



Comparative Evaluation of Survival Rate of Implant Placement Using Three Different Indirect Sinus Floor Elevation Techniques: A Systematic Review and Meta –Analysis

Dr. Sachin Agrawal¹, Dr. Kalpesh Vaishnav², Dr. Ravi Joshi³, Dr. Surbhi Patel⁴, Dr. Hetangi Patel⁵, Dr. Harshal Sabuwala⁶

Department of prosthodontics, Karnavati School of dentistry, Karnavati University Ahmedabad

(Received: 16 March 2025

Revised: 20 April 2025

Accepted: 15 June 2025)

KEYWORDS

Dental implant, Indirect sinus elevation, Osteotome approach, Hydraulic pressure approach, Antral balloon approach, Survival rate.

ABSTRACT:

Introduction: Extreme atrophy of the edentulous maxilla is a common problem that requires augmentation surgery for achieving a sufficient alveolar bone volume allowing for dental implant placement. Lateral sinus membrane elevation for the posterior maxilla is a reliable procedure. The sinus lift procedure is not straight-forward and is associated with complications that may compromise the stability of the graft and the overall success of the treatment, such as the perforation of the sinus membrane, which occurs in more than 20% of cases To investigate the survival rate of indirect sinus floor elevation a systematic review and meta- analysis was conducted.

Objectives: This systematic review and meta-analysis aim to compare survival rate of three different Indirect sinus lift elevation technique

Methods: A systematic electronic literature search was conducted through PubMed, The Cochrane Central Register of Controlled Trials (Central), and Science direct. A hand search was also performed for individual journals and reference lists of selected studies. Randomized controlled clinical trials and crossover clinical trials from 2014 to 2024 with follow up of more than 6 month were included. The Cochrane Collaboration's tool was used for assessing the risk of bias of included studies.

Results: Three distinct indirect sinus floor elevation investigations totalling nine were completed. To determine the implant survival rate, every study was incorporated into the meta-analysis. The forest plot was created for the indirect strategy (Proportion 0.980, with CI 0.960LL – 0.995 UL), and there is no statistical difference between these indirect techniques.

Conclusions: The survival rate of implants implanted utilizing various indirect sinus lift approach procedures does not differ statistically significantly. As a result, the method is chosen based on the Guidelines provided for every kind of indirect procedure.

1. Introduction

Placing dental implants in edentulous patients has grown in popularity as a therapy option.[1] The clinician must assess the patient for sufficient bone volume for the implant operation when considering implant-supported prosthetic alternatives. The quantity and quality of the supporting bone are directly related to the maintenance of long-term stability. For the treating clinician, restoring the edentulous maxilla presents many difficulties, particularly when ridge resorption is severe. Trauma,

periodontal disease, pathology, congenital abnormalities, poorly fitting prostheses, or disuse atrophy from chronic edentulism can all lead to alveolar bone resorption. Even when a patient's remaining bone is of poor quality or quantity, it is now quite rare to inform them that they are not candidates for dental implants.[2]

The maxillary sinus is a pyramid-shaped cavity, with the peak pointing towards the zygoma and the base next to the nasal wall. Until the permanent teeth erupts, the sinus's size is negligible. Adult sinuses typically measure 2.5 to 3.5 cm in width, 3.6 to 4.5 cm in height, and 3.8 to



4.5 cm in depth. Its volume is estimated to be between 12 and 15 cm². It reaches the canine and premolar regions anteriorly. The most inferior point of the sinus floor is typically located close to the first molar region. If the area is edentulous, the sinus will grow larger as you age [3,4]

The following are indications for sinus augmentation

1. Patients with no history of sinus pathosis
2. Inadequate residual bone height (<10 mm of bone height)
3. Severely atrophic maxillary arch
4. Poor quality and quantity of bone in the maxillary posterior region.

The following are contra indications for sinus augmentation

1. Recent history of radiation therapy in maxilla
2. Uncontrolled systemic diseases such as diabetes mellitus
3. Acute/chronic maxillary sinusitis
4. Heavy smoking habit
5. Alcohol abuse
6. Psychosis
7. Severe allergic rhinitis
8. Tumors or large cyst in the maxillary sinus
9. Oro-antral fistula.

2. Objectives

To evaluation of survival rate of implant placement using three different indirect sinus floor elevation technique the Antral balloon approach, Hydraulic pressure approach, and osteotome approach.

3. Methods

RESEARCH QUESTION

The aim of this systematic review and meta-analysis were to answer the PICOTS question:

“In maxillary posterior edentulous arch sinus floor elevation technique implant survival rate with three different indirect sinus floor elevation technique”

Study protocol

The present systematic review has been performed in line with the guideline provided by PRISMA (preferred Reporting items for Systematic Review and Meta-Analysis [15,16]). Although a protocol detailing the

multiple aspects of the methodology was designed before commencing the review, it was registered in international Prospective Register of Systematic Review (PROSPERO) under CRD420250655938

The PICOTS format provided by the Centre For Evidence-Based Medicine for systematic literature search to answer the research question was formulated as below

PICOTS

P – POPULATION: Maxillary posterior edentulous arch.
I – INTERVENTION: Maxillary sinus floor elevation technique.

C - COMPARISON: Maxillary sinus floor elevation technique using three different indirect sinus floor elevation.

O – OUTCOME: Survival rate of dental implant.

T - TIME: Studies published from 2014 to 2024, with the minimum follow-up of 6 months.

S – STUDY: Prospective RCT, crossed over clinical trial, non-randomized control trial

Search strategy

Three electronic databases were used:

(a) The National Library of Medicine (MEDLINE via PubMed)

(b) Google Scholar

(c) Cochrane library

These databases were individually searched for the studies published between 2014 to 2024. Last search was done on April 2024. [15,16]

The following MeSH term were used along with bullion operators ‘AND’ ‘OR’ ‘NOT’:

(Direct sinus) AND (sinus floor elevation)) OR (indirect sinus)) AND (sinus floor elevation)) OR (crestal sinus)) OR (lateral window approach) OR (dental implant) AND (bone graft)

Study selection and intervention:

Inclusion criteria:

1) Studies published between 2014 to 2024.

2) Studies published in the English language only.

3) Studies done on Humans only.

4) Studies were done in maxillary posterior edentulous arch.



- 5) Prospective and randomized control trial non randomized control trial.
- 6) Sample size of patient ≥ 20
- 7) Follow up of patient ≥ 6 months.
- 8) Studies with all different sinus floor elevation.

Exclusion criteria:

- 1) Studies including systemic review, meta-analysis, in vitro studies
- 2) Studies done on animals.
- 3) Non clinical studies
- 4) Studies with inadequate data
- 5) Sample size of patient ≥ 20

Follow up of patient < 6 months

4. Results

Two independent investigators performed the study selection. After initial search total 928 studies were found. First studies were filtered according to year of publication (2014-2024) and language (studies published in English language only). This search excluded 662 studies. After that screening of 266 full text articles was done for eligibility. Only 192 studies performed on human species were included. 6 studies were excluded as it were systematic review and meta-analysis. Now further study selection done by two investigators independently and assessed study for eligibility by initially screening titles, abstract and keywords for final inclusion. Finally, 39 full text articles were accessed for eligibility. 26 studies were excluded depending on inclusion and exclusion criteria. Ultimately, 9 studies

were included for final study. For cross-references, all reference lists of the selected studies were checked. Along with it, the following journals were hand-searched from the years 2014 to 2024: Journal of Prosthetic Dentistry, Journal of British Dental Association International Journal of Prosthodontics, Journal of Advanced Prosthodontics, Journal of Oral Implantology and The International Journal of Oral and Maxillofacial Implants. (FIGURE 1)

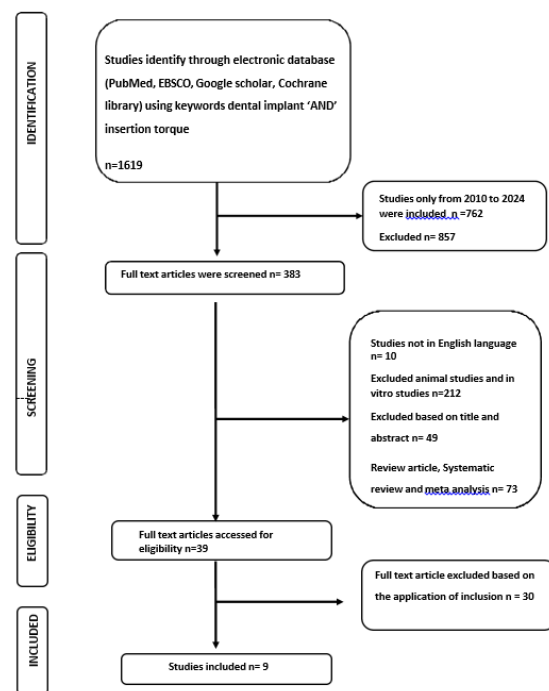


Figure 1: PRISMA 2020 flow diagram

Table 1: Data extracted from the studies included in the present systematic review

No.	Study year	Study type	No of patient	No of implant	Sinus augmentation technique	With or Without graft	Residual bone height	Gained bone height	Follow up period	No of failure	Survival rate
1	Liet et al 2013	Clinical report	23	33	Indirect using hydraulic pressure	Bio-oss	2-5mm	7.5+/- 0.9 mm	2-3 yr	0	100%
2	Girish rao 2014	Prospective study	34	62	Antral ballon sinus elevation	Auto genou s bone	6.2+/- 2.4mm	7.5 mm (5.2-10.5)	3 yr	2	96.77%



						retrieved from chin +platlet rich plasma	Mean 3.8+/-0.5mm	Mm			
3	Brizula et al 2014	Prospective study	37	36	Osteotome using indirect sinus lift	-	4-9mm (7.4+/-0.4 mm)	1.8+/-0.3mm	2 yr	2	91.6%
4	Hussen and hassan et al 2017	Prospective study	24	32	Osteotome (indirect) with AMBE	ORC graft	≤6mm	6.48 avg mm	1yr	3	90.62%
5	Aditirawat et al 2019	Prospective study	21	26	Osteotome (indirect)	-	Mean 6.8 +/-1.89 mm	8.72+/-1.55 Mm	6 month	0	100%
6	Jon yushi 2020	Prospective study (RCT)	26	38	Osteotome sinus floor elevation	-	< 4mm		10	4	89.2%
7	Manekar Vs 2020	Prospective study	17	26	Hydraulic sinus lift technique	-		5-6 mm	1 yr	0	100%
8	Ning kang 2022	A non RCT	20	60	Modified osteotome (crestal approach)	Bio oss	2.84+/-0.94 – 6.09+/-0.69	12+/-2.66 to 13.43+/-1.8	6 month	0	100%
9	Teresa lombardi 2022	Prospective multicenter study	71	59	Transcrestal osteotomy	Xeno graft	3.8+/-1mm (range 1.2-4.9)	6.1+/-2.2 mm	32 month	0	100%

Assessment of risk of bias in included studies

All studies which were meeting the inclusion criteria then underwent risk of bias assessment. Risk of bias assessment was done by two investigators independently for each study using the standard guideline given in the Cochrane handbook for systematic reviews of interventions for randomized studies and ROBINS – I tool was used for non-randomized studies.

For Randomized studies the author’s judgments, the Cochrane collaboration’s tool categorized the study methods as “Low risk,” “High risk,” or “Unclear risk” of bias-related to following domains

For the assessment, ROBINS-I categorized study methods as “Low risk”, “High risk”, or “Unclear risk” for bias related to the following domains.[15,16]

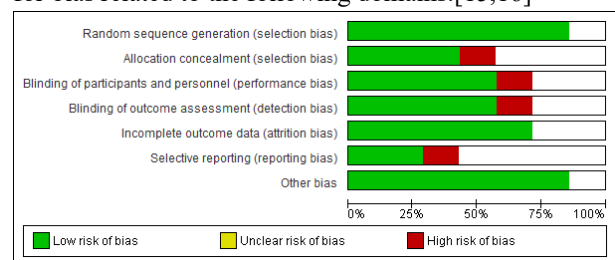


Figure 2: Risk of bias summary using Cochrane collaboration tool for randomized studies

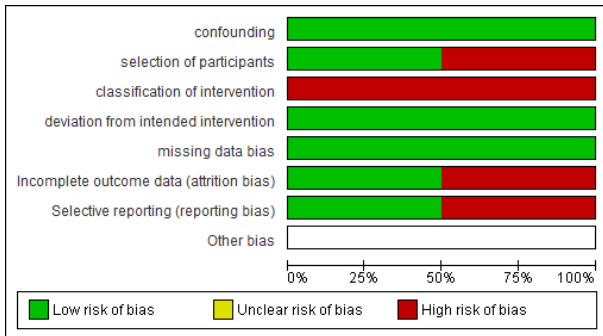


Figure 3: Risk of bias graph using ROBINS – I tool for non-randomized studies

5. Meta- analysis

Table 2: Data related to survival rate of implant with indirect sinus lift techniques which was subjected to meta-analysis

N O	STUDY	Total implant	Survived implant	Proportion	95 % UL	95% LL
1	LIET AT EL 2013	33	33	1.000	1.0000	0.896
2	GIRISH RAO ET AL 2014	62	60	0.968	0.9903	0.945648
3	BRIZULA ET AL 2014	36	34	0.944	1.0191	0.8689
4	HUSSEN AND HASSAN 2017	32	29	0.906	1.0071	0.80489
5	ADITI RAWAT ET AL 2019	26	26	1.000	1.0000	0.871
6	JOHN YU SHI ET AL 2020	38	34	0.895	0.9925	0.7975
7	MANEKAR VS ET	26	26	1.000	1.0000	0.871

	AL 2020					
8	NING KANG ET AL 2022	60	60	1.000	1.0000	0.940
9	TERESA LOMBARDI ET AL 2022	59	59	1.000	1.0000	0.939

BINARY – RANDOM EFFECT MODEL

ESTIMATE PROPOTION	95% LL	95%UL	SE	P-VALUE
0.980	0.960	0.995	0.008	<0.001

HETEROGENEITY

tau ²	Q (df = 8)	Het. P – Value	I ²
0.0001	10	0.26	20%

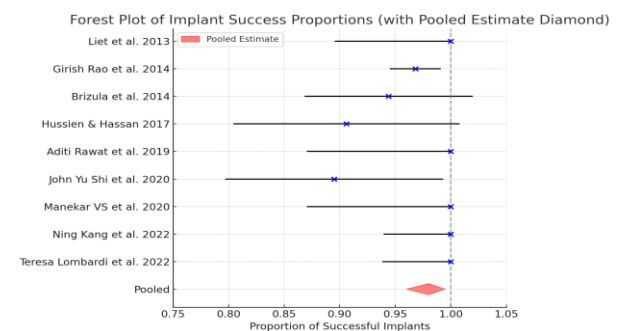


Figure -4 Forest Plot of implant success Proportion (with pooled Estimated Diamond)

The 98% success rate of dental implants, with a narrow confidence interval, indicates both high effectiveness and precision, strongly supporting that the true success rate is near 98%. The 95% CI (0.960–0.995) suggests a true success rate of 96%–99.5%. A small SE (0.008) indicates precision, and a P-value <0.001 confirms strong statistical significance against a null value like 50%. Heterogeneity in the meta-analysis is low, with $\tau^2 = 0.0001$, indicating minimal variance in true effects. The Q-statistic (df = 8) is 10, suggesting no excess heterogeneity, supported by a P-value of 0.26 (>0.05). An I² of 20% shows that only a small portion of variation is due to heterogeneity, aligning with the threshold for



low heterogeneity (<25%). This forest plot illustrates implant success proportions from multiple studies, summarizing individual estimates and a pooled overall estimate from a random-effects meta-analysis. The bottom row ("Pooled") represents this overall estimate, visualized by a red diamond. The diamond's centre (~0.98) indicates the pooled proportion, while its width reflects the 95% confidence interval. Its narrow shape and proximity to 1.0 suggest a high success rate with strong confidence.

6. Discussion

The best evidence found in the scientific literature is thought to be systematic reviews. Depending on the availability of Remaining, various methods have been employed for maxillary sinus lift surgeries in order to insert implants in the posterior maxilla region. In order to assess the available information on different maxillary sinus floor elevations, this systematic review was conducted. This systematic review's main goal was to analyse the survival results of implants inserted using different indirect sinus lift procedures. This systematic review found and included two clinical studies, nine clinical studies, and seven prospective studies. Because *in vivo* studies are well recognised for providing fundamental scientific knowledge and for their clinical relevance, they were included in this review.

Due to variations in implant types, patient follow-up, the amount of residual bone present, techniques, and evaluation methodologies, it is challenging to compare the many research on maxillary sinus lift techniques.

Out of the nine included studies, 372 implants were implanted indirectly in the current investigation. The osteotome, modified osteotome, hydraulic pressure, and antral membrane balloon elevation approaches were among the nine included investigations. [8,11]

A total of 273 individuals participated in this trial, which used several indirect sinus lift techniques. Eleven of the 372 implants that were placed were unsuccessful. Additionally, 361 implants survived overall. With an implant survival proportion of 0.980, the overall implant survival percentage of combining various indirect sinus lift techniques is 98%. With a 98% overall survival rate,

11 of the 372 implants that were inserted utilizing indirect procedures failed.

Five investigations were conducted utilising the osteotome technique, which has the advantages of being less invasive, involving fewer surgical complications, requiring less time for healing and recovery, and improving maxillary bone density, which contributes to good stability. In these five studies, a total of 171 patients had 219 implants placed, 6 of which failed. Sinus floor augmentation by indirect technique with osteotome approach combined with simultaneous implant placement can be an excellent method for restoring partial edentulism. [6,7,10,12,13] As a result, 6 of the 219 implants that were inserted utilising osteotome sinus floor elevation failed, yielding a 97.2% overall survival rate.

Two investigations were conducted utilising the hydraulic pressure method, which offered benefits. In order to do bone grafting and implant insertion, this study describes a novel technique that eliminates the need for traditional curetting equipment by raising and separating the Schneiderian membrane from the sinus floor bone. The technique has the benefit of being quick and easy to perform, removing the need to create a buccal bone window or retract huge flaps. The patient experiences fewer postoperative symptoms, which is an additional benefit. In these two investigations, 40 patients in total had 59 implants implanted; of these 59, none of them failed. [8,11]

These two studies include total 58 patients and 94 implants were placed, out of these 94 implants 5 implants were failed. Hence, a total of 5 implants failed out of 94 implants placed using Antral membrane balloon elevation approach with the overall survival rate of 94.68%. The AMBE technique with augmentation has been a highly successful and predictable procedure. It facilitates lifting the sinus membrane gently and displacing it upward. The graft material is deposited into the space thus created. Implants may be placed simultaneously with the graft. [9,14]

7. Conclusion

Hence, summarizing and highlighting the findings of this systematic review, the following conclusions are drawn:



Overall survival rate of implant placed by indirect approach is 96.576 %

Overall survival rate of implant placed by osteotome approach is 96.16%

Overall survival rate of implant placed by Antral Balloon approach is 93.695

Overall survival rate of implant placed by Hydraulic pressure approach is 100 %

Due to the limited number of well-performed studies published to date, this systematic review concludes that, there is less statistically significant difference in the survival rate of implant placed using osteotome approach, Antral Balloon approach, Hydraulic pressure approach procedures. Hence, the technique is selected as per the indications given for each indirect procedure.

References

- Aghaloo, T. L., Misch, C., Lin, G. H., Iacono, V. J., & Wang, H. L. (2016). Bone Augmentation of the Edentulous Maxilla for Implant Placement: A Systematic Review. *The International journal of oral & maxillofacial implants*, 31 Suppl, s19–s30. <https://doi.org/10.11607/jomi.16suppl.g1>
- Iwanaga, J., Wilson, C., Lachkar, S., Tomaszewski, K. A., Walocha, J. A., & Tubbs, R. S. (2019). Clinical anatomy of the maxillary sinus: application to sinus floor augmentation. *Anatomy & cell biology*, 52(1), 17–24. <https://doi.org/10.5115/acb.2019.52.1.1.7>
- Aruna Wimalaratna Indirect Sinus Lift: An Overview of Different Techniques DOI: 10.26717/BJSTR.2021.33.005447
- Zhao, X., Gao, W., & Liu, F. (2018). Clinical evaluation of modified transalveolar sinus floor elevation and osteotome sinus floor elevation in posterior maxillae: study protocol for a randomized controlled trial. *Trials*, 19(1), 489. <https://doi.org/10.1186/s13063-018-2879>
- Rawat, A., Thukral, H., & Jose, A. (2019). Indirect Sinus Floor Elevation Technique with Simultaneous Implant Placement without Using Bone Grafts. *Annals of maxillofacial surgery*, 9(1), 96–102. https://doi.org/10.4103/ams.ams_11_19
- Brizuela, A., Martín, N., Fernández-Gonzalez, F. J., Larrazábal, C., & Anta, A. (2014). Osteotome sinus floor elevation without grafting material: Results of a 2-year prospective study. *Journal of clinical and experimental dentistry*, 6(5), e479–e484. <https://doi.org/10.4317/jced.51576>
- Manekar V. S. (2020). Graftless crestal hydraulic sinus lift with simultaneous implant insertion. *National journal of maxillofacial surgery*, 11(2), 213–218. https://doi.org/10.4103/njms.NJMS_38_19
- Hussein, L. A., & Hassan, T. A. L. (2017). The Effectiveness of Oxidized Regenerated Cellulose as a Graft Material in Transalveolar Osteotome Sinus Lift Procedure. *The Journal of craniofacial surgery*, 28(7), 1766–1771. <https://doi.org/10.1097/SCS.0000000000003943>
- Jun-Yu Shi | Yi-Rao Lai | Shu-Jiao Qian | Shi-Chong Qiao | Maurizio S Hong-Chang La Clinical, radiographic and economic evaluation of short-6-mm implants and longer implants combined with osteotome sinus floor elevation in moderately atrophic maxillae: A 3-year randomized clinical trial DOI: 10.1111/jcpe.13444
- Li, J., Lee, K., Chen, H., & Ou, G. (2013). Piezoelectric surgery in maxillary sinus floor elevation with hydraulic pressure for xenograft and simultaneous implant placement. *The Journal of prosthetic dentistry*, 110(5), 344–348. <https://doi.org/10.1016/j.prosdent.2013.04.002>
- Kang, N., & Liu, C. (2022). Modified Osteotome Sinus Floor Elevation Technique for Multiple Edentulous Spaces: A Non-Randomized Controlled Trial. *International journal of environmental research and public health*, 19(13), 8019. <https://doi.org/10.3390/ijerph19138019>
- Lombardi, T., Lamazza, L., Bernardello, F., Ziętek, G., Stacchi, C., & Troiano, G. (2022). Clinical and radiographic outcomes following transcrestal maxillary sinus floor elevation with injectable xenogenous bone substitute in gel form: a prospective multicenter study. *International journal of implant dentistry*, 8(1), 32. <https://doi.org/10.1186/s40729-022-00431-5>
- Rao, G. S., & Reddy, S. K. (2014). Antral balloon sinus elevation and grafting prior to dental implant placement: review of 34 cases. *The International journal of oral & maxillofacial implants*, 29(2), 414–418. <https://doi.org/10.11607/jomi.3075>
- Fleming, P. S., Seehra, J., Polychronopoulou, A., Fedorowicz, Z., & Pandis, N. (2013). A PRISMA



assessment of the reporting quality of systematic reviews in orthodontics. *The Angle orthodontist*, 83(1), 158–163.
<https://doi.org/10.2319/032612-251.1>

15. Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS medicine*, 6(7), e1000097.
<https://doi.org/10.1371/journal.pmed.1000097>
16. Higgins JP, Green S, editors. *Cochrane Handbook for Systematic Reviews of Interventions*. Ver. 5.1.0: The Cochrane Collaboration; 2011