine, Department of Biomedicine, University of Porto, Porto, Portugal

[4]Faculty of Nutrition and Food Sciences, Department of Histology, University of Porto, Porto, Portugal

[5]Institute for Research and Innovation in Health - I3s, University of Porto, Porto, Portugal

Correspondence
Francisco Diogo Carvalho Correia, Department of Oral Surgery and Periodontology, Faculty of Dental Medicine, University of Porto, Porto, Portugal.
Email: franciscodcorreia@gmail.com

Funding information
Fundação para a Ciência e a Tecnologia, Grant/Award Number: UIDB/00127/2020

Abstract

The posterior alveolar bone region of the maxilla has, in more than 40% of the cases, a height inferior to 4 mm, thus making rehabilitation with implants a clinical challenge. This focus literature review was carried out through an exhaustive literature search in PubMed, ScienceDirect, LILACS, Web of Science, Scielo and Cochrane Library. The aim was to illustrate and analyse various factors that should be accounted for while applying the maxillary sinus elevation technique. The lateral osteotomy technique is carefully described including its indications, complications, contraindications, as well as, different factors to take into account, such as the use of electric piezo, graft materials, membranes and the expected success rates.

KEYWORDS
bone regeneration, bone substitutes, maxillary sinus, sinus augmentation, sinus floor elevation, sinus lift

INTRODUCTION

Placing dental implants in the posterior jaw is a challenge due to the presence of the maxillary sinus, especially when bone availability is limited. In 40% of these sites, the bone height is 4 mm or less[1] and, in cases of extreme bone resorption, it can lead to cases of bone height apically to the maxillary sinus smaller than 1 mm.[2] This two-way bone resorption that occurs in the posterior region of the maxilla is due to the centripetal loss of the alveolar bone and the pneumatization of the sinus, together with histophysiological bone characteristics, such as a very medullary and little cortical bone.[3,4] One of the solutions is the regeneration of bone in the posterior maxilla through surgery using the lateral window of the maxillary sinus, the technique with the greatest scientific documentation.[1,5,6] However, besides being a complex technique, its use requires a careful screening of patients and a previous risk-benefit analysis that considers the systemic pathologies and behavioural habits of the patient,[5] such as smoking or oral hygiene. The alternatives to this sinus approach include short implants (if enough remaining bone) or zygomatic implants.[5,7–9] Since zygomatic implants is a complex procedure, requiring hospitalisation in most cases, and short implants are not always possible, the sinus lift procedure is the main indication for most posterior maxillary rehabilitation cases with dental implants.[5,7–9]

The purpose of this literature review is to describe the elevation of the maxillary sinus procedure using the lateral window technique, as well as to gather current data on its indications, limitations, success rates and post-intervention complications.

MATERIALS AND METHODS

The scientific articles used in this focus literature review were screened between October 2019 and December 2019 by two research (FC and RFA). The set of initial papers were collected from the electronic databases PubMed, ScienceDirect, LILACS, Web of Science, Scielo and Cochrane Library. Electronic search was limited to English, Portuguese, Spanish, Italian and French. The keywords and/or MeSH terms 'sinus floor augmentation', 'sinus lift' and 'Sinus Floor Augmentation (Mesh) AND Humans (Mesh).' lead to 5697 articles. After elimination of duplicates and title/abstract reading, the number of articles went down to 278 and, after full-text reading, 103 papers were selected to be included in this focus review. Papers targeting animal studies, case report and case series were excluded, whereas those aiming two-stage lateral window technique complications, contraindications, as well as different factors to take into account, such as the use of electric piezo, graft materials, membranes and the expected success rates were included in this review.

WINDOW TECHNIQUE

The lateral window technique or lateral osteotomy technique, also known as sinus lift or Caldwell-Luc technique, was first described and presented in an oral communication by Tatum H. Jr. in 1977 and only published by him in 1986,[10] being first published by Boyne and James in 1980.[11] It is presented as the technique for sinus elevation with greater scientific documentation[1,5,6] and is a predictable, a safe procedure, with a low rate of complications and high rates of implant success, regardless of residual bone height.[12]

This technique that aims at placing the bone graft material involves a surgical approach through an osteotomy on the lateral wall of the maxillary sinus and a careful elevation of the *Schneider* membrane to create a defined space between it and the floor of the maxillary sinus.[1,13–16] The technique can be described as follows:

Osteotomy just-antero-superior to the zygomatic abutment, followed by a spherical drill bit No. 6 or No. 8 at 16,000 rpm, or piezoelectric instrument. It is important to consider that the size of the lateral osteotomy varies according to the prosthetic area to be replaced, depending on the limiting anatomical factors and the initial surgical planning.

A window is made in which the 'hinge' is in a cranial position, 'the window is opened' into the sinus and, at the same time, it is possible with this maneuver to start lifting the *Schneider* membrane. Then, the space formed with the bone graft is filled, the opening is covered with a membrane and sutured. Figure 1 presents the different steps to perform this technique.

Different factors that need to be taken into account will be described in the next chapters of this paper, such as technique complications, contraindications, the use of electric piezo or rotating instruments, as well as the type of graft materials, the placement of a membrane on the lateral wall and the expected success rates.

Indications

This technique is mainly indicated when the bone height below the maxillary sinus varies between 1 and 5 mm in height, for subsequent placement of standard-length dental implants, allowing a median implant survival rate of 95.5% (61.2%–100%).[17]

An initial height of 5 mm is considered the threshold for simultaneous placement of the implants together with the elevation of the maxillary sinus using the lateral technique.[17] However, it is possible to place the implants simultaneously in ridges with an initial height ≥1 mm.[1,18] The decision to perform a simultaneous (lateral osteotomy plus implant placement) or staggered (first lateral osteotomy surgery and a second implant

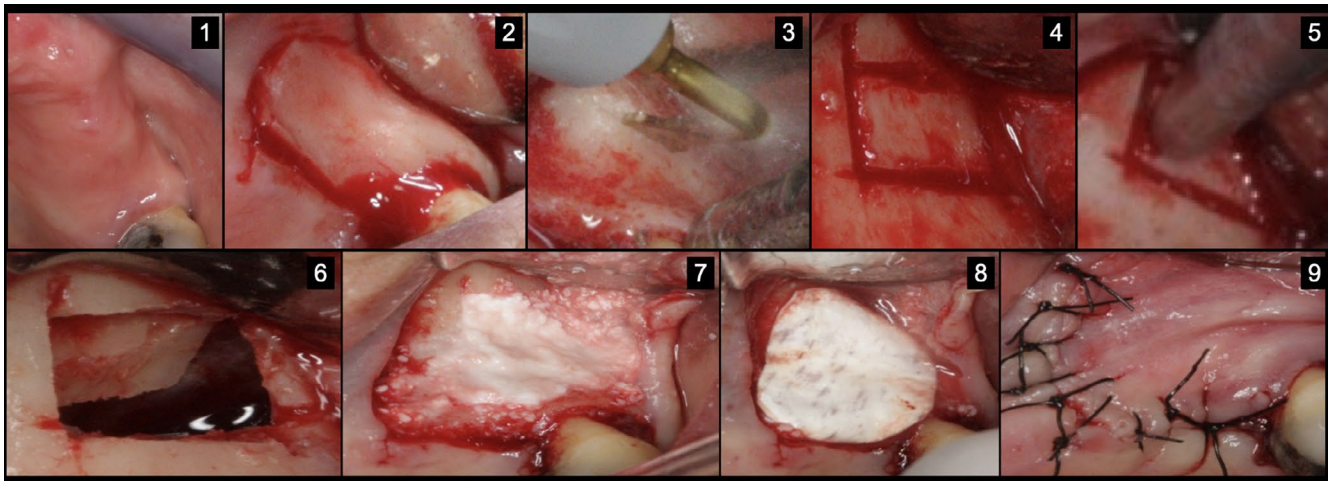

FIGURE 1 Illustration of the steps of the Lateral Window Technique. Legend: (1) initial photo; (2) incision; (3) osteotomy with a piezoelectric instrument; (4) osteotomy shape; (5) osteotome to help concluding the osteotomy; (6) Schneider membrane lift up; (7) graft material placed; (8) collagen membrane placed on the lateral wall; (9) suture of the flap.

placement surgery) should be based on an individual assessment of risk factors assessing whether it is possible to achieve primary implant stability, which is a *sine qua non* condition for success. For this assessment, it is crucial to evaluate also the quantity and quality of the implant, bone availability.[1,18]

Contraindications

The prior evaluation of the patients' pathologies is extremely important, considering that it can interfere with the regenerative capacity and increase the rates of complications. A thick *Schneider* membrane or large mucous cysts can increase the risk or obstruction of the ostium or sinusitis after elevation of the maxillary sinus.[19] Some authors[13,14,20,21] consider as absolute contraindications to implant placement in the posterior maxilla: chemotherapy and radiotherapy to treat a recent or impending tumour, drug or alcohol dependence and blood dyscrasias that directly affect the bone metabolism, intravenous bisphosphates, tumoural pathologies of the maxillary sinuses and destructive sinus surgery. As relative contraindications can be considered: pathologies such as diabetes, osteoporosis or Crohn's disease, behavioural habits such as smoking, poor oral hygiene and some types of systemic medication such as bisphosphonates.[13,20–23]

Preoperative

A preoperative clinical and radiographic screening using computed tomography (CT) or conical beam computed tomography (CBCT) of the maxillary sinus is mandatory to detect any pathologies, asymmetries, to know the anatomy including septa, to quantify the thickness of the lateral wall, the volume and the shape that needs regeneration.[1,13,23–25] CT also allows to perform a virtual pre-surgical planning,[26] as well as, to verify the location of the upper, anterior and posterior alveolar canals, including their anastomosis.[27] Another important factor, that can be analysed, is the height at which the osteotomy should be performed, to achieve optimal maxillary sinus window.[14]

If there is evidence of acute or chronic sinusitis or other pathologies, the patient must be referred to an otorhinolaryngologist.[1,21,28] Preoperative sinusitis is a positive predictive factor for the development of acute postoperative sinusitis[1]

The use of chlorhexidine mouthwash prior to surgical interventions is a preventive measure to reduce the risk of infections ensuring the aseptic control of the surgical field.[13,14,29] The additional use of antibiotics is also advisable in order to avoid infections and graft reductions due to the presence of undesired bacteria.[20,27]

Complications

In terms of complications, this technique has a low incidence compared to other bone regeneration techniques.[17,23,24] The complications described in the literature are divided into intraoperative complications (such as perforation or haemorrhage of *Schneider*'s membrane) and postoperative complications (nosebleed, wound infection, sinusitis, exposure to the graft or barrier membrane, graft infection, cysts formation and dehiscence).[1,12,13,15,22,30–42] The most frequent intraoperative complication is perforation of the *Schneider* membrane (0%–60%), which is well-tolerated, with normal recovery and regeneration of the membrane over the postoperative bone graft in most cases. If the sinus membrane is not repaired with a substitute membrane (e.g. non-reabsorbable collagen membrane) complications, including graft and dental implant loss, can happen to jeopardise the sinus surgery procedure.[12,13,15,22,24,28,30–43] Due to its prevalence, we dedicate a section in this paper (3.4.1) to the causes, prevention and repair methodologies of *Schneider*'s membrane.

Anatomically, the main impacting factors for this technique are the septa, and the infra-orbital neuro-vascular structures.

To observe the path of the posterior alveolar superior artery and anastomosis in the intra and extra-bony branches, a CT or CBCT are essential to analyse the height of the passage from the basal bone, the diameter and the course, avoiding haemorrhagic complications due to lacerations in the branches of the maxillary artery or intraosseous vascular channel, in the lateral antrum wall of the maxillary sinus, which can be found in more than 50% of cases.[28,44] The performance of lateral osteotomy with piezoelectric instruments that selectively cut the bone without additional soft tissue injuries to the detriment of rotary drills, helps to reduce the risk.[44]

Another complication is the leakage of the graft material into the maxillary sinus or the movement of the membrane that causes an ostium obstruction, preventing the drainage of sinus mucus which increases the risk of infection.[21] However, despite these potential complications, the risk of infection is low and less than 5%.[21]

Overfilling the sinus can also result in blockage of the ostium, especially if inflammation of the membrane or the presence of a thickened sinus mucosa exists. The elevated *Schneiderian* membrane increases in thickness after surgery, reaching more than 6 mm after 7 days, taking months until the membrane thickness returns to the initial thickness, and this recovery time is directly correlated with the extension of the maxillary sinus elevation.[45]

In case of an ostium block and consequently a postoperative infection without initial resolution, the re-entry and removal of a portion of the graft and the change in the antibiotic protocol may be appropriate.[21]

The use of filters to collect autografts translates into an increased risk of infection located in the maxillary sinus (13.0% vs. 4.0%).[29] In the study by Barone et al. in 2006[41] a greater likelihood of maxillary sinus infections was also observed in smoking patients.

Sinus infections after a bone graft can cause serious complications due to the proximity of the maxillary sinus with various vital structures (example: brain, cavernous sinus),

and can cause sinusitis, orbital cellulitis, meningitis, osteomyelitis, thrombosis of the cavernous sinus, among others.[13]

Postoperative complications occur less frequently (3.6%), sinus infections can be avoided since they tend to occur mainly in previously unhealthy sinus, and should be detected in preoperative exams.[5,24]

Acute postoperative sinusitis occurs in approximately 3%–20% of sinus elevation procedures and represents the most common short-term complication.[13,21,46] Usually, the infection starts more than a week after surgery and resolves with an antibiotic, the risk proportionally increases the amount of graft used.[21,46,47]

Suturing stripping with an incision opening is an uncommon postoperative risk, since the site of the lateral osteotomy is at least 5 mm from the bone crest.[21] The consequences of opening the incision can be delayed healing, leakage of graft material into the oral cavity and increased risk of infection. If a portion of the non-resorbable membrane is exposed, the area must be cleaned at least twice a day with a mouthwash of chlorhexidine and, if it does not close after two months, a new surgery must be performed in order to remove the membrane and reconnect the tissues.[21]

Complications - perforations in the *Schneider* membrane

Regarding the intraoperative complications, the most common during maxillary sinus elevation surgery due to the lateral osteotomy is the tearing of the *Schneider* membrane. It can occur due to pre-existing perforation, during lateral osteotomy or when the membrane is detached and elevated, which is not influenced by age or gender.[21,37] The maintenance of the Schneider membrane is desirable to guarantee better vascularisation, graft stability and environmental conditions for the maturation of the inserted bone graft materials.[48] Perforation of the *Schneiderian* membrane is therefore a relevant complication considering that it leads to a decrease in apical bone regeneration and can lead to graft migration or failure, bacterial contamination of the graft and double the risk of incidence of infections, or of acute or chronic sinusitis, as well how to increase the need to use antibiotics.[14,22,32,37–39,48–50] However, there are also studies in the literature that do not support the negative effects of membrane perforation, such as graft loss and compromised final result, increased postoperative complications, or even decreased implant survival rate.[22,35,51]

To prevent perforations of the *Schneider* membrane, a meticulous assessment of several aspects that increase the risk of perforation should be performed, namely anatomical variations, thickness of the lateral bone wall, residual crest, size and position of the septa, morphology of the nasal floor, membrane thickness, presence of pathologies of the maxillary sinus, surgery to previous sinusitis, possible oroantral communications, infections and experience of the surgeon.[25,31,33,36,52–54]

The width of the maxillary sinus is a relevant variable. The risk of perforation is higher (62.5%) when the membrane is elevated in the anterior and narrow regions and where the lateral and median walls of the sinus have an angle of less than 30°. This risk decreases to 28.6% when it approaches the medial area (30°–60°) and becomes null when it reaches the posterior region (>60°).[31]

The septa are the most common bone anatomical variant in the maxillary sinus and one of the biggest causes for perforation of the *Schneider* membrane, varying between 13% and 59.7%.[21,33,52]

Surgically, the approach may vary depending on the location, size and number of septa present. In the presence of a septum, the design of the lateral osteotomy window should be modified in order to provide better access to the surgical instruments and try to include them in order to minimise the risk of perforation and improve the view of the surgical site when the membrane is raised.[14,21,28,31]

The thickness of *Schneider*'s membrane is also one of the relevant variables for the probability of perforation and it tends, on average, to increase from the region of the first premolar until reaching its maximum thickness in the region of the second molar.[32] The thickness of the *Schneider* membrane may be relevant to the risk of perforation. For example, the retrospective study by Lum et al. 2017[55] reports a perforation rate of 28.1% and found an association between membrane perforation and the presence of a thinner membrane, which is directly related to a lower height bone. On the other hand, Insua et al.[53] describes that the thickness between 1 mm and 1.5 mm of the membrane presents the greatest tendency for perforation. The same authors suggest that the increased rate of perforation of the membrane may be more related to the changes induced by inflammatory conditions, which promote a change in thickness and epithelium in that membrane.[53] A thicker membrane, but with epithelial damage and chronic inflammation, may be more prone to perforation than a thinner, but healthy membrane with an intact epithelial layer.[53] Patients with periodontal disease and smoking patients are more likely to have a thicker membrane.[51]

The perforation of *Schneider*'s membrane does not appear to be significant in the mean of vital bone and in the survival of implants. Froum et al. 2013[56] registered 26.3% ±6.3% (mean ± standard deviation) in case of membrane perforation (and its repair) and 19.1% ± 6.3% when not perforated, not being these differences translated in a statistically significant way in the survival of the implants (95.5% when perforated the membrane vs. 100% when not perforated).

The treatment of a *Schneider* membrane perforation consists of providing a stable coverage of the perforated area to contain the graft material.[31] The first step in treating a perforation is to raise the surrounding membrane to reduce the stress on the region and to prevent further perforation. Subsequently, the size and position of the area must be assessed.[31] If the perforation is small, there is the hypothesis that it self-regenerates due to the formation of a clot or leaflet of the *Schneider* membrane.[31] If the perforation is relevant

(>5 mm), it must be covered by a stable resorbable membrane that serves as a barrier between the sinus and the graft material.[31] In case the perforation is extensive (>10 mm), it is recommended to use a large stabilised resorbable membrane that extends over the side wall.[31] When using a resorbable membrane to seal the perforation, it must overlap the margins over 5 mm in diameter around the perforation.[21] After sealing the perforation, the surgical procedure can be completed in the same way as in cases where a perforation has not occurred.[21]

The repetition of the surgical procedure can be considered, and the second procedure should be performed never before 6 to 8 weeks after the first surgical attempt.[14]

Piezo versus rotating instruments

The use of the piezoelectric instrument, in front of the rotary instruments to perform lateral osteotomy of access to the maxillary sinus, is justified by the fact that the possibility of accidental perforation of the *Schneider* membrane is lower, since the piezoelectric only cuts hard tissues. Another advantage is the reduction of trauma to adjacent tissues, the reduction of intraoperative haemorrhage, the reduction of the risk of vessel damage, as well as the improvement of intraoperative visibility and the reduction of pain and oedema.[13,22,31,36,50,57–62] The biggest disadvantage of the piezoelectric is the delay in performing the osteotomy, which can lead to bone heating.[22,57,58,63] This time difference is on average 2 minutes (3 minutes for rotary instruments vs. 5 minutes for piezoelectric).[59] On the other hand, two studies[62,64] found no statistically significant differences in terms of risks, traumas or perforations of the *Schneider* membrane. In the systematic review by Geminiani et al. 2017,[63] intraoperative risks, including rupture of the membrane, are not reduced using piezoelectric surgery, sonic surgery, osteotome or trephine, when compared with the conventional surgical technique. The 2007 study by Wallace et al.[60] reports a 27% reduction in the occurrence of *Schneider* membrane perforations when using piezoelectric compared to conventional rotary instruments.

Graft materials and growth factors

The graft materials used in the lateral maxillary sinus osteotomy technique described in the literature include particulate or block autograft, particulate lyophilized demineralised frozen allograft, xenografts, non-resorbable alloplastic hydroxyapatites and combination with BMP-2, among others.[1,65]

The first authors to describe the use of autograft and its application to the maxillary sinus were Wood and Moore[66] in 1988. In terms of bone substitute, tricalcium phosphate was the first bone substitute to be used successfully in sinus elevation by Tatum[67] in 1986. Currently, materials from non-autologous grafts or in combination with autografts are well documented in the literature, with no statistically significant differences in clinical results and implant survival rate compared to autografts.[24,65,68]

However, the use of some bone regeneration materials can lead to inflammatory reactions or infections.[43] For example, in the 2017 clinical trial by Kolerman et al.,[69] in which the maxillary sinuses were grafted with an alloplastic graft (biphasic calcium phosphate), evidence of a mild and chronic inflammatory infiltration was observed, which mainly included lymphocytes and multinucleated giant cells. Biomaterials such as collagen xenograft of porcine origin the maxillary sinus have a lower risk of infection or inflammation.[43,70]

In histomorphometric analyses, defined as the gold-standard for estimating the amount of new bone formation in the grafted sites and verifying differences in the use of different biomaterials,[31,71] there are large variations in the amount of vital bone (5% at 60%), according to the different types of graft, which histologically influences the quality of the bone obtained.[1]

The osteogenic properties of the autograft and the xenograft are different, allowing a reabsorption/apposition of new bone that tends to be greater in the xenograft.[70,72] When bone substitutes are used, the growth of the newly formed bone is delayed by the absence of osteogenic cells and their osteogenic growth factors, which lead to the delay in placing the implants and loading them.[14]

The slow reabsorption when using bovine xenografts is its greatest disadvantage described in the literature, in many cases it is incomplete even after many years, which means that a considered graft volume is not replaced by new vital bone.[73] For this reason, other types of xenografts that have a great capacity for resorption and deposition of new bone, such as collagen xenograft of porcine origin, may be part of the advancement in regenerative techniques of maxillary sinus elevation by lateral osteotomy[72] The ability to resorb and deposit new bone from collagen xenograft of porcine origin is a result of the influence of collagen on cellular and molecular activity, inducing the adhesion of osteoclasts to the surface of the biomaterial[72,74]

Cordella et al. (2016)[71] observed that the average amount of new bone formed, and residual bone graft was not significantly different for bovine xenograft and porcine xenograft, when compared with alloplastic biomaterials. In comparison, for the mixture of xenograft and autograft with the mixture of autograft and allograft, the latter shows a faster turnover and a faster decrease in biological action after 6 months.[75]

The use of autograft shows results similar to the use of other bone substitutes, but it has the great advantage of rapid bone maturation due to the presence of osteogenic cells and osteogenic growth factors,[17,40,71] making it possible to perform the second early surgical phase.[24]

The autograft is almost completely absorbed within six months, as evidenced by Starch-Jensen et al.[40] who found a significantly higher proportion of mineralised bone during the early healing phase, when the autograft was used as a

graft material (compared to several bone substitutes used alone or in combination with autologous bone). However, after a healing period of more than 9 months, no statistically significant differences were found between the different treatment modalities.[40]

Analysis of the literature does not allow us to glimpse scientific evidence to prove that the use of platelet-rich plasma (PRP) or platelet-rich fibrin (PRF) in sinus lift surgery has positive improvements in bone graft regeneration, especially in terms of clinical results and effectiveness. Finally, mixtures such as P-PRP plus with beta phase tricalcium phosphate (b-TCP) or PRF plus with b-TCP are not superior to b-TCP alone.[50,76–78] In the case of the use of cellular techniques of regenerative medicine, it is observed that the use of these promoters does not bring additional advantages[79]

The use of recombinant human growth factors is hitherto limited almost exclusively to recombinant human PDGF BB homodimer (rhPDGF-BB) and recombinant human bone morphogenetic protein 2 and 7 (rhBMPs2 and 7 and growth differentiation factor 5), and there is no evidence to support their use in maxillary sinus elevation procedures.[80] However, the use of rhBMPs-2 can improve and accelerate the maturation process.[81]

The patient's age is also a variable that affects bone formation. However, Wolf M.'s 2014[82] clinical trial did not show significant differences between age groups (group 1–41 and 52 years old; group 2– 66 and 71 years old).

It is possible to infer that bone substitute materials are as effective as autograft, when used alone or in combination with autologous bone, with an equivalent implant survival rate over an observation period of 5 years.[40,83] The use of bone substitutes is associated with advantages for the patient, which include reduced morbidity, a less invasive procedure and shorter surgical time.[40]

Postoperative radiological assessment

The radiological study using CT and CBCT is crucial for the study and planning of clinical cases and allows to measure changes at the bone level over time and the behaviour of biomaterials, ensuring the predictability of maxillary sinus elevation.[26,84–86] The use of 2D radiographs (orthopantomography and periapical radiographs) allows observing bone remineralisation.[87] Comparing the radiological results with studies that used different grafts, different results are found in the literature in terms of vertical gains, between 5.8 and 18.3 mm.[88–92] The average vertical gains observed in the 2016 Bayesian network study by Merli et al.[93] were 7.44 ± 1.95 mm. When interpreting these results, we infer that when using biomaterials, we are not dependent on the patient's bone availability or the collection technique used.

Increases in bone height that exceed the length of the implant to be placed result in increases that will not be used and that tend, over time, to reabsorb regardless of the graft used.[40,92]

The differences in bone height gain with the use of bone graft mixed with some type of cell growth promoter are not clinically relevant.[79,94] For example, the use of PRP did not positively influence the results in the 2016 Kiliç S and Güngörmüş M randomised clinical trial[95] when purchasing β-TCP +PRP and β-TCP.

Barrier membrane on the lateral wall

The placement of resorbable or non-resorbable barrier membranes on the later wall of the osteotomy at the end of the procedure for placing the graft material aims to help contain the graft, prevent soft tissue encapsulation, the invagination of connective tissue into the sinus jaw and increase the success rate of dental implants.[1] The membrane also prevents the passage of epithelial cells into the grafted area. Finally, the amount of vital bone can influence implant survival.[15,23,31,96,97]

This influence is evident in the 2013 Barone A. split-mouth clinical trial[98] that compared the effect of placing a collagen membrane on the sidewall versus do not place, filling both maxillary sinuses with porcine xenograft. The author[98] reported that in the group where a membrane was used on the side wall there was a mean percentage of smaller connective tissue (50.6% ± 18.7% vs. 59.3% ± 15.4%), a total percentage of larger bone (49.4% ± 18.7% vs. 40.7% ± 15.4%) and a percentage of residual graft also higher (18.4% ± 20.3% vs. 12, 6% ± 12.4%).

Implant success rates

The survival rates of the implants, in a first phase are closely linked to the realisation of a good surgical protocol and to a good primary stability when placing the implant. Over time, survival rates are mainly affected by smoking habits and pathologies that make patients immunocompromised (e.g. poorly controlled diabetes) and poor oral hygiene. For these reasons, control of risk factors and periodontal support treatment consultations are essential.[99,100] Marginal bone loss is intrinsically related to the type of prosthetic connection (in external connections it is greater), smoking habits and history of periodontitis, these being factors that negatively influenced the maintenance of the peri-implant bone.[101]

Evaluating the literature data on the implant survival rate after maxillary sinus graft by lateral osteotomy, different systematic reviews report average rates above 90% and present results similar to implants placed in native bone. These results are not influenced by the timing of implant loading since placing dental implants simultaneously or in a second surgical phase, does not demonstrate to have significant impact on the survival rate of dental implants.[1,17,96,102–104]

The graft material used does not appear to be a highly influential factor in the survival rate of dental implants, observing similar survival rates of the implants placed in the

maxillary sinuses that had been filled only with bone substitutes (96.1%) or when it was included autograft (95.8%).[17] The same is observed when using PRP as a supporting material for implant failure or complications.[105] When maxillary sinus elevations are performed with autologous iliac crest blocks, the survival rate is 83.5% and is reduced substantially to 78.7% when the implants are placed simultaneously.[17] Considering only studies with five or more years of follow-up, there is a 97% survival rate for implants with autograft grafting. 95% with bovine xenograft.[40]

Considering the time window in which dental implant failure occurs, it is observed that more than 80% of cases occur during the first 6 months of loading, 97.1% in the first year and that the late loss of implants (up to 2 years from connection) is significantly affected by bone quality.[102]

Another important factor is the roughness of the implant surface and its influence on the biomechanical quality of the osteointegrated bone. Implants with a rough surface show greater integration and resistance of bone contact when compared to smooth surface implants, with lower rates of survival when smooth-surface implants are used.[67,99]

The use of a membrane to cover the lateral window increases the survival rate of the implants. This trend is observed in the 98% success rate variation vs. 92.7%, when a membrane is not used.[17] It is important to note that the 2009 review by Jensen et al.[17] indicates that if studies using implants with smooth surfaces were excluded, the survival rates with and without the use of a membrane were almost identical.

CONCLUSIONS

The technique of elevating the maxillary sinus through a lateral window is a safe and well-documented technique in the literature, with high rates of survival and success of dental implants in the long term.

The commonest complication that occurs with this technique is the perforation of the *Schneider* membrane, which, depending on the extent of the rupture, can be repaired intrasurgically.

Simultaneous placement of dental implants should only be performed in cases where the bone height is greater than 5 mm, otherwise, a two-step technique should be chosen.

The use of different graft materials is well documented in the literature, but it is essential to bear in mind that the non-use of autograft increases the time of bone maturation. On the other hand, placing a membrane on the side wall increases the amount of vital bone and special attention should be paid to the different pathologies that may contraindicate this technique when carrying out the clinical history.

SUPPORTING INFORMATION

This work was supported by Portuguese funds through the Portuguese Foundation for Science and Technology (FCT), within the IEETA/UA project (UIDB/00127/2020, www.ieeta.pt) and by Portugal 2020 under the Competitiveness and Internationalization Operational Program.

CONFLICT OF INTEREST

The authors declare no conflict of interest, either directly or indirectly, in any of the products listed in the manuscript.

ORCID

Francisco Correia https://orcid.org/0000-0002-8215-4657
Sónia Gouveia https://orcid.org/0000-0002-0375-7610
Daniel H. Pozza https://orcid.org/0000-0002-2119-4479
António Campos Felino https://orcid.org/0000-0002-3429-062X
Ricardo Faria-Almeida https://orcid.org/0000-0001-9265-0913

REFERENCES

1. McAllister BS, Haghighat K. Bone augmentation techniques. J Periodontol. 2007;78:377–96.
2. Small SA, Zinner ID, Panno FV, Shapiro HJ, Stein JI. Augmenting the maxillary sinus for implants: report of 27 patients. Int J Oral Maxillofac Implants. 1993;8:523–8.
3. Jaffin RA, Berman CL. The excessive loss of Branemark fixtures in type IV bone: a 5-year analysis. J Periodontol. 1991;62:2–4.
4. Lekholm U, Zarb GA. Patient selecion. In: Branemark P-I, Zarb GA, Albrektsson T eds. Tissue Integrated Prsotheses. Chicago: Quibtessence, 1985: 199-209.
5. Sanz M, Donos N, Alcoforado G, Balmer M, Gurzawska K, Mardas N, et al. Therapeutic concepts and methods for improving dental implant outcomes. Summary and consensus statements. The 4th EAO Consensus Conference 2015. Clin Oral Implant Res. 2015;11:202–6.
6. Rao GS, Reddy SK. Antral balloon sinus elevation and grafting prior to dental implant placement: review of 34 cases. Int J Oral Maxillofac Implant. 2014;29:414–8.
7. Schincaglia GP, Thoma DS, Haas R, Tutak M, Garcia A, Taylor TD, et al. Randomized controlled multicenter study comparing short dental implants (6 mm) versus longer dental implants (11–15 mm) in combination with sinus floor elevation procedures. Part 2: clinical and radiographic outcomes at 1 year of loading. J Clin Periodontol. 2015;42:1042–51.
8. Aparicio C, Manresa C, Francisco K, Claros P, Alández J, González-Martín O, et al. Zygomatic implants: indications, techniques and outcomes, and the zygomatic success code. Periodontol. 2000;2014:41–58.
9. Chrcanovic BR, Albrektsson T, Wennerberg A. Survival and complications of zygomatic implants: an updated systematic review. J Oral Maxillofac Surg. 2016;74:1949–64.
10. Tatum H Jr. Maxillary and sinus implant reconstructions. Dent Clin North Am. 1986;30:207–29.
11. Boyne PJ, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone. J Oral Surgery (American Dental Association 1965). 1980;38:613–6.
12. Urban IA, Monje A, Lozada JL, Wang HL. Long-term evaluation of peri-implant bone level after reconstruction of severely atrophic edentulous maxilla via vertical and horizontal guided bone regeneration in combination with sinus augmentation: a case series with 1 to 15 years of loading. Clin Implant Dent Relat Res. 2017;19:46–55.
13. Li J, Wang HL. Common implant-related advanced bone grafting complications: classification, etiology, and management. Implant Dent. 2008;17:389–401.
14. van den Bergh JP, ten Bruggenkate CM, Disch FJ, Tuinzing DB. Anatomical aspects of sinus floor elevations. Clin Oral Implants Res. 2000;11:256–65.

15. Gandhi Y. Sinus grafts: science and techniques-then and now. J Maxillofac Oral Surg. 2017;16:135–44.
16. Raja SV. Management of the posterior maxilla with sinus lift: review of techniques. J Oral Maxillofac Surg. 2009;67:1730–4.
17. Jensen SS, Terheyden H. Bone augmentation procedures in localized defects in the alveolar ridge: clinical results with different bone grafts and bone-substitute materials. Int J Oral Maxillofac Implants 2009;24(Suppl):218–36.
18. Peleg M, Garg AK, Mazor Z. Predictability of simultaneous implant placement in the severely atrophic posterior maxilla: A 9-year longitudinal experience study of 2132 implants placed into 731 human sinus grafts. Int J Oral Maxillofac Implants. 2006;21:94–102.
19. Phothikhun S, Suphanantachat S, Chuenchompoonut V, Nisapakultorn K. Cone-beam computed tomographic evidence of the association between periodontal bone loss and mucosal thickening of the maxillary sinus. J Periodontol. 2012;83:557–64.
20. Sugerman PB, Barber MT. Patient selection for endosseous dental implants: oral and systemic considerations. Int J Oral Maxillofac Implants. 2002;17:191–201.
21. Sezavar M, Mesgarzadeh V, Shafayifard S, Soleimanpour MR. Management of Bone Grafting Complications in Advanced Implant Surgery. 2015.
22. Sakkas A, Schramm A, Winter K, Wilde F. Risk factors for postoperative complications after procedures for autologous bone augmentation from different donor sites. J CraniomaxilloFac Surg. 2018;46:312–22.
23. Tasoulis G, Yao SG, Fine JB. The maxillary sinus: challenges and treatments for implant placement. Compendium of continuing education in dentistry (Jamesburg, NJ : 1995). Compend Contin Educ Dent. 2011;32:10-4, 16, 18-19; quiz 20, 34.
24. Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. Int J Oral Maxillofac Implants 2009;24(Suppl):237–59.
25. Monje A, Catena A, Monje F, Gonzalez-García R, Galindo-Moreno P, Suarez F, et al. Maxillary sinus lateral wall thickness and morphologic patterns in the atrophic posterior maxilla. J Periodontol. 2014;85:676–82.
26. Correia F, Salgado A. Tomografia computorizada cone-beam e a sua aplicação em medicina dentária. Rev Port Estomatol Med Cir Maxilofac. 2012;53:47–52.
27. Nicolielo LF, Van Dessel J, Jacobs R, Martens W, Lambrichts I, Rubira-Bullen IR. Presurgical CBCT assessment of maxillary neurovascularization in relation to maxillary sinus augmentation procedures and posterior implant placement. Surg Radiol Anat. 2014;36:915–24.
28. Lee JE, Jin SH, Ko Y, Park JB. Evaluation of anatomical considerations in the posterior maxillae for sinus augmentation. World J Clin Cases. 2014;2:683–8.
29. Purcz NM, Birkenfeld F, Oetke M, Will M, Purcz L, Gaßling V, et al. Increased infection rates of sinus floor elevations after the use of a bone filter. Clin Oral Invest. 2015;19:1115–9.
30. Dragan E, Odri GA, Melian G, Haba D, Olszewski R. Three-dimensional evaluation of maxillary sinus septa for implant placement. Med Sci Monit. 2017;23:1394–400.
31. Danesh-Sani SA, Loomer PM, Wallace SS. A comprehensive clinical review of maxillary sinus floor elevation: anatomy, techniques, biomaterials and complications. The British journal of oral & maxillofacial surgery. 2016;54:724–30.
32. Yang SM, Park SI, Kye SB, Shin SY. Computed tomographic assessment of maxillary sinus wall thickness in edentulous patients. J Oral Rehabil. 2012;39:421–8.
33. Tadinada A, Jalali E, Al-Salman W, Jambhekar S, Katechia B, Almas K. Prevalence of bony septa, antral pathology, and dimensions of the maxillary sinus from a sinus augmentation perspective: a retrospective cone-beam computed tomography study. Imaging science in dentistry. 2016;46:109–15.
34. Ghasemi S, Fotouhi A, Moslemi N, Chinipardaz Z, Kolahi J, Paknejad M. Intra- and postoperative complications of lateral maxillary sinus augmentation in smokers vs nonsmokers: a systematic review and meta-analysis. Int J Oral Maxillofac Implants. 2017;32:759–67.
35. de Almeida Ferreira C, Martinelli C, Novaes A, Pignaton T, Guignone C, de Almeida A, et al. Effect of maxillary sinus membrane perforation on implant survival rate: a retrospective study. Int J Oral Maxillofac Implants. 2017;32:401–7.
36. Al-Dajani M. Incidence, risk factors, and complications of schneiderian membrane perforation in sinus lift surgery: a meta-analysis. Implant Dent. 2016;25:409–15.
37. Nolan PJ, Freeman K, Kraut RA. Correlation between Schneiderian membrane perforation and sinus lift graft outcome: a retrospective evaluation of 359 augmented sinus. J Oral Maxillofac Surg. 2014;72:47–52.
38. Fugazzotto P, Melnick PR, Al-Sabbagh M. Complications when augmenting the posterior maxilla. Dent Clin North Am. 2015;59:97–130.
39. Uribarri A, Bilbao E, Marichalar-Mendia X, Martinez-Conde R, Aguirre JM, Verdugo F. Bone remodeling around implants placed in augmented sinuses in patients with and without history of periodontitis. Clin Implant Dent Relat Res. 2017;19:268–79.
40. Starch-Jensen T, Aludden H, Hallman M, Dahlin C, Christensen AE, Mordenfeld A. A systematic review and meta-analysis of long-term studies (five or more years) assessing maxillary sinus floor augmentation. Int J Oral Maxillofac Surg. 2018;47:103–16.
41. Barone A, Santini S, Sbordone L, Crespi R, Covani U. A clinical study of the outcomes and complications associated with maxillary sinus augmentation. Int J Oral Maxillofac Implants. 2006;21:81–5.
42. Nkenke E, Stelzle F. Clinical outcomes of sinus floor augmentation for implant placement using autogenous bone or bone substitutes: a systematic review. Clin Oral Implants Res. 2009;20(Suppl 4):124–33.
43. Barone A, Crespi R, Aldini NN, Fini M, Giardino R, Covani U. Maxillary sinus augmentation: histologic and histomorphometric analysis. Int J Oral Maxillofac Implants 2005;20:519–25.
44. Danesh-Sani SA, Movahed A, ElChaar ES, Chong Chan K, Amintavakoli N. Radiographic evaluation of maxillary sinus lateral wall and posterior superior alveolar artery anatomy: a cone-beam computed tomographic study. Clin Implant Dent Relat Res. 2017;19:151–60.
45. Makary C, Rebaudi A, Menhall A, Naaman N. Changes in sinus membrane thickness after lateral sinus floor elevation: a radiographic study. Int J Oral Maxillofac Implants. 2016;31:331–7.
46. Chen Y-W, Lee F-Y, Chang P-H, Huang C-C, Fu C-H, Huang C-C, et al. A paradigm for evaluation and management of the maxillary sinus before dental implantation. Laryngoscope. 2018;128:1261–7.
47. Kayabasoglu G, Nacar A, Altundag A, Cayonu M, Muhtarogullari M, Cingi C. A retrospective analysis of the relationship between rhinosinusitis and sinus lift dental implantation. Head Face Med. 2014;10:53.
48. Ata-Ali J, Diago-Vilalta JV, Melo M, Bagan L, Soldini MC, Di-Nardo C, et al. What is the frequency of anatomical variations and pathological findings in maxillary sinuses among patients subjected to maxillofacial cone beam computed tomography? A systematic review. Med Oral Patol Oral Cir Bucal. 2017;22:e400–9.
49. Shiffler K, Lee D, Aghaloo T, Moy PK, Pi-Anfruns J. Sinus membrane perforations and the incidence of complications: a retrospective study from a residency program. Oral Surg Oral Med Oral Pathol Oral Radiol. 2015;120:10–4.
50. Al-Dajani M. Recent trends in sinus lift surgery and their clinical implications. Clin Implant Dent Relat Res. 2016;18:204–12.
51. Monje A, Diaz KT, Aranda L, Insua A, Garcia-Nogales A, Wang HL. Schneiderian membrane thickness and clinical implications for sinus augmentation: a systematic review and meta-regression analyses. J Periodontol. 2016;87:888–99.
52. Wen SC, Chan HL, Wang HL. Classification and management of antral septa for maxillary sinus augmentation. Int J Periodontics Restorative Dent. 2013;33:509–17.

53. Insua A, Monje A, Urban I, Kruger L, Garaicoa-Pazmiño C, Sugai J, et al. The sinus membrane-maxillary lateral wall complex: histologic description and clinical implications for maxillary sinus floor elevation. Int J Periodontics Restorative Dent. 2017;37:e328–36.
54. Kim M-J, Jung U-W, Kim C-S, Kim K-D, Choi S-H, Kim C-K, et al. Maxillary sinus septa: prevalence, height, location, and morphology. A reformatted computed tomography scan analysis. J Periodontol. 2006;77:903–8.
55. Lum AG, Ogata Y, Pagni SE, Hur Y. Association between sinus membrane thickness and membrane perforation in lateral window sinus augmentation: a retrospective study. J Periodontol. 2017;88:543–9.
56. Froum SJ, Khouly I, Favero G, Cho SC. Effect of maxillary sinus membrane perforation on vital bone formation and implant survival: a retrospective study. J Periodontol. 2013;84:1094–9.
57. Carini F, Saggese V, Porcaro G, Baldoni M. Piezolelectric surgery in dentistry: a review. Minerva Stomatol. 2014;63:7–34.
58. Covani U, Barone A, Cornelini R, Crespi R. Clinical outcome of implants placed immediately after implant removal. J Periodontol. 2006;77:722–7.
59. Vercellotti T, De Paoli S, Nevins M. The piezoelectric bony window osteotomy and sinus membrane elevation: introduction of a new technique for simplification of the sinus augmentation procedure. Int J Periodontics Restorative Dent. 2001;21:561–7.
60. Wallace SS, Mazor Z, Froum SJ, Cho SC, Tarnow DP. Schneiderian membrane perforation rate during sinus elevation using piezosurgery: clinical results of 100 consecutive cases. Int J Periodontics Restorative Dent. 2007;27:413–9.
61. Stacchi C, Lombardi T, Cusimano P, Berton F, Lauritano F, Cervino G, et al. Bone scrapers versus piezoelectric surgery in the lateral antrostomy for sinus floor elevation. The Journal of craniofacial surgery. 2017;28:1191–6.
62. Delilbasi C, Gurler G. Comparison of piezosurgery and conventional rotative instruments in direct sinus lifting. Implant Dent. 2013;22:662–5.
63. Geminiani A, Tsigarida A, Chochlidakis K, Papaspyridakos PV, Feng C, Ercoli C. A meta-analysis of complications during sinus augmentation procedure. Quintessence Int. 2017;48:231–40.
64. Barone A, Santini S, Marconcini S, Giacomelli L, Gherlone E, Covani U. Osteotomy and membrane elevation during the maxillary sinus augmentation procedure. A comparative study: piezoelectric device vs. conventional rotative instruments. Clin Oral Implants Res. 2008;19:511–5.
65. Correia F, Faria Almeida R, Lemos Costa A, Carvalho J, Felino A. Levantamento do seio maxilar pela técnica da janela lateral: tipos enxertos. Rev Port Estomatol Med Cir Maxilofac. 2012;53:190–6.
66. Wood RM, Moore DL. Grafting of the maxillary sinus with intraorally harvested autogenous bone prior to implant placement. Int J Oral Maxillofac Implants. 1988;3:209–14.
67. Pjetursson BE, Tan WC, Zwahlen M, Lang NP. A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. J Clin Periodontol. 2008;35:216–40.
68. Esposito M, Felice P, Worthington HV. Interventions for replacing missing teeth: augmentation procedures of the maxillary sinus. Cochrane Database Syst Rev. 2014;5:CD008397.
69. Kolerman R, Nissan J, Rahmanov M, Vered H, Cohen O, Tal H. Comparison between mineralized cancellous bone allograft and an alloplast material for sinus augmentation: a split mouth histomorphometric study. Clin Implant Dent Relat Res. 2017;19:812–20.
70. Barone A, Ricci M, Covani U, Nannmark U, Azarmehr I, Calvo-Guirado JL. Maxillary sinus augmentation using prehydrated corticocancellous porcine bone: hystomorphometric evaluation after 6 months. Clin Implant Dent Relat Res. 2012;14:373–9.
71. Corbella S, Taschieri S, Weinstein R, Del Fabbro M. Histomorphometric outcomes after lateral sinus floor elevation procedure: a systematic review of the literature and meta-analysis. Clin Oral Implants Res. 2016;27:1106–22.
72. Silvestri M, Martegani P, D'Avenia F, Farneti M, Capri D, Paolantoni G, et al. Simultaneous sinus augmentation with implant placement: histomorphometric comparison of two different grafting materials. A multicenter double-blind prospective randomized controlled clinical trial. Int J Oral Maxillofac Implants. 2013;28:543–9.
73. Yip I, Ma L, Mattheos N, Dard M, Lang NP. Defect healing with various bone substitutes. Clin Oral Implants Res. 2015;26:606–14.
74. Ramirez-Fernandez MP, Calvo-Guirado JL, Mate-Sanchez Del Val JE, Delgado-Ruiz RA, Negri B, Barona-Dorado C. Ultrastructural study by backscattered electron imaging and elemental microanalysis of bone-to-biomaterial interface and mineral degradation of porcine xenografts used in maxillary sinus floor elevation. Clin Oral Implants Res. 2013;24:523–30.
75. Galindo-Moreno P, de Buitrago JG, Padial-Molina M, Fernandez-Barbero JE, Ata-Ali J, O'Valle F. Histopathological comparison of healing after maxillary sinus augmentation using xenograft mixed with autogenous bone versus allograft mixed with autogenous bone. Clin Oral Implants Res. 2018;29:192–201.
76. Lemos CA, Mello CC, dos Santos DM, Verri FR, Goiato MC, Pellizzer EP. Effects of platelet-rich plasma in association with bone grafts in maxillary sinus augmentation: a systematic review and meta-analysis. Int J Oral Maxillofac Surg. 2016;45:517–25.
77. Comert Kilic S, Gungormus M, Parlak SN. Histologic and histomorphometric assessment of sinus-floor augmentation with beta-tricalcium phosphate alone or in combination with pure-platelet-rich plasma or platelet-rich fibrin: a randomized clinical trial. Clin Implant Dent Relat Res. 2017;19:959–67.
78. Pocaterra A, Caruso S, Bernardi S, Scagnoli L, Continenza MA, Gatto R. Effectiveness of platelet-rich plasma as an adjunctive material to bone graft: a systematic review and meta-analysis of randomized controlled clinical trials. Int J Oral Maxillofac Surg. 2016;45:1027–34.
79. Correia F, Pozza DH, Gouveia S, Felino A, Faria EAR. The applications of regenerative medicine in sinus lift procedures: a systematic review. Clin Implant Dent Relat Res. 2017;20:229–42.
80. Schliephake H. Clinical efficacy of growth factors to enhance tissue repair in oral and maxillofacial reconstruction: a systematic review. Clin Implant Dent Relat Res. 2015;17:247–73.
81. Gomes-Ferreira PH, Okamoto R, Ferreira S, De Oliveira D, Momesso GA, Faverani LP. Scientific evidence on the use of recombinant human bone morphogenetic protein-2 (rhBMP-2) in oral and maxillofacial surgery. Oral and maxillofacial surgery. 2016;20:223–32.
82. Wolf M, Wurm A, Heinemann F, Gerber T, Reichert C, Jäger A, et al. The effect of patient age on bone formation using a fully synthetic nanocrystalline bone augmentation material in maxillary sinus grafting. Int J Oral Maxillofac Implants. 2014;29:976–83.
83. Pilipchuk SP, Plonka AB, Monje A, Taut AD, Lanis A, Kang B, et al. Tissue engineering for bone regeneration and osseointegration in the oral cavity. Dent Mat. 2015;31:317–38.
84. Iezzi G, Piattelli A, Giuliani A, Mangano C, Manzon L, Degidi M, et al. Molecular, cellular and pharmaceutical aspects of bone grafting materials and membranes during maxillary sinus-lift procedures. Part 1: a general overview. Curr Pharm Biotechnol. 2017;18:19–32.
85. Soardi CM, Suarez-Lopez del Amo F, Galindo-Moreno P, Catena A, Zaffe D, Wang HL. Reliability of cone beam computed tomography in determining mineralized tissue in augmented sinuses. Int J Oral Maxillofac Implants. 2016;31:352–8.
86. Mazzocco F, Lops D, Gobbato L, Lolato A, Romeo E, del Fabbro M. Three-dimensional volume change of grafted bone in the maxillary sinus. Int J Oral Maxillofac Implants. 2014;29:178–84.
87. Andreasi Bassi M, Lopez MA, Confalone L, Carinci F. Hydraulic sinus lift technique in future site development: clinical and histomorphometric analysis of human biopsies. Implant Dent. 2015;24:117–24.
88. Pagliani L, Andersson P, Lanza M, Nappo A, Verrocchi D, Volpe S, et al. A collagenated porcine bone substitute for augmentation

at Neoss implant sites: a prospective 1-year multicenter case series study with histology. Clin Implant Dent Relat Res. 2012;14:746–58.
89. Mangano C, Sinjari B, Shibli JA, Mangano F, Hamisch S, Piattelli A, et al. A human clinical, histological, histomorphometrical, and radiographical study on biphasic HA-Beta-TCP 30/70 in maxillary sinus augmentation. Clin Implant Dent Relat Res. 2015;17:610–8.
90. Sverzut AT, Rodrigues DC, Lauria A, Armando RS, de Oliveira PT, Moreira RW. Clinical, radiographic, and histological analyses of calcium phosphate cement as filling material in maxillary sinus lift surgery. Clin Oral Implants Res. 2015;26:633–8.
91. Panagiotou D, Ozkan Karaca E, Dirikan Ipci S, Cakar G, Olgac V, Yilmaz S. Comparison of two different xenografts in bilateral sinus augmentation: radiographic and histologic findings. Quintessence Int. 2015;46:611–9.
92. Mordenfeld A, Lindgren C, Hallman M. Sinus floor augmentation using Straumann(R) BoneCeramic and Bio-Oss(R) in a split mouth design and later placement of implants: a 5-Year report from a longitudinal study. Clin Implant Dent Relat Res. 2016;18:926–36.
93. Merli M, Moscatelli M, Mariotti G, Pagliaro U, Bernardelli F, Nieri M. A minimally invasive technique for lateral maxillary sinus floor elevation: a Bayesian network study. Clin Oral Implants Res. 2016;27:273–81.
94. Kelly MP, Vaughn OL, Anderson PA. Systematic review and meta-analysis of recombinant human bone morphogenetic protein-2 in localized alveolar ridge and maxillary sinus augmentation. J Oral Maxillofac Surg. 2016;74:928–39.
95. Kilic SC, Gungormus M. Cone beam computed tomography assessment of maxillary sinus floor augmentation using beta-tricalcium phosphate alone or in combination with platelet-rich plasma: a randomized clinical trial. Int J Oral Maxillofac Implants. 2016;31:1367–75.
96. Wallace SS, Froum SJ. Effect of maxillary sinus augmentation on the survival of endosseous dental implants. A systematic review. Ann Periodontol. 2003;8:328–43.
97. Iezzi G, Piattelli A, Giuliani A, Mangano C, Barone A, Manzon L, et al. Molecular, cellular and pharmaceutical aspects of bone grafting materials and membranes during maxillary sinus-lift procedures. Part 2: detailed characteristics of the materials. Curr Pharm Biotechnol. 2017;18:33–44.
98. Barone A, Ricci M, Grassi RF, Nannmark U, Quaranta A, Covani U. A 6-month histological analysis on maxillary sinus augmentation with and without use of collagen membranes over the osteotomy window: randomized clinical trial. Clin Oral Implants Res. 2013;24:1–6.
99. Javed F, Romanos GE. Role of implant diameter on long-term survival of dental implants placed in posterior maxilla: a systematic review. Clin Oral Invest. 2015;19:1–10.
100. Correia F, Gouveia S, Felino AC, Costa AL, Almeida RF. Survival rate of dental implants in patients with history of periodontal disease: a retrospective cohort study. Int J Oral Maxillofac Implants. 2017;32:927–34.
101. Galindo-Moreno P, Fernandez-Jimenez A, Avila-Ortiz G, Silvestre FJ, Hernandez-Cortes P, Wang HL. Marginal bone loss around implants placed in maxillary native bone or grafted sinuses: a retrospective cohort study. Clin Oral Implants Res. 2014;25:378–84.
102. Traini T, Piattelli A, Caputi S, Degidi M, Mangano C, Scarano A, et al. Regeneration of human bone using different bone substitute biomaterials. Clin Implant Dent Relat Res. 2015;17:150–62.
103. Del Fabbro M, Testori T, Francetti L, Weinstein R. Systematic review of survival rates for implants placed in the grafted maxillary sinus. Int J Periodontics Restorative Dent. 2004;24:565–77.
104. Aghaloo TL, Misch C, Lin GH, Iacono VJ, Wang HL. Bone augmentation of the edentulous maxilla for implant placement: a systematic review. Int J Oral Maxillofac Implants. 2016;31(Suppl):s19–30.
105. Abdalla RIB, Alqutaibi AY, Kaddah A. Does the adjunctive use of platelet-rich plasma to bone graft during sinus augmentation reduce implant failure and complication? Systematic review and meta-analysis. Quintessence Int. 2018;49:139–46.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Correia F, Gouveia S, Pozza DH, Campos Felino A, Faria-Almeida R. Lateral window technique: A focus review. Oral Surg. 2021;00:1–10. https://doi.org/10.1111/ors.12649