One-stage approach to implant placement in the posterior atrophic maxilla: a review of the literature

Nadim Sleman[1*]
Ali Khalil[2]

[1] Oral and maxillofacial surgery department, Tishreen University, Latakia, Syria
[2] Head of oral and maxillofacial surgery department, Tishreen University, Latakia, Syria

Corresponding author: Nadim Sleman
e-mail: nfs.nadim@gmail.com

Abstract

Rehabilitating the posterior atrophic maxilla presents a significant challenge due to the need to create sufficient bone volume for implant placement. The amount of existing bone height is critical in deciding between a one-stage or two-stage lateral sinus lift procedure. This review investigates the feasibility of implant placement in the atrophic maxilla during simultaneous maxillary sinus floor augmentation, focusing on implant survival rates, particularly when the bone height is less than 5 mm. By analyzing implant survival rates in this specific scenario, this comprehensive review contributes to the understanding of successful implant integration in the posterior atrophic maxilla.

Keywords: Dental implants, Maxillary floor elevation, Lateral sinus floor elevation, Survival rate, One-stage implant placement.

Introduction

Insufficient bone volume in the posterior maxilla is a common anatomical limitation for implant placement. This bone loss significantly impacts the selection of the most suitable rehabilitation method for edentulous patients. While removable prostheses can serve as a treatment option for posterior edentulism, studies have shown that this approach can negatively affect masticatory function and potentially compromise the prognosis of adjacent teeth when compared to implant-supported rehabilitations. (1,2)
The placement of dental implants in the posterior maxilla poses a significant challenge due to the frequent occurrence of vertical bone height reduction. This reduction is often attributed to pneumatization of the maxillary sinus, the natural process of aging, and early tooth loss. The presence of D4 bone quality in this region further exacerbates the difficulty. To address these challenges, a range of treatment modalities are available, tailored to the specific degree of bone atrophy. These include sinus augmentation, indirect sinus lifts, short implant placement, vertical alveolar ridge regeneration, and the utilization of alternative implant sites such as the tuberosity, pterygoid process, zygoma, or placement of tilted implants. (3)
The sinus floor elevation procedure using the standard lateral approach was developed in the late 1970s to create a suitable environment for implant placement. This technique, initially introduced by Tatum, was later refined by Boyne and James, as well as Wood and Moore. (4,5)
To restore bone volume in the atrophied posterior maxilla, a sinus lift procedure is performed by elevating the sinus membrane and using bone grafts to maintain the space, facilitating bone regeneration according to the principles of guided bone regeneration (GBR). (6)
According to the principles of guided bone regeneration, during the sinus lift procedure, the bone graft serves as a space holder beneath the elevated sinus membrane (6). This biological insight underscores the significance of the graft material's osteoconductive properties in the sinus lift process. The osteogenic source for bone healing originates from two anatomical areas: the basal bone of the sinus cavity and the periosteum,

How to Cite

N. Sleman, A. Khalil.
One-stage approach to implant placement in the posterior atrophic maxilla: a review of the literature.
Oral and Implantology
Vol. 17 No. 1 (2025), 60-66.
DOI: 10.11138/oi.v17i1.66

which is the basal cell layer of the Schneiderian membrane. In line with this biological principle, Mish developed a classification for treating the edentulous posterior maxilla based on the available bone beneath the antrum and the width of the ridge. (7)

This classification, which assesses the ability to stabilize the implant during the initial surgery, outlines three treatment options. Clinically, a minimum native bone crest height of 3mm is required for a one-stage procedure. The choice between one- or two-stage techniques depends on the residual bone available and the potential for achieving primary stability. A one-stage technique using either a lateral or transalveolar approach is recommended for higher crests, while a two-stage technique with a lateral window approach is suggested for lower crests, with implant placement occurring after a healing period. Severely resorbed maxillae pose significant challenges for bone regeneration and implant success, as studies indicate less than 10% bone regeneration (8) and a 5–20% risk of implant failure even with autogenous bone grafts.(9)

Several techniques have been developed to achieve adequate bone dimensions for implant placement in the atrophic posterior maxilla (10,11). Recent advancements in surgical techniques and biomaterials have led to excellent outcomes for implant-supported restorations. (12-14)

Sinus floor augmentation procedures have consistently demonstrated high implant survival rates exceeding 90%, as confirmed by recent systematic reviews. (15-17) However, pre-existing sinus conditions may require ENT (ear, nose, and throat) specialist evaluation, and complications like membrane perforation, bleeding, and post-operative discomfort can occur, particularly with lateral approaches. (18,19)

Studies suggest a minimum bone height of 4-5 mm is needed for immediate implant placement in the same surgery of sinus lifting (20-23). This is supported by Geurs et al. (2001), who found significantly higher implant loss rates when residual bone height was 4 mm or less compared to 5 mm or greater (24).

This comprehensive review aimed to assess the efficacy of a **one-stage surgical procedure** for implant placement in maxillary sinus floor augmentation and to examine implants survival rates, focusing on cases with an average residual bone height of 5 mm or less.

Methods

This comprehensive review encompassed human studies published across all years and sourced from various databases, including MEDLINE-PubMed, Google Scholar, and ScienceDirect. The search strategy also involved manually reviewing the reference lists of all selected full-text articles. The search utilized relevant keywords and focused on English-language publications.

This review included studies examining one-stage maxillary sinus floor augmentation (MSFA) and implant placement in cases of atrophic posterior maxilla with a vertical bone height of 5 mm or less. The selection process prioritized studies that defined implant survival rates. All study designs were considered, including prospective, retrospective, and randomized controlled trials (RCTs) (Table 1).

Evolution of maxillary sinus floor augmentation

Maxillary sinus floor augmentation (MSFA), also known as sinus floor elevation, has become a standard procedure for addressing bone loss in the posterior maxilla. This technique allows for the placement of dental implants in areas where bone has been compromised due to sinus pneumatization, alveolar bone atrophy, or trauma. Hilt Tatum's pioneering work in the 1970s (25) established the concept of using the maxillary sinus cavity to increase bone volume with graft materials, leading to greater implant-to-bone contact once the graft matures. While the initial procedure described by Boyne and James (5) differed from current practices, it laid the foundation for modern MSFA techniques. Since then, a vast body of research has emerged exploring various grafting materials and modifications to the procedure (26,27).

The maxillary sinus, which is the largest paranasal sinus, is a pyramid-shaped cavity with average dimensions of 36-45 mm in height, 23-25 mm in width, and 38-45 mm in length. Its volume averages 15 ml (28).

The sinus's anterior wall extends from the inferior orbital rim to the maxillary alveolar process, containing the infraorbital neurovascular bundle. The thin superior wall forms the floor of the orbit. The posterior wall separates the sinus from the pterygopalatine fossa, which houses the posterior superior alveolar nerve and blood vessels, the pterygoid plexus of veins, and the internal maxillary artery.

The medial wall, the lateral wall of the nasal cavity, contains the primary ostium, the main drainage channel for sinus secretions. The lateral wall, forming the buccal aspect of the sinus, contributes to the posterior maxillary and zygomatic processes and provides access for lateral wall sinus graft procedures.

Maxillary sinus septa, first described by Underwood in 1910 (29), can be classified as primary (formed during maxillary and teeth development) or secondary (acquired after tooth loss) (30). Most septa are located between the second premolar and first molar (31) and can complicate sinus augmentation procedures. If a septum fully divides the sinus, multiple lateral windows are created during sinus opening to bypass the septum (32).

The maxillary sinus is lined by the Schneiderian membrane, a pseudostratified columnar respiratory epithelium with cilia. This membrane, typically 0.13-0.5 mm thick, is composed of basal, columnar, and goblet cells.(33) It must be fully detached from the sinus floor for successful elevation. However, the distal portion of the sinus can extend significantly. (34)

Sinus membrane perforation risk is related to the angle between the lateral and medial walls. Angles greater than 60° have no perforation risk, while angles between 30° and 60° have a 28.6% risk, and angles less than 30° have a 62.5% risk. (35) Overfilling the sinus with graft material can lead to membrane necrosis, sinusitis, and graft loss.

Table 1. Study and patient characteristics of the included studies.

Author, year	Study design	Group treatment	Number of patients	Number of implants	Survived implants	Failed implants	Grafting material	Mean follow-up	Success/survival rate
Pistilli et al. 2022 (43)	PROSPECTIVE COHORT STUDY	SFE and simultaneous implant placement	43	113	113	0	MP3, Heterologous cortico-cancellous bone mix	5.11year (SD: 2.47	100%
Felice et al. 2013 (44)	Randomized controlled trial	SFE and simultaneous implant placement	30	30	27	3	bone substitute	4months	90%
		SFE and delayed implant placement	30	30	29	1			96.6%
Simonpieri et al, 2011 (53)	PROSPECTIVE COHORT STUDY	SFE and simultaneous implant placement	20	52	52	0	L-PRF CLOTS	72 (24-72) months	100%
Canullo et al, 2012 (54)	PROSPECTIVE COHORT STUDY	SFE and simultaneous implant placement	30	67	65	2	HA + SILICE GEL (nanobone)	24 months	97,01 %
Manso et al, 2010 (48)	PROSPECTIVE COHORT STUDY	1 group: autogenous bone and bioactive resorbable graft	45	160	158	2	autogenenous (retromolar)+ (syntetic bioactive resorbable graft)	61,7 (20-132) months	98%
Rodriguez et al, 2003 (55)	PROSPECTIVE COHORT STUDY	SFE and simultaneous implant placement	15	70	65	5	DPBB+ PRP	6-36 months	92.9%
Mendonca-Caridad et al, 2013 (52)	Controlled clinical trial	SFE and simultaneous implant placement	15	46	44	2	calvaria+ PRP+B-TCP	12,8 months	95.7%

The maxillary premolars and molars have a close relationship with the sinus, with molar roots being closer than premolar roots. (36) The mesiobuccal root apex of the second molar is closest to the sinus wall (average 0.83 mm), while the lingual root apex of the first premolar is furthest. (37)

The maxillary sinus receives blood supply from branches of the maxillary artery, including the infraorbital, posterior lateral nasal, and posterior superior alveolar arteries. The greater palatine artery may also contribute to the inferior portion. (38) The lateral wall is supplied by the infraorbital and posterior superior alveolar arteries, while the medial wall receives blood from the posterior lateral nasal artery.

The lateral wall features both extraosseous (buccal tissues) and intraosseous (buccal bone plate) anastomoses between the infraorbital and posterior superior alveolar arteries. The extraosseous anastomosis, located around 23–26 mm from the ridge, can cause bleeding during flap preparation. The intraosseous anastomosis, approximately 16–19 mm from the ridge, may appear as a radiolucency on CBCT scans. This intraosseous vessel must be considered during lateral window preparation to avoid excessive bleeding. (39)

The selection of a maxillary sinus elevation and augmentation technique is influenced by both the surgeon's preference and the patient's individual anatomy. Factors such as the remaining bone height and the desired amount of lift play a significant role in this decision. Thus, the decision of selecting direct approach is related to lower alveolar bone height.

Two primary approaches exist: Direct and Indirect. (40) The direct approach utilizes a lateral window technique. Indirect approaches include:

1. Osteotome sinus floor elevation
2. Bone added sinus floor elevation
3. Minimally invasive transalveolar sinus approach
4. Antral membrane balloon elevation

The direct/lateral window technique involves direct visualization and instrumentation of the sinus membrane through an opening in the maxillary sinus's lateral wall.

Steps of the Technique:

1. **Anesthesia**: Starting with infraorbital, posterior superior alveolar, and greater palatine nerve blocks, along with subperiosteal anesthesia via slow infiltration (1 ml/min).
2. **Incision**: By creating a soft-tissue incision at least 10-15 mm anterior to the sinus wall, followed by a mid-crestal incision using a 15C blade. Then, raising a full-thickness flap to access the canine fossa, zygomatic arch, and posterior maxillary wall while ensuring the periosteum remains intact.
3. **Lateral Window/Antrostomy**: A specific outline of the window on the buccal bone is planned based on the sinus and implant requirements (typically 20 mm mesiodistally and 15 mm apicocoronally). A high-speed handpiece is used to create the window, avoiding sharp edges. Depending on access, the antrostomy may be elevated or removed entirely.
4. **Sinus Membrane Elevation**: By carefully detaching and elevating the sinus membrane using blunt instruments and curettes, ensuring integrity by monitoring the membrane during patient breathing.
5. **Implant Site Preparation**: If 3-4 mm of quality residual bone is present, implants can be placed immediately; otherwise, delayed placement of implants 4-6 months after MSFA. Undersized osteotomy is used to protect the sinus membrane.
6. **Graft Placement**: The sinus membrane is protected with a collagen membrane, then the graft is filled in the least accessible areas first, ensuring not to compact tightly to allow for vascularization. Platelet-rich fibrin may also be used as a grafting material.
7. **Membrane Placement**: A resorbable membrane is placed over the window, which adheres without the need for fixation screws.
8. **Suturing**: The incision is closed with nonresorbable monofilament sutures and horizontal mattress sutures.

The efficacy of different surgical approaches (two-stage vs. one-stage)

Many studies have evaluated the results of two-stage surgical approaches to restore lost teeth in the posterior atrophic maxilla, achieving good results despite the time required for bone graft maturation. A retrospective study by Friberg et al. (2016) (41) evaluated the clinical and radiographic outcomes of a two-stage surgical technique involving lateral sinus floor elevation using bovine bone (BioOss®) and subsequent implant placement. The study concluded that the implant survival rate was 99.0% considering those engaging BioOss®.

Some attempts to shorten treatment time evaluated both immediate and delayed implant placement after maxillary sinus floor elevation. A retrospective study by Jurisic et al. (2008) (42) investigated the clinical outcomes of dental implants placed in augmented maxillary sinuses using different surgical techniques. The study compared the use of an osteotome versus a lateral approach, along with synchronous or delayed implant placement. The researchers concluded that all groups achieved optimal implant survival rates, with no statistically significant variations observed.

Vertical bone height was less of an obstacle after simultaneous implant placement in severely resorbed alveolar bone. A retrospective clinical study conducted by Pistilli et al. in 2022 (43) examined implant-supported restorations in severely resorbed maxillae (less than 3 mm) following sinus lift procedures using xenografts and guided surgery. The findings indicated that there was no loss of implants after a mean follow-up period of 5.11 years (SD: 2.47). Additionally, no cases of peri-implant mucositis or peri-implantitis were reported throughout the follow-up period. Therefore, simultaneous implants placement alongside lateral sinus floor augmentation in atrophic posterior maxillae did not exacerbate the outcomes.

Pietro Felice et al. (2013) (44) conducted a randomized controlled trial to evaluate the effectiveness of one-stage versus two-stage lateral sinus lift procedures in patients with limited bone height (1-3 mm) and sufficient width (at least 5 mm). The study, which delayed implant placement by four months in the two-stage group, found

no significant difference in implant survival between the two approaches. However, the one-stage procedure was associated with a slightly increased risk of implant failure.

Implant survival rate

Albrektsson and colleagues' success criteria (45,46) focused on key parameters like marginal bone loss, implant mobility, peri-implant infection with pus formation, and persistent pain. Across the included studies, the implant survival rate ranged from 90% to 100% after an average follow-up of 36 months.

Implant failure rates were further analyzed based on the surgical procedure (one-stage or two-stage). While one-stage techniques exhibited a slightly higher failure rate, the difference was not statistically significant. Multiple clinical studies have supported these findings (47,48), suggesting that immediate implant placement, when sufficient bone height allows for primary stability, remains a viable and successful surgical approach.

When assessing the factors that influence the survival or success rate of implants, it is important to note that only four studies (9, 49-51) provided data on insertion torque and the crown/implant ratio as potential risk factors for failure. Notably, one study (52) found that in the two-stage procedure group, a significantly higher percentage of implants were inserted with a torque exceeding 30 cmN (97.9% compared to 18.2%). Additionally, more sites were identified as having soft bone quality for stage-1 implants (81% versus 0%). In contrast, a controlled clinical trial by Cha et al. (9) indicated that if an initial stability of 15 Ncm was not achieved according to the torque gauge, a larger diameter implant was utilized. No other studies provided information on insertion torque.

Biological complications

Biological complications during sinus lift procedures were categorized as either intrasurgical (membrane perforation) or post-surgical (acute sinusitis). While membrane perforation was the most frequently reported intraoperative complication, none of the reviewed studies found a link between this complication and implant treatment outcome.

One study (9) examined 217 sinus membranes, finding that 35 were perforated. Despite placing 68 implants in these perforated sites, only 3 implants failed. Statistical analysis (chi-square test with Fisher's exact test) revealed no significant difference in success rates between implants placed in perforated and non-perforated sinuses (p=0.7162). All perforated membranes were sealed with a collagen membrane.

In a study by Simonpieri et al. (2011) (53), significant Schneiderian membrane perforations were observed and treated by covering the perforations with PRF membranes. This approach resulted in zero implant loss during the six-year follow-up period.

Post-surgical complications were less common. One study (52) reported a single case of graft infection linked to membrane perforation. Another study (54) described five cases of sensory disturbances due to incisive nerve injury during graft harvesting. Finally, one study (55) reported a case of sinusitis.

Conclusion

This comprehensive review of available studies on implant placement in the posterior atrophic maxilla, while acknowledging limitations in the level of clinical evidence, reveals no significant differences in implant survival rates between one-stage and two-stage lateral sinus lift procedures. This result holds regardless of the type of graft material used. Available data suggests that both approaches, with their variations in graft materials, are equally effective in achieving successful implant integration in this challenging anatomical region.

Abbreviations

Guided bone regeneration (GBR)
Maxillary sinus floor augmentation (MSFA)
Randomized controlled trials (RCTs)

Declaration section

Ethical Approval and Consent to participate: not applicable.
Consent for publication: not applicable.
Availability of supporting data: the datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.
Competing interests/Authors' contributions: the authors declare that they have no conflict of interest
Funding: there was no funding.

References

1. Aquilino SA, Shugars DA, Bader JD, White BA. Ten-year survival rates of teeth adjacent to treated and untreated posterior bounded edentulous spaces. J Prosthet Dent 2001; 85:455–460.
2. Fueki K, Kimoto K, Ogawa T, Garrett NR. Effect of implant-supported or retained dentures on masticatory performance: a systematic review. J Prosthet Dent 2007; 98:470–477.
3. Schleier P, Bierfreund G, Schultze-Mosgau S, Moldenhauer F, Kupper H, Freilich M. Simultaneous dental implant placement and endoscope-guided internal sinus floor elevation: 2-year post-loading outcome. Clin Oral Implants Res 2008; 19:1163-70.
4. Tatum OH. Maxillary sinus grafting for endosseous implants. Presented at the Annual Meeting of the Alabama Implant Study Group: Birmingham, AL; 1977.
5. Boyne PJ, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone. J Oral Surg 1980; 38:613–617.
6. S. Lundgren, S. Andersson, F. Gualini, L. Sennerby, Bone reformation with sinus membrane elevation: a new surgical technique for maxillary sinus floor augmentation, Clin. Implant Dent. Relat. Res. 6 (2004) 165–173.
7. R.R. Resnik, Misch's Contemporary Implant Dentistry, 4th ed., Elsevier, St. Louis, 2020.
8. C. Stacchi, T. Lombardi, R. Ottonelli, F. Berton, G. Perinetti, T. Traini, New bone formation after transcrestal sinus floor elevation was influenced by sinus cavity dimensions: a prospective histologic and histomorphometric study, Clin. Oral. Implant Res. 29 (2018) 465–479, https://doi.org/10.1111/clr.13144.
9. Cha HS, Kim A, Nowzari H, Chang HS, Ahn KM. Simultaneous sinus lift and implant installation: prospective study of consecutive two hundred seventeen sinus lift and four hundred sixty-two implants. Clin Implant Dent Relat Res. 2014 Jun;16(3):337-47. doi: 10.1111/cid.12012. Epub 2012 Nov 15. PMID: 23157674.
10. Tatum H Jr. Maxillary and sinus implant reconstructions. Dent Clin North Am 1986; 30:207–229.

11. Summers RB. A new concept in maxillary implant surgery: the osteotome technique. Compendium 1994; 15:154–156. 158 passim; quiz 162.
12. Zhen F, Fang W, Jing S, Zuolin W. The use of a piezoelectric ultrasonic osteotome for internal sinus elevation: a retrospective analysis of clinical results. Int J Oral Maxillofac Implants 2012; 27:920–926.
13. Tonetti MS, Hammerle CH. Advances in bone augmentation to enable dental implant placement: consensus report of the Sixth EuropeanWorkshop on Periodontology. J Clin Periodontol 2008; 35:168–172.
14. Rickert D, Vissink A, Slater JJ, Meijer HJ, Raghoebar GM. Comparison between conventional and piezoelectric surgical tools for maxillary sinus floor elevation. A randomized controlled clinical trial. Clin Implant Dent Relat Res 2013; 15:297–302.
15. Del FabbroM, Rosano G, Taschieri S. Implant survival rates after maxillary sinus augmentation. Eur J Oral Sci 2008; 116:497–506.
16. 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– 240.
17. Esposito M, Grusovin MG, Rees J, Karasoulos D, Felice P, Alissa R, Worthington HV, Coulthard P. Interventions for replacing missing teeth: augmentation procedures of the maxillary sinus. Cochrane Database Syst Rev. 2010 Mar 17;(3):CD008397. doi: 10.1002/14651858.CD008397. Update in: Cochrane Database Syst Rev. 2014 May 13;(5):CD008397. doi: 10.1002/14651858.CD008397. pub2. PMID: 20238367.
18. Katranji A, Fotek P, Wang HL. Sinus augmentation complications: etiology and treatment. Implant Dent 2008; 17:339–349.
19. Schwartz-Arad D, Herzberg R, Dolev E. The prevalence of surgical complications of the sinus graft procedure and their impact on implant survival. J Periodontol 2004; 75: 511–516.
20. Misch CE, Dietsh F. Endosteal implants and iliac crest grafts to restore severely resorbed totally edentulous maxillae-a retrospective study. J Oral Implantol 1994; 20(2):100-10.
21. Jensen OT, Shulman LB, Block MS, Iacono VJ. Report of the Sinus Consensus Conference of 1996. Int J Oral Maxillofac Implants 1998; 13: 11-32.
22. Peleg M, Mazor Z, Chaushu G, Garg AK. Sinus floor augmentation with simultaneous implant placement in the severely atrophic maxilla. J Periodontol 1998 ;69: 1397–1403.
23. Chen TW, Chang HS, Leung KW et al. Implant placement immediately after the lateral approach of the trap door window procedure to create a maxillary sinus lift without bone grafting: a 2-year retrospective evaluation of 47 implants in 33 patients. J Oral Maxillofac Surg 2007 ; 65(11):2324-8.
24. Geurs NC1, Wang IC, Shulman LB, Jeffcoat MK. Retrospective radiographic analysis of sinus graft and implant placement procedures from the Academy of Osseointegration Consensus Con-ference on Sinus Grafts. Int J Periodontics Restorative Dent 2001; 21(5):517-23.
25. Tatum H., Jr Maxillary and sinus implant reconstructions. Dent Clin North Am. 1986;30:207–29. (PubMed) (Google Scholar) (Ref list)
26. Smiler DG. The sinus lift graft: Basic technique and variations. Pract Periodontics Aesthet Dent. 1997;9:885–93. (PubMed) (Google Scholar) (Ref list)
27. Wallace SS, Tarnow DP, Froum SJ, Cho SC, Zadeh HH, Stoupel J, et al. Maxillary sinus elevation by lateral window approach: Evolution of technology and technique. J Evid Based Dent Pract. 2012;12:161–71. (PubMed) (Google Scholar) (Ref list)
28. 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. (PubMed) (Google Scholar) (Ref list)
29. Underwood AS. An inquiry into the anatomy and pathology of the maxillary sinus. J Anat Physiol. 1910;44:354–69. (PMC free article) (PubMed) (Google Scholar) (Ref list)
30. Krennmair G, Ulm CW, Lugmayr H, Solar P. The incidence, location, and height of maxillary sinus septa in the edentulous and dentate maxilla. J Oral Maxillofac Surg. 1999;57:667–71. (PubMed) (Google Scholar) (Ref list)
31. Ulm CW, Solar P, Krennmair G, Matejka M, Watzek G. Incidence and suggested surgical management of septa in sinus-lift procedures. Int J Oral Maxillofac Implants. 1995;10:462–5. (PubMed) (Google Scholar) (Ref list)
32. Kim MJ, Jung UW, Kim CS, Kim KD, Choi SH, Kim CK, et al. Maxillary sinus septa: Prevalence, height, location, and morphology. A reformatted computed tomography scan analysis. J Periodontol. 2006;77:903–8. (PubMed) (Google Scholar) (Ref list)
33. Kaufman E. Maxillary sinus elevation surgery: An overview. J Esthet Restor Dent. 2003;15:272–82. (PubMed) (Google Scholar) (Ref list)
34. Woo I, Le BT. Maxillary sinus floor elevation: Review of anatomy and two techniques. Implant Dent. 2004;13:28–32. (PubMed) (Google Scholar) (Ref list)
35. Cho SC, Wallace SS, Froum SJ, Tarnow DP. Influence of anatomy on Schneiderian membrane perforations during sinus elevation surgery: Three-dimensional analysis. Pract Proced Aesthet Dent. 2001;13:160–3. (PubMed) (Google Scholar) (Ref list)
36. Fry RR, Patidar DC, Goyal S, Malhotra A. Proximity of maxillary posterior teeth roots to maxillary sinus and adjacent structures using denta scan® Indian J Dent. 2016;7:126–30. (PMC free article) (PubMed) (Google Scholar) (Ref list)
37. Eberhardt JA, Torabinejad M, Christiansen EL. A computed tomographic study of the distances between the maxillary sinus floor and the apices of the maxillary posterior teeth. Oral Surg Oral Med Oral Pathol. 1992;73:345–6. (PubMed) (Google Scholar) (Ref list)
38. Solar P, Geyerhofer U, Traxler H, Windisch A, Ulm C, Watzek G, et al. Blood supply to the maxillary sinus relevant to sinus floor elevation procedures. Clin Oral Implants Res. 1999;10:34–44. (PubMed) (Google Scholar) (Ref list)
39. Elian N, Wallace S, Cho SC, Jalbout ZN, Froum S. Distribution of the maxillary artery as it relates to sinus floor augmentation. Int J Oral Maxillofac Implants. 2005;20:784–7. (PubMed) (Google Scholar) (Ref list)
40- Bathla SC, Fry RR, Majumdar K. Maxillary sinus augmentation. J Indian Soc Periodontol. 2018 Nov-Dec;22(6):468-473. doi: 10.4103/jisp.jisp_236_18. PMID: 30631223; PMCID: PMC6305100.
41- Friberg B, Hana M, Mahdi HR, Jemt T. Clinical and radiographic outcomes of lateral sinus floor elevation: a retrospective study. Swed Dent J. 2016;40(2):121-132. PMID: 28853784.
42. Jurisic M, Markovic A, Radulovic M, Brkovic BM, Sándor GK. Maxillary sinus floor augmentation: comparing osteotome with lateral window immediate and delayed implant placements. An interim report. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008 Dec;106(6):820-7. doi: 10.1016/j.tripleo.2008.04.025. Epub 2008 Jul 7. PMID: 18602304.
43. Pistilli R, Canullo L, Pesce P, Pistilli V, Caponio VCA, Sbricoli L. Guided implant surgery and sinus lift in severely resorbed maxillae: A retrospective clinical study with up to 10 years of follow-up. J Dent. 2022 Jun;121:104137. doi: 10.1016/j.jdent.2022.104137. Epub 2022 Apr 21. PMID: 35461972.
44. Felice P, Pistilli R, Piattelli M, Soardi E, Pellegrino G, Corvino V, Esposito M. 1-stage versus 2-stage lateral maxillary sinus lift procedures: 4-month post-loading results of a multicenter randomised controlled trial. Eur J Oral Implantol. 2013 Summer;6(2):153-65. PMID: 23926587.
45. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. Int J OralMaxillofacial Implants 1986; 1 : 11-25.
46. Misch CE, Perel ML, Wang HL et al. Implant success, survival, and failure: the International Congress of Oral Implantologists (ICOI) Pisa Consensus Conference. Implant Dent 2008 Mar;17:5-15. doi: 10.1097/ ID.0b013e3181676059.
47. Canullo L, Patacchia O, Sisti A, Heinemann F. Implant

restoration 3 months after one stage sinus lift surgery in severely resorbed maxillae: 2-year results of a multicenter prospective clinical study. Clin Implant Dent Relat Res 2012;14 :412-20.

48. Rodriguez A, Anastassov GE, Lee H, Buchbinder D, Wettan H. Maxillary sinus augmentation with deproteinated bovine bone and platelet rich plasma with simultaneous insertion of endosseous implants. J Oral Maxillofac Surg. 2003 Feb;61(2):157-63. doi: 10.1053/joms.2003.50041. PMID: 12618990.
49. Di Lallo S, Ricci L, Orecchioni S, Piattelli A et al. Resonance frequency analysis assessment of implants placed with a simultaneous or a delayed approach in grafted and nonografted sinus sites: a 12-month clinical study. Clin Implant Dent Relat Res 2014; 3: 394-400.
50. Manso MC, Wassal T. A 10-years longitudinal study of 160 implants simultaneously installed in severely resorbed posterior maxillas grafted with autogenous bone and synthetic bioactive resorbable graft. Implant Dent 2010; 4: 351-360.
51. Canullo L, Patacchia O, Sisti A, Heinemann F. Implant restoration 3 months after one stage sinus lift surgery in severely resorbed maxillae: 2-year results of a multicenter prospective clinical study. Clin Implant Dent Relat Res 2012;14 :412-20.
52. Felice P, Pistilli R, Piattelli M et al. 1-stage versus 2-stage lateral sinus lift procedures: 1-year post loading results of a multicentre randomized controlled trial. Eur J Oral Implantol 2014 ;7(1):65-75.
53. Simompieri A, Choukroun J, Del Corso M et al. Simultaneous sinus-lift microthreaded implants and leucocyte-and platelet-rich fibrin as sole grafting material: a 6-years experience. Implant Dent 2011; 20: 2-12.
54. Peleg M, Mazor Z, Garg AK. Augmentation grafting of the maxillary sinus and simultaneous im-plant placement in patients with 3 to 5 mm of residual alveolar bone height. Int J Oral Maxillofac Implants 1999;14:549-56.
55. Mendonça-Caridad JJ, Nuñez M, Juiz-Lopez P et al. Sinus floor elevation using a composite graft clinical outcome of immediate implant placement. Int J O Maxillofac Implants 2013; 1: 252-260.