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Indirect Sinus Lift Without Graft Placement and with Immediate Implant Placement- A Systematic Review

Abstract:

Background: Due to persistent ridge resorption and maxillary sinus pneumatization, the maxillary posterior region has historically been difficult to implant in. To overcome these challenges various techniques have been developed. Among which sinus lift procedures; either direct or indirect are most commonly used. This systematic review investigates the success of immediate implant placement combined with indirect sinus lift without grafting in the maxillary posterior region. Specifically, it evaluates the rates of implant survival and endosinus bone formation.

Aim: To review the literature on indirect sinus lift without graft placement and with immediate implant placement following the PRISMA Guidelines.

Methodology: A systematic search was conducted on two electronic databases, PubMed and Cochrane Central, for studies published between 2010–2020. The search terms included "sinus augmentation," "sinus lift," "sinus elevation," and "indirect technique." The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed for data collection.

Results: In the initial search, 1361 articles in total were located. A total of 20 papers were chosen for full text review after duplicates were removed and titles and abstracts were screened. In this systematic review, 8 articles were chosen; 12 publications were rejected for a variety of reasons.

Conclusion: The studies included in this review evaluated the efficacy of indirect sinus elevation without grafting material, combined with immediate implant placement, for augmenting bone volume in the maxillary posterior region. All studies reported evidence of endosseous bone formation, with implant survival rates ranging from 90% to 100%.

Key-words: Immediate implant, indirect sinus lift, endosinus bone gain, implant survival rate, graftless, Systematic review.

Introduction:

Nowadays, dental implants are a treatment option for individuals who are missing their teeth and need prosthetic rehabilitation. A sufficient amount and quality of bone are essential for dental implant placement[1]. After tooth loss, the residual ridge continues to erode. Remaining ridge resorption is also associated with increased maxillary sinus pneumatization close to the posterior maxilla[2]. As a result, sufficient bone is lost; without bone regeneration, implant placement is not possible. It is possible to enlarge the sinus floor and perform a sinus membrane lift operation to solve this challenge. You can do the sinus lift operation directly or indirectly.

Tatum[3] introduced the direct sinus lift method in 1974, and Boyne and James[4] later published their clinical analysis on it in 1980. Tatum's method involved approaching the sinus from

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the crest. Later, this method was altered to use lateral sinus osteotomy as the approach to the sinus since direct visualisation appeared to be more viable in cases of diminished subantral bone. After raising the sinus membrane, a bone replacement was put in place, and either the implant was put in right away or afterwards. Summers introduced the trans alveolar procedure, commonly known as the indirect sinus lift approach, in 1994[5,6,7]. Using several osteotomes, the sinus was raised through the alveolar ridge in this procedure. The membrane and the graft material used to surround the implant were lifted and shaped using a series of osteotomes[8-11]. Implants with indirect sinus lift and bone substitute have a survival percentage of between 93.5% and 100%[12,13].

The sinus lift technique has been carried out using a variety of graft alternatives, mostly autogenous bone grafts, as well as alloplast, allograft, and xenograft[8–13]. After conducting the sinus lift technique, graft substitute preserves the volume of the sinus membrane[14]; however, the selection of graft substitute has been contentious. The sinus lift procedures have also been performed without using graft substitute[14-17] and gave favorable results. After sinus augmentation, new bone development happens as a result of the formation of a blood clot-filled space that induces bone deposition in accordance with the directed tissue regeneration principle[18–20] and the osteogenic potential of the maxillary sinus membrane[21–22]. Numerous writers concur that maintaining enough bone volume around the implant and promoting osseointegration don't always require the use of graft substitutes. It has been deduced that the risk of infections is decreased when there is no graft substitute[23]. Indirect sinus floor elevation without using the graft substitute is a quick and less invasive technique.

Study Design:

This systematic review investigates the efficacy of indirect sinus lift without grafting material for implant placement in the atrophic posterior maxilla. Specifically, it evaluates the outcomes of this technique by analyzing endosseous bone formation following implant insertion and the survival rate of the implants.

Material and Methods:

Study Setting

Information source/Search strategy

Human studies of indirect sinus lift using osteotomes without using graft substitute and immediate implant placement were included in this review. Two independent reviewers (PG and AS) conducted a thorough search on two electronic databases (Pubmed and Cochrane Central) with a 2010–2020 publication year constraint. The terms "sinus augmentation," "sinus lift," "sinus elevation," and "indirect technique" were employed. A manual examination of the references from the included articles was done in addition to the search.

This systematic review followed the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) standards. This systematic review's PROSPERO registration number is CRD 42020222274.

Participants:

The current systematic review's objective is to analyse the available data to assess the treatment's effectiveness. In particular, it will examine the endosinus bone gain (ESBG) following implant placement, overall implant survival rate, implant stability, and complications experienced by patients who underwent indirect maxillary sinus elevation surgery without the use of a graft substitute and immediate implant placement.

Inclusion And Exclusion Criteria:

The Inclusion Criteria Are:

1. Published articles on Indirect sinus lift technique using osteotomes without using graft substitute and immediate implant placement in atrophic maxilla
2. Human studies with a minimum follow-up time of 2 years or more.

Studies having mean residual alveolar bone height more than 5mm

3. Studies containing not less than 10 patients.
4. Published Articles in the English language.

Exclusion criteria :

1. Systematic reviews, literature reviews, case reports, case series having less than 10 patients.
2. Studies on animals.
3. Studies comparing direct and indirect sinus elevation, or studies on direct sinus lift.
4. Non-English language articles.
5. Studies with insufficient data.

Data analysis:

Two reviewers (PG, AS) independently chose the titles and summaries of the studies found through the search, and in the event of a dispute between the reviewers, a consensus was established through discussion. Authors, study design, patient

count, patient age, implant count, residual bone height (RBH), loading time, endosinus bone gain (ESBG), implant survival, marginal bone loss (MBL), and complications encountered were among the criteria used in the data collection process.

Quality assessment of studies included:

All of the studies that were part of this review's assessment of the risk of bias used an effective public health practise project (EPHPP)24. The six domains of this instrument include withdrawals and dropouts, blinding, confounders, study design, and selection bias. Each study's overall evaluation was categorised as strong when no component received a weak rating, moderate when only one component received a weak rating, and weak when two or more components received a weak rating.

The extracted data were tabulated and stratified based on when they were extracted. In Table -1, information pertaining to various features of the included studies has been listed.

Table-1 Characteristic of included studies

Authors	Type of study	No of patients	Mean age (yr)	No of implants	Mean Loading time (months)	Mean follow up time (months)	Mean Residual bone height (mm)
Dp et al[25] 2011	retrospective study	17	55	27	2-3	24	>5and <10
He et al[26] 2011	Retrospective study	22	43.4+-13.8	27	6	25+-8	6.7+-1.2
Fermergård et al[27]2012	Retrospective study	36	64+-12	53	3-4	36	6.3+-0.3
Nedir et al[28] 2015	Prospective controlled clinical trial	17	54.2+-9.6	25	3	120	5.4+-2.3
Spinelli et al[29] 2015	Clinical prospective study	39	54.5	66	5	42.9	6.7 +- 1.6
Si et al[30] 2016	Retrospective study	80	48.8	96	3-4	108	6.75+-1.91
Zill et al[31] 2016	Retrospective	176	54.9+-10	326	3	60	5.9+-1.7
Najm et al[32] 2018	Retrospective	17	54.2+-9.6	25	3	120	5.4+-2.3

Authors	Stability	Endo-Sinus bone gain (mm	Marginal bone loss (mean)	Implant survival rate (%)	Membrane perforation	Technical complication	Implant Brand
Dp et al[25] 2011	achieve primary stability	-	-	100%	-	One patient encountered bridge loosening twice so replaced with screw retained system.	Straumann AG, Basel, Switzerland
He et al[26] 2011	Primary torque 43N/cm	2.5+-1.5	No bone loss	100%	0	-	Osstem Implant System, Busan, Korea; BEGO Implant System, Bremen, Germany
Fermergård et al[27] 2012	Good primary stability	-	0.5+-0.08mm	94%	-	-	Astra Tech
Nedir et al[28] 2015	achieve primary stability	3.0+-1.4	1.0+-0.9	100%	4	Minor fracture of porcelain veneer of a 3 unit FPD.	Straumann AG, Basel, Switzerland
Spinelli et al[29] 2015	45-55Ncm	6.4+-1.6	0.51+-0.29	98.83%	-	No complication	Nobelspeedy Groovy and nobelactiveinternal, Nobel Biocare AB
Si et al[30] 2016	-	2.16+-1.13	0.50+-1.69	90.60%	-	-	Straumann AG
Zill et al[31] 2016	-	4.5+-1.4	0.5+-0.8mm	92.7%	14	Six patients prosthesis remade, minor complication in 7 patients	Straumann, Waldenburg, Switzerland
Najm et al[32] 2018	-	-	-	100%	4	-	Straumann AG

Study Size:

Two electronic databases contributed a total of 1361 items to the combined literature search (PubMed- 809, Cochrane central- 509). After excluding 292 duplicates, an initial evaluation of titles and abstracts was done which rendered 1049 articles exclusion.

Results:

20 papers in all were obtained for full-text reading[25–43], and 12 potentially pertinent studies were eliminated after full-text evaluation[37–44] for a variety of reasons (Table 2). This systematic review[25–32] included a total of 8 studies for analysis (Table 1). Any disagreement between the reviewers during the articles selection procedure were resolved by discussion. (Figure-1)

Figure-1 shows the flow chart of the selection of the studies.

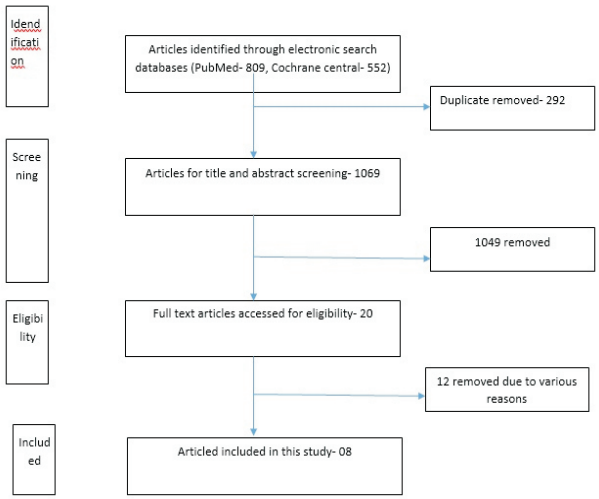

Table-2

Articles excluded from study

S. No	Author	Reason for exclusion
1.	Gu et al [33] 2014	Mean alveolar bone height not adequate
2.	Suk-arj et al [34] 2019	Follow up not adequate
3.	Shi et al[35] 2020	Duplicate study
4.	Rawat et al[36] 2020	Follow up not adequate
5.	Soardi et al[37] 2019	Bone graft substitute used
6.	Bassi et al[38] 2015	Lateral approach
7.	Caban et al[39] 2017	Patients on hypertensive drugs
8.	French et al[40] 2016	Data not sufficient
9.	Trombelli et al [41] 2014	Case series (3 patient)
10.	Attar et al[42] 2018	Bone substitute used
11.	Thomas et al[43] 2018	Bone substitute used
12.	Nedir et al 2010	Duplicate study

Evaluation of the assessed studies' quality:

In table 3 and figure 2, the risk of bias evaluation was presented. Due to convenience sampling or non-probability sampling approaches, which are insufficiently representative of the target population, all studies were deemed inadequate in terms of selection bias. In relation to study design, all studies design were categorised as moderate for being descriptive cohort without control group except only one study[28] which was considered strong for being controlled clinical trial. With respect to control of confounding factor, no studies controlled the confounders in statistical analysis so all the studies were rated weak. Concerning to Blinding, some studies did not describe the blinding and in some studies the evaluation was done by other than the treating professional were rated as moderate[29,30]. In rest of the studies where evaluation was done by the treating professional itself, was considered weak. While the majority of studies claimed to have used reliable, validated methodologies to assess treatment outcomes, not all of them provided proof of this. With the exception of two studies, all of the studies were graded strong in terms of withdrawals and dropouts because these numbers never exceeded 80%.31,32 were rated as moderate because more than 20% of students dropped out or withdrew. Due to the substantial risk of bias evident in all of the included investigations, all of the studies were given a poor rating. (Figure-2)

Figure-2 Risk of bias in 08 articles included in this research.

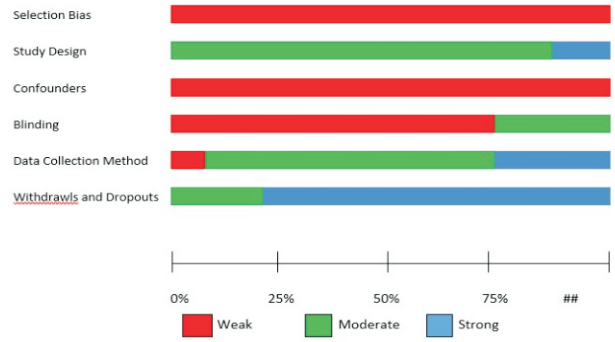

Table-3 Quality assessment of studies included

Study	Selection bias	Design	Confounders	Blinding	Data collection method	Withdrawals and dropouts
Dp et al[25] 2011	Weak	Moderate	Weak	Weak	Weak	Strong
He et al[26] 2011	Weak	Moderate	Weak	Weak	Strong	Strong
Fermergård et al[27] 2012	Weak	Moderate	Weak	Weak	Moderate	Strong
Nedir et al[28] 2015	Weak	Strong	Weak	Weak	Moderate	Strong
Spinelli et al[29] 2015	Weak	Moderate	Weak	Moderate	Moderate	Strong
Si et al[30] 2016	Weak	Moderate	Weak	Moderate	Strong	Strong
Zill et al[31] 2016	Weak	Moderate	Weak	Weak	Moderate	Moderate
Najm et al[32] 2018	Weak	Moderate	Weak	Weak	Moderate	Moderate

Characteristic of the study:

This systematic review included a total of eight investigations, of which two were prospective studies[28–29] and six were retrospective studies[25–27,30–32]. The 404 individuals in the 8 studies that were included had a total of 635 implants put; the patients' mean ages ranged from 40 to 64 years. In each of the studies that were examined, implants were inserted concurrently with the sinus elevation technique.

The healing period for loading of implants was 2-3 months in 1 study[25], 3-4 months in 5 studies[27-28,30-32], 5 months in 1 study[29], and 6 months in 1 study[26]. Concerning the assessment method, 3 studies used intraoral periapical radiography (IOPA)[27,28,31], 2 studies used orthopantogram[25,30] (OPG), 2 studies used Cone beam computed tomography[26,32] (CBCT), and another study[29] used all the three radiographic technique CBCT, OPG along with IOPA. The mean follow up period ranges from 2 years to 10 years; 05 years in 1 study[31], in 3 studies[25-27,29] it was in between 24 to 42 months, more than 100 months in 3 studies[28,30,32]. The included studies' average residual bone height was greater than 5mm. All investigations have indicated a good value for bone gain. In five studies[25,26,28,29,32], the implant protrusion length (IPL) has been examined. All of the included studies analysed the implant survival rate, and only a small number also looked at minor bone loss and associated consequences.

Implant survival rate:

In the reviewed studies the implant survival rate ranged from 90% to 100%. Only 3 studies[27,30,31] reported implant survival rate below 95%, 1 study[29] reported 98.83% and 4 studies[25]26,28,32] had recorded a survival rate of 100%.

The lowest implant survival rate in this systematic review was reported by Si et al[31]. In his study he reported a total of 9 implants failure in which 4 implants failed during the healing phase and another 5 implants were failed after functional loading rendering implant survival rate of 90.6%. He also analysed the implant survival rate association with residual bone height, in which he concluded that patient with more than 5mm RBH had survival rate of 93.5% compared to 78.9% survival rate in pateints having RBH less than 5mm concluding that implant survival rate was high with residual bone height more than 5mm. Zill et al[32], in their study reported With a mean RBH of 5.9mm and 7 implant failures out of 113 implants, the implant survival rate was 92.7%. He also came to the conclusion that the likelihood of implant survival increased by 1.6 times for every additional millimetre in RBH. In four studies[25-26,28,32], the implant survival rate was reported to be 100%.

Changes in bone dimensions:

In the included studies 05 studies have reported dimensions of bone gain, 06 studies mentioned the marginal bone loss and 5 studies had talked about the implant protrusion length (IPL) at a various time intervals.

The maximum mean bone gain was reported by Spinelli et al[29] of 6.4mm over 3 years with mean RBH of 6.7mm. He also reported the mean marginal bone loss of 0.32 mm between baseline to 1 year, 0.1mm between 1 to 2 year, 0.08 mm between 2 to 3 year, indicating stable marginal bone level after 2 years. Cumulative mean marginal bone loss at 3 year follow up was 0.51mm. All implants were able to attain primary stability with insertion torques ranging from 45 to 55 Ncm. Nedir et al[28] reported, endosinus bone gain of 3.2 mm and 3mm, implant protrusion length (IPL) decreased from 4.9mm to 1.5mm and 1.9mm, mean marginal bone loss 0.8mm and 1mm, at 5 and 10 year follow up respectively with mean RBH of 5.4 mm.

Zill et al[31] in his study reported a mean bone gain of 4.5mm with mean RBH of 5.9mm, little bone loss on average of 0.5 mm, of which 84% showed mean MBL of less than 1mm over 5 year of follow up.

Another 2 studies [26,30] reported mean bone gain of between 2 to 3 mm. He et al[26] reported IPL of 3.85mm postoperatively. After 6 months of implant placement, 4 implants apex was covered with bone and no bone coverage was found in remaining 23 implants, suggesting that apex was covered with only sinus membrane or with nothing. Si et al[30] reported a bone gain of 2.95mm and 2.16 mm, mean MBL of 0.46mm and 0.50mm at follow up of 4 and 9 year respectively. Mean IPL was 2.52mm with a range from 0.06mm to 7.30 mm. After follow up of 4-9 years, 46.1% implants showed dense periapical bone in sinus cavities, and 39.3% showed newly formed lamina dura over sinus lining. Suk-arj et al[34] reported the mean IPL of 2.02mm, he

categorized IPL into 3 groups; group 1, 1–1.5 mm; group 2, 2–2.5 mm; and group 3, 3 mm. There were 1.25 mm, 1.86 mm, and 2.38 mm of endo-sinus bone gain respectively in all the three group.

Potential complications.

Membrane perforation was the most frequently reported prosthetic complication, while chipping and fracture of the porcelain prosthesis were the most frequently reported prosthetic problems, according to the papers that were examined. Zill et al[31] reported the maximum membrane perforation in total 14 patients out of 113 patients, 6 patient reported with peri-implantitis during follow up which was treated conservatively. 7 prostheses were remade, 5 due to ceramic fracture and within 1 year of loading and 1 due to aesthetic concern (retraction of gingiva after 6 months). Nedir et al[28] reported membrane perforation at 4 sites where 3 short implants of 8mm and 1 short implant of 6mm were placed. A minor fracture of porcelain veneer of a 3 unit FPD was also reported. Another study[32] reported membrane perforation at 4 sites where 3 short implants of 8mm, and 1short implant of 6mm were placed. He et al[26] did not encountered any complication. Dp et al[25] reported the bridge loosening twice in a patient that was replaced with screw-retained system. Other studies[25,27,30] did not document about complications.

Discussion:

Study Selection and Implant Characteristics:

- Eight studies were included in this systematic review, encompassing a total of 404 patients and 635 implants.
- Implant length ranged from 6 to 13 mm, with a diameter exceeding 4 mm. The most commonly used implant dimensions were 8, 10, 12, and 13 mm in length, and 4.1 and 4.5 mm in diameter.
- Shorter implants (6 and 8 mm) were employed in some studies (28, 31) to address situations involving membrane perforation. These implants demonstrated successful outcomes without complications.
- No significant association between implant size and success rates was observed within the reviewed studies.

Residual Bone Height and Primary Implant Stability:

- Consistent with previous research, the reviewed studies suggest that an indirect sinus lift technique necessitates a minimum residual bone height (RBH) exceeding 4–5 mm to optimize primary implant stability, which was achieved in all included articles.
- Techniques for assessing implant stability varied across the studies. Two investigations (26, 29) employed initial torque values ranging from 30 to 55 Ncm.
- Nedör et al. (24, 29) evaluated stability using finger pressure, while Dp et al. (25) solely mentioned achieving stability without specifying the assessment method.

Residual Bone Height and Implant Failure:

- Si et al. (30) reported a higher incidence of implant failure in individuals with RBH less than 5 mm compared to patients with RBH exceeding 5 mm. However, Gu et al. (28) documented a mean baseline RBH of 2.81 mm, and French et al. did not observe a greater prevalence of complications or implant failures in cases with RBH below 5 mm. Further research is warranted to elucidate this relationship.

Clot Formation and Bone Regeneration:

- The quality of the blood clot directly impacts new bone formation following indirect sinus lift without grafting. The formed clot functions as a scaffold for bone regeneration. Stem cells, growth factors, and anchoring elements play critical roles in this process.
- The effectiveness of this technique significantly depends on the osteogenic potential of the sinus membrane (21, 22) and the surrounding bone acting as an anchoring element (50).

Endosseous Bone Gain:

- All studies reported endosseous bone gain ranging from 1.8 mm to 6.4 mm, aligning with the findings of Martinez et al. who documented a mean gain of 3.43 mm. This opens avenues for further analysis of endosseous gain without grafting materials.

Implant Survival Rate:

- The implant survival rate reported by Martinez et al. in their comprehensive study and meta-analysis of graftless indirect sinus lift ranged from 93.5% to 100%. This systematic review observed a similar range, with survival rates between 90% and 100%.
- Implant survival was evaluated using various criteria. The majority of studies (25-26, 28, 30) employed the criteria outlined by Buser and Cochrane, encompassing:
  - Absence of clinically detectable implant mobility

- Lack of pain or other subjective patient experiences
- Absence of recurring peri-implant infections
- Absence of persistent radiolucency around implants

- Fermergård et al. (27) assessed implant survival based on criteria including clinical stability, absence of implant pain, and no periapical bony defects or peri-implantitis.

- Spinelli et al. (29) utilized the criteria proposed by Van Steenberghe in their study.

- Zill et al. (31) evaluated survival based on the implant quality scale established by the International Congress of Oral Implantologists (ICOI) Pisa consensus conference 2017 (48). This scale categorizes implants into four groups according to clinical circumstances: success (optimal health), satisfactory survival, compromised survival, and failure (clinical or complete failure).

- Certain studies (33, 35, 36) did not discuss the employed implant survival criteria. The reason behind implant failures in these studies could not be determined.

Management of Sinus Perforation:

- Some reviewed articles reported sinus perforations managed by placing short implants via the transcrestal or lateral approach. As discussed by Fugazzotto et al., management of perforated Schneiderian membranes primarily depends on the perforation's location and size.

- In cases of perforation, the implantologist should avoid applying undue pressure to prevent further enlargement. Minor perforations may heal spontaneously, while management of minor perforations can involve bioabsorbable membranes or collagen tape. Suturing or fibrin adhesives can be used to seal larger perforations.

Conclusion:

This systematic review investigated the efficacy of indirect sinus lift without grafting material for implant placement in the atrophic posterior maxilla. The included studies demonstrated promising outcomes, with implant survival rates exceeding 90% (ranging from 90% to 100%). Furthermore, all studies reported evidence of endosseous bone formation, suggesting potential for further research into this technique's ability to promote bone regeneration within the sinus cavity.

However, limitations exist. The studies did not consistently report the criteria used to assess implant failure, hindering the ability to pinpoint the exact causes of failure in some cases. Future research should address this gap by employing standardized criteria for evaluating implant success and failure. Additionally, further investigations are warranted to elucidate the factors influencing implant failure rates and refine this promising technique for optimal clinical outcomes.

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