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Assessment of Implant Stability in Direct and Indirect Sinus Lift Procedure - A Systematic Review and Meta-Analysis

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ABSTRACT

REVIEW ARTICLE

Background and Objective : The sinus lift procedure, also known as maxillary sinus augmentation, aims to augment the bone volume in the maxillary sinus region, facilitating the placement of dental implants with adequate support and stability. The direct sinus lift procedure involves accessing the maxillary sinus through a lateral window approach, followed by elevation of the sinus membrane and placement of bone graft materials. The indirect sinus lift technique involves the use of osteotomes or hydraulic pressure devices to elevate the sinus floor, creating space for bone graft materials without the need for an extensive surgical window. The objective is to systematically review the existing scientific literature in providing a comprehensive, quantitative analysis on effectiveness between direct sinus lift and indirect sinus lift procedure for implant stability.

Methods: Review was adhered to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines 2020 and registered in PROSPERO – CRD42024530982. Electronic databases were searched for studies evaluating the effectiveness between direct sinus lift and indirect sinus lift procedure for implant stability and reporting outcomes in terms of overall mean increase in bone height and development of pain, gingival inflammation and swelling. Quality assessment of included studies was evaluated through Cochrane risk of bias (ROB)-2 tool. The standardized mean difference (SMD) and risk ratio (RR) was used as summary statistic measure with random effect model and p value <0.05 as statistically significant through Review manager (RevMan) version 5.3.

Results: Five randomized controlled trial (RCTs) fulfilled the eligibility criteria and were included in qualitative synthesis and four studies for meta -analysis. Included studies had moderate to low risk of bias. Meta-analysis revealed that pooled estimate through SMD signified that overall bone

height was 0.31 (-2.26 – 1.63) times greater in indirect sinus lift procedure while pooled estimate through RR reported that pain 0.72 (0.46 – 1.13) and gingival swelling was 0.97 (0.51 – 1.84) lesser in direct sinus lift procedure while swelling was 1.26 (0.49 – 3.24) times higher in indirect sinus lift procedure. Funnel plot did not reveal any significant asymmetry indicating absence of possible publication bias in meta-analysis.

Conclusion: Greater increase in bone height was seen with indirect sinus lift procedure. Direct sinus lift procedure was associated more with development of subjective symptoms. Furthermore, clinical studies with greater follow up period and sample size should be conducted to validate our study findings.

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INTRODUCTION

The restoration of posterior maxillary edentulism through dental implantology has witnessed remarkable advancements, offering patients an enhanced quality of life and functional rehabilitation [1]. However, the successful placement of dental implants in cases of limited bone volume remains a significant clinical challenge [2].

The sinus lift procedure, an indispensable technique in implant dentistry, has emerged as a pivotal solution to address this challenge and enable optimal implant integration in the posterior maxilla [3]. The sinus lift procedure, also known as maxillary sinus augmentation, aims to augment the bone volume in the maxillary sinus region, facilitating the placement of dental implants with adequate support and stability [4].

The posterior maxilla is particularly susceptible to bone resorption following tooth loss due to the presence of the maxillary sinus, which gradually expands as a consequence of tooth loss and aging [5]. As a result, the vertical bone height in this region often becomes insufficient for standard implant placement. In response to this clinical dilemma, two primary techniques have been developed: the direct sinus lift procedure and the indirect sinus lift procedure. These techniques have revolutionized implant dentistry by providing clinicians with effective strategies to increase bone volume and enable successful implant osseointegration in cases of compromised bone height [6].

The direct sinus lift procedure involves accessing the maxillary sinus through a lateral window approach, followed by elevation of the sinus membrane and placement of bone graft materials [7]. This technique has evolved over time, incorporating advancements in grafting materials and surgical instrumentation to enhance outcomes and minimize complications [8]. The indirect sinus lift technique, on the other hand, presents an alternative approach to augmenting the sinus floor. It involves the use of osteotomes or hydraulic pressure devices to elevate the sinus floor, creating space for bone graft materials without the need for an extensive surgical window [9]. This technique has gained popularity due to its reduced invasiveness and shorter healing times.

As implant dentistry continues to evolve, it is crucial to critically assess and compare these two sinus lift techniques [10]. Understanding their procedural nuances, indications, contraindications, clinical outcomes, and patient experiences is essential for making informed decisions and achieving successful implant rehabilitation in the posterior maxilla.

To date, the evidence review has not provided a comprehensive quantitative analysis of direct and indirect sinus lift procedures to determine the best choice for implant stability. Therefore,

we updated our research on related articles and conducted a systematic review to compare and evaluate the better implant stability through direct and indirect sinus lift procedures in adults.

MATERIALS AND METHODOLOGY

Protocol development

This review was conducted and performed according to the preferred reporting items for systematic review and meta-analysis (PRISMA) statement [11] and registered in

Prospective Registration of Systematic Review (PROSPERO)- CRD42024530982.

Study design

The following focused research question in the Participants (P), Exposure (E), Comparison (C) and Outcome (O) format was proposed "Is there any difference in the effectiveness between direct sinus lift and indirect sinus lift procedure for implant stability?"

The PICO criteria for this review were as follows:

P (Participants) – patients requiring implant placement

E (exposure) – direct sinus lift procedure

C (Comparison) – indirect sinus lift procedure

O (Outcome) – assessing implant stability in terms of-

Primary outcome- overall mean increase in bone height post-operatively

Secondary outcome- development of pain, gingival inflammation and swelling

Eligibility Criteria:

a) Inclusion Criteria: following were the inclusion criteria

1) Studies published between January 2000 – December 2023 and having relevant sufficient data on the effectiveness between direct sinus lift and indirect sinus lift procedure for implant stability

2) Studies reporting study outcomes in terms of overall mean increase in bone height and development of pain, gingival inflammation and swelling

3) Randomized controlled trial (RCT), comparative and prospective studies were selected

4) Studies from open access journals and published in English language

5) Articles reporting the study outcomes in terms of mean and standard deviation (SD)

b) Exclusion Criteria: following were the exclusion criteria

1) Any studies conducted before 2000

2) Articles in language other than English language

3) Reviews, abstracts, letter to the editor, editorials, animal studies and in vitro studies were excluded

Search Strategy

A comprehensive electronic search was performed till December 2023 for the studies published within the last 23 years (from 2000 to 2023) using the following databases: PubMed, google scholar and EBSCOhost to retrieve articles in the English language. The searches in the clinical trials database, cross-referencing and grey literature were conducted using Google Scholar, Greylist, and OpenGrey.

Appropriate key words and Medical Subject Heading (MeSH) terms were selected and combined with Boolean operators like AND. The relevant data was searched using the following keywords and their combinations: "dental implant" (MeSH term) AND "alveolar bone height" (MeSH term); "maxillary sinus" (MeSH term) AND "direct sinus lift" (MeSH term) AND "indirect sinus lift" (MeSH term); "bone height" (MeSH term) AND "maxillary sinus augmentation" (MeSH term) AND "minimal invasive procedure" AND "atrophic maxilla" AND "guided tissue regeneration" AND "randomized controlled trial" (MeSH term); "comparative study" AND "prospective study" (MeSH term).

Screening Process

The search and screening, according to previously established protocol were conducted by two authors. A two-phase selection of articles was conducted. In phase one, two reviewers reviewed titles and abstracts of all articles. Articles that did meet inclusion criteria were excluded. In phase-two, selected full articles were independently reviewed and screened by same reviewers. Any disagreement was resolved by discussion. When there was no mutual agreement between the two reviewers, a third reviewer was involved to make final decision. The final selection was based on consensus among all three authors. The corresponding authors of study were contacted via email where further information was required.

Data extraction

For all included studies, following study details were extracted under the following heading: author(s), country of study, year of study, sample size, study design, direct and indirect sinus techniques used, parameters assessed, follow up duration and conclusion.

EVALUATION OF METHODOLOGICAL QUALITY

The methodological quality among included clinical trials or randomized controlled trials (RCT) was executed by using Cochrane collaboration risk of bias (ROB) -2 tool [12] through its various domains in Review Manager (RevMan) 5.3 software.

Statistical analysis

Statistical analysis was conducted using RevMan 5.3 with standardized mean difference (SMD) serving as the summary measure. Significance was determined at the threshold of $p<0.05$ [13].

Assessment of heterogeneity

The Cochranes test for heterogeneity was employed to assess the significance of any differences in treatment effect estimations among trials. Heterogeneity was deemed statistically significant if the P-value was <0.01 [14].

Investigation of publication bias

The study assessed publication bias using Begg's funnel plot, which plots the effect size against

standard error. Asymmetry in the funnel plot may indicate potential publication bias.

RESULTS

Study Selection

After eliminating duplicates, the reference list of included studies underwent screening, resulting in the exclusion of studies. Following this, full text articles were assessed for eligibility and articles that did not meet the inclusion criteria were excluded. Five studies were included in the review and four studies were included in meta-analysis as illustrated in **Figure 1.**

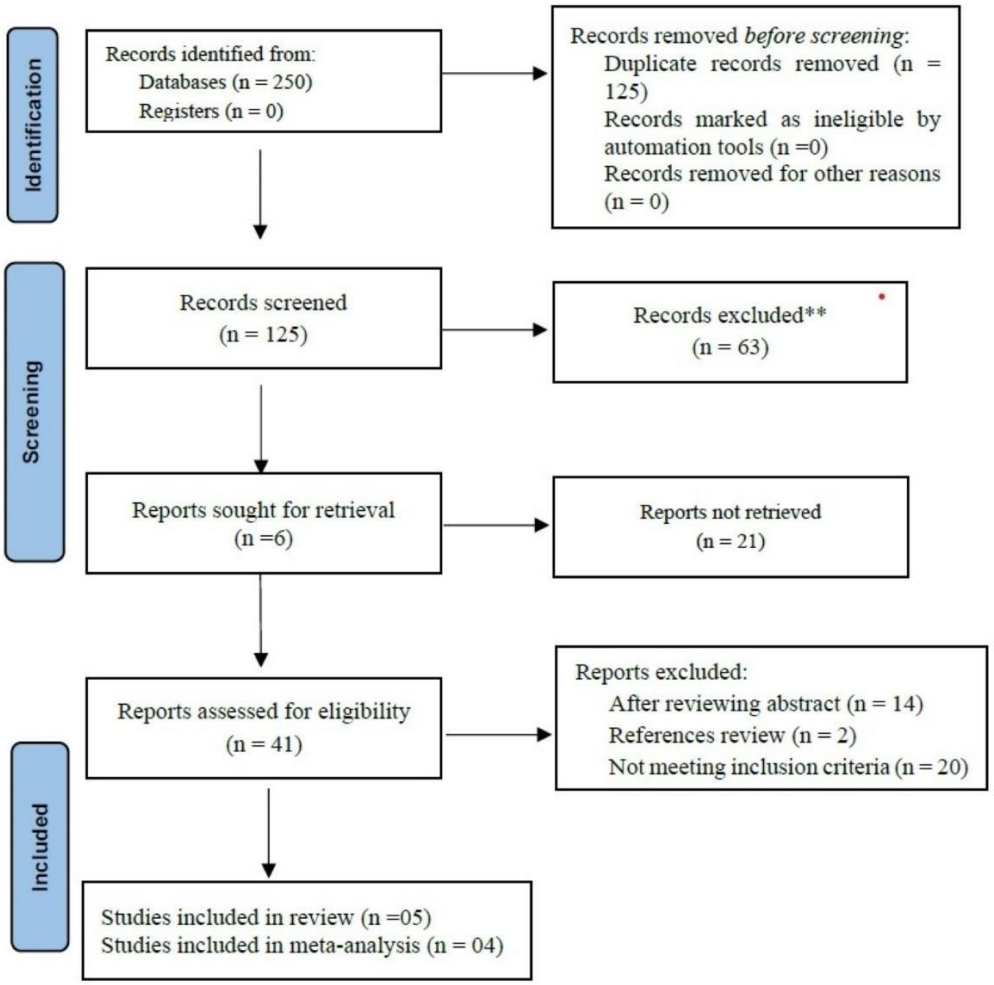

Figure 1. PRISMA 2020 Flow Diagram

STUDY CHARACTERISTICS

As shown in **Table 1** below, data was evaluated from five studies [15-19] from an aggregate of 330 implants of which 149 implants were placed by direct sinus lift procedure and 168 implants by indirect sinus lift procedure. All the included studies had randomized controlled trial study design. Among the included studies, four studies[21-24] were conducted in India and one study [19] in Pakistan. All the included studies compared the two procedures/techniques and evaluated clinical outcome in terms of mean increase in bone height post-operatively and subjective outcomes in terms of development of pain, gingival inflammation and swelling post-operatively. Studies were assessed for a time period of 12th week to 6 months.

Mean increase in bone height post-operatively

Four studies [15, 17-19] assessed the bone height post-operatively. Daniel et al [15] , found a mean bone height of 12.09 ± 0.83 and 12.09 ± 0.83 with direct and indirect sinus lift procedure at the end of procedure. Atiq et al [19] , found a mean bone increase of 12.21±0.77 and 9.05±1.69 with direct and indirect technique while Balaji et al [17]. and Ghatak et al [18] , found that indirect sinus lift procedures showed a greater bone height of 9.53±1.45 and 13.22 compared to direct sinus lift procedure of 6.20±1.31 and 10.13, signifying that indirect sinus lift procedure showed greater overall mean increase in bone height.

Pain, gingival inflammation and swelling

Subjective outcomes like pain, gingival inflammation and swelling were evaluated by two studies [16,19] . Both the studies had a follow up period at 1st, 3rd, 6th and 12 weeks. Pal et al [16] , found pain (6/10 and 8/10), gingival inflammation (5/10 and 3/10) and swelling (5/10 and 3/10) with no symptoms being observed at 3rd, 6th and 12 weeks by direct and indirect sinus lift procedure respectively. Similarly, it was observed that Atiq et al., reported development of pain (9/29 and 13/29), gingival inflammation (12/29 and 15/29) and swelling (6/29 and 8/29) by direct and indirect sinus lift procedure respectively, while no subjective symptoms were seen at 3rd, 6th and 12 weeks.

Table 1: Shows Descriptive Details of Included Studies

Author, years of study	Country	Study design	Sample size	Direct and indirect sinus lift techniques	Parameters assessed	Follow up duration	Conclusion
Daniel et al., 2012 [15]	India	RCT	22	Direct technique – through the canine fossa Indirect technique – osteotome technique	Mean increase in bone height	6 months	Average increase in bone height was greater in direct than indirect technique
Pal et al., 2012 [16]	India	RCT	20	Direct technique – lateral antrostomy Indirect technique – osteotome technique	pain, gingival inflammation status, stability, swelling and bone height	12 weeks	Greater increase in bone height was seen with direct technique

Balaji et al., 2013 [17]	India	RCT	207	Direct technique – osteotome technique Indirect technique – crestal approach	Alveolar width, gain in bone height	Not mentioned	Greater increase in bone height was seen with indirect technique
Ghatak et al.,2017 [18]	India	RCT	20	Direct technique – lateral window technique Indirect technique – bone graft	Gain in bone height	3 months	Greater increase in bone height was seen with indirect technique
Atiq et al., 2022 [19]	Pakistan	RCT	58	Indirect sinus approach – drill between sinus floor and top of skull Direct sinus approach – behind through the canine fossa, opening into sinus antero-laterally.	Pain, gingival inflammation, swelling, mean increase in bone height post-operatively and change in bone height	12 weeks	Lesser gain in bone height was seen with indirect technique

Table 2: Characteristics of excluded studies

Author (year)	**Reason for exclusion**
Khairy N, Abu-Taleb N (2023) [20]	Case series
Riben C, Thor A (2012) [21]	References review
Kumar H, Agarwal A, Thakur MK(2018) [22]	After reviewing abstract
Yassin Alsabbagh A, Alsabbagh MM (2017) [23]	Ex vivo study

Table 3: Assessment of risk of bias in included studies

Sr no.	Authors (Year)	Type of study	Random sequence generation	Allocation concealment	Blinding of participants	Blinding of outcome	Incomplete outcome data	Selective reporting
1	Atiq et al., 2022[25]	RCT	Low	Low	Low	High	Low	Low
2	Balaji et al., 2013[23]	RCT	High	Low	Low	High	Low	Low
3	Daniel et al., 2012[21]	RCT	Low	High	High	Low	Low	Low
4	Ghatak et al., 2017[24]	RCT	High	High	Low	Low	Low	Low
5	Pal et al., 2012[22]	RCT	Low	High	High	Low	Low	Low

The quality of included studies was evaluated based on **Cochrane Collaboration's Risk of Bias Tool**, and accordingly, a numeric score (NOS Score) was assigned. It was designed to evaluate bias based on participant selection, study group comparability in a cross-sectional study, attainment of exposure in case-control studies, and outcome of interest in a cohort study. The NOS uses a nine-star rating system with a maximum of high quality, 4 to 6 will be considered moderate quality, and 0 to 3 will be considered low quality or very high risk of bias. We completed a 'Risk of bias' table for each included study. The high risk of bias was seen for random sequence generation, allocation concealment, blinding of outcome assessment. All of the included studies reported moderate to lowest risk of bias. Domains of incomplete outcome data, selective reporting and other bias were given the lowest risk of bias by included studies

QUALITY ASSESSMENT OF INCLUDED STUDIES

The high risk of bias was seen for random sequence generation, allocation concealment, blinding of outcome assessment. All of the included studies reported moderate to lowest risk of bias. Domains of incomplete outcome data, selective reporting and other bias were given the lowest risk of bias by included studies as depicted in **Figure 2 and 3** as shown below

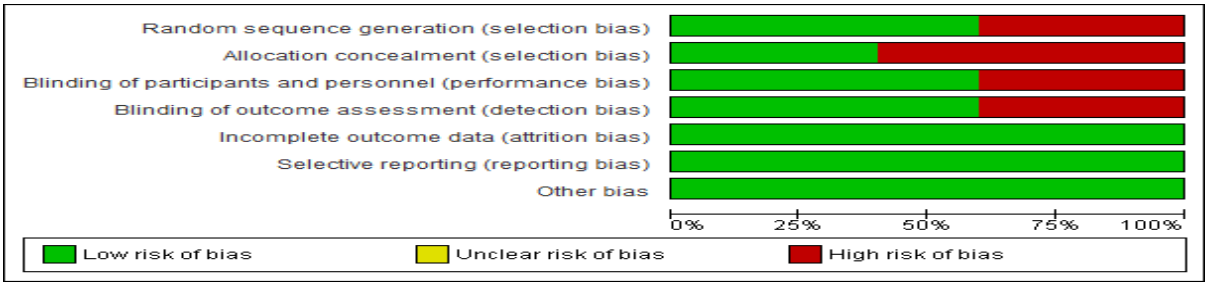

Figure 2: Shows Risk of Bias Graph: presented as percentages across all included studies.

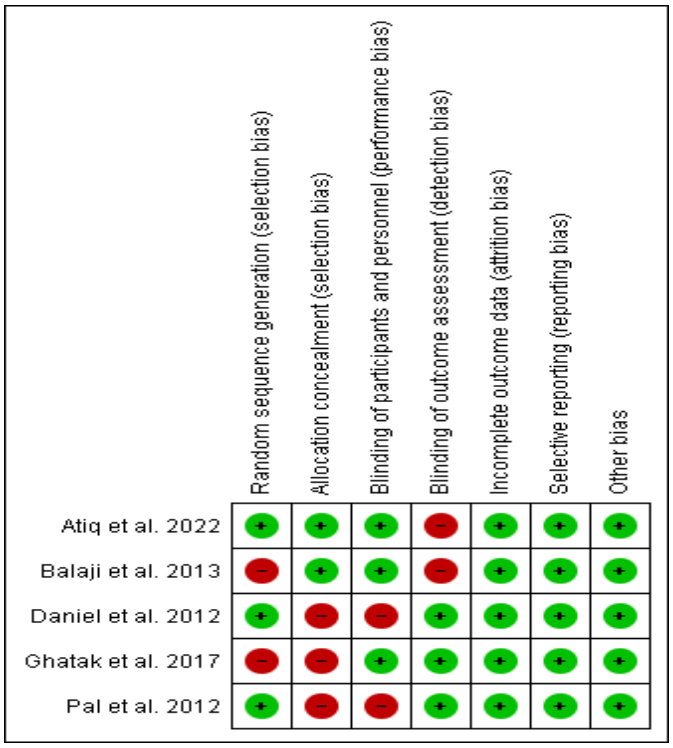

Figure 3: Shows Risk of Bias Summary: for each included study

SYNTHESIS OF RESULTS

The meta-analysis was performed for assessing the effectiveness of direct and indirect sinus lift procedures for implant stability in terms of increase in bone height post-operatively, effect on pain, gingival inflammation and swelling at 1st week **as shown below in figures 4-11.**

A) Mean increase in post-operative bone height

Two studies [15, 17-19] containing data on 297 implants, of which (*n*=139) implants were placed by direct sinus lift and (*n*=158) implants by indirect sinus lift for mean increase in bone height post-operatively. As shown in **Figure 4.** The Standard Mean Deviation (SMD) is 0.31 (-2.26 – 1.63) and the pooled estimates signifies that overall increase in bone height on an average was 0.31 times lesser in implants placed by direct sinus lift procedure (p>0.05).

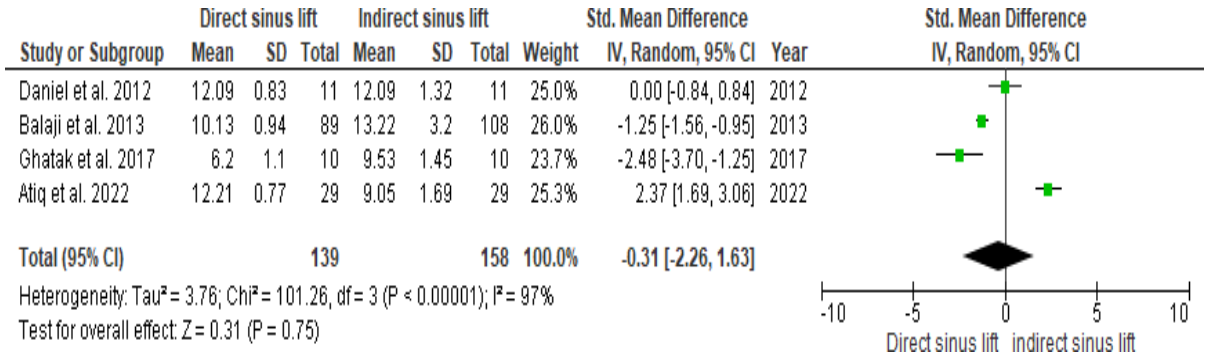

Fig 4: comparison between mean increase in bone height between direct and indirect sinus lift procedure

The funnel plot did not show significant asymmetry, indicating absence of publication bias as shown in **Figure 5.**

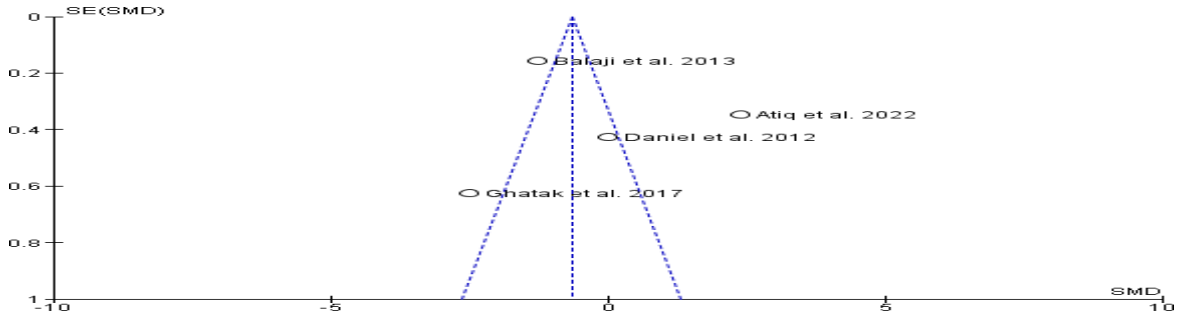

Figure 5: showing Begg's Funnel plot demonstrating absence of publication bias.

B) Pain at 1st week

Two studies [16,19] containing data on 78 implants, of which (*n*=39) implants were placed by direct sinus lift and (*n*=39) implants by indirect sinus lift for development of pain at 1st week post-operatively. As shown in **Figure 6.**

The Risk Ratio(RR) is 0.72 (0.46 – 1.13) and the pooled estimates favours direct sinus lift signifies that overall pain at 1st week on an average was 0.72 times lesser in implants placed by direct sinus lift procedure (p>0.05)

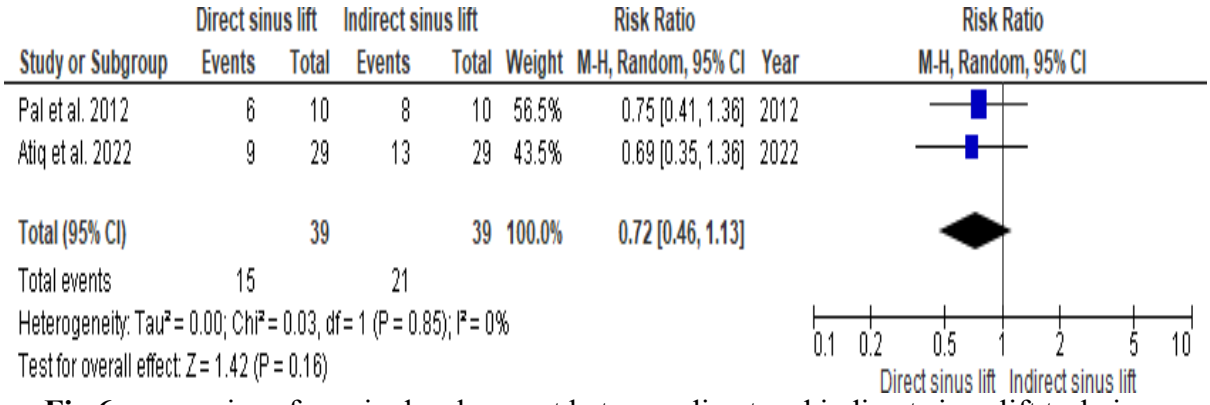

Fig 6: comparison for pain development between direct and indirect sinus lift technique

The funnel plot did not show significant asymmetry, indicating absence of publication bias as shown in **Figure 7.**

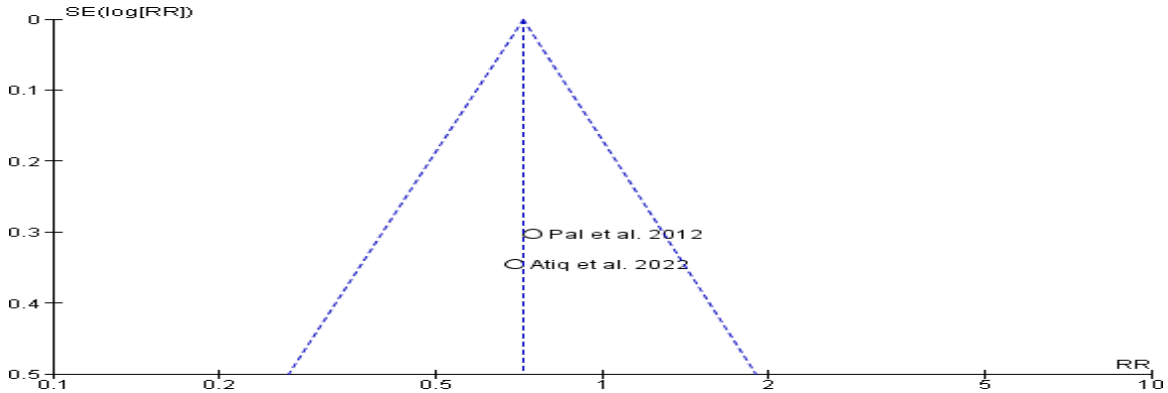

Figure 7: showing Begg's Funnel plot demonstrating absence of publication bias.

C) Gingival inflammation

Two studies [16.19] containing data on 78 implants, of which (*n*=39) implants were placed by direct sinus lift and (*n*=39) implants by indirect sinus lift for development of gingival development at 1st week post-operatively. As shown in **Figure 8.** The Risk Ratio (RR) is 0.97 (0.51 – 1.84) and the pooled estimates favours direct sinus lift signifies that overall gingival development at 1st week on an average was 0.97 times lesser in implants placed by direct sinus lift procedure (p>0.05)

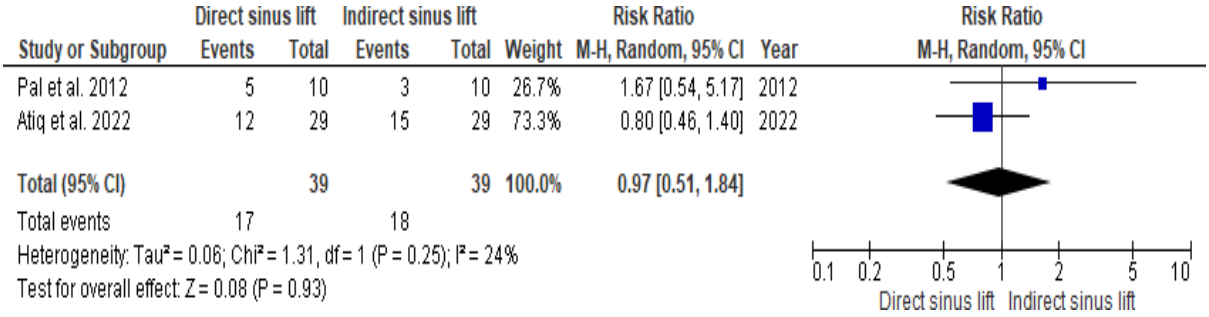

Fig 8: gingival inflammation between direct and indirect sinus lift procedure

The funnel plot did not show significant asymmetry, indicating absence of publication bias as shown in **Figure 9.**

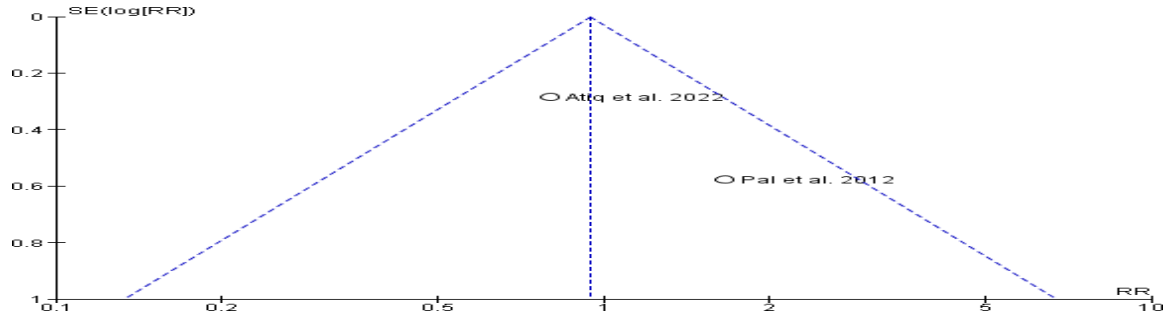

Figure 9: showing Begg's Funnel plot demonstrating absence of publication bias.

D) Swelling

Two studies [16,19] containing data on 78 implants, of which (*n*=39) implants were placed by direct sinus lift and (*n*=39) implants by indirect sinus lift for development of swelling at 1st week post-operatively. As shown in **Figure 10.** The Risk Ratio (RR) is 1.26 (0.49 – 3.24) and the pooled estimates favours indirect sinus lift signifies that overall swelling at 1st week on an average was 1.26 times higher in implants placed by indirect sinus lift procedure (p>0.05).

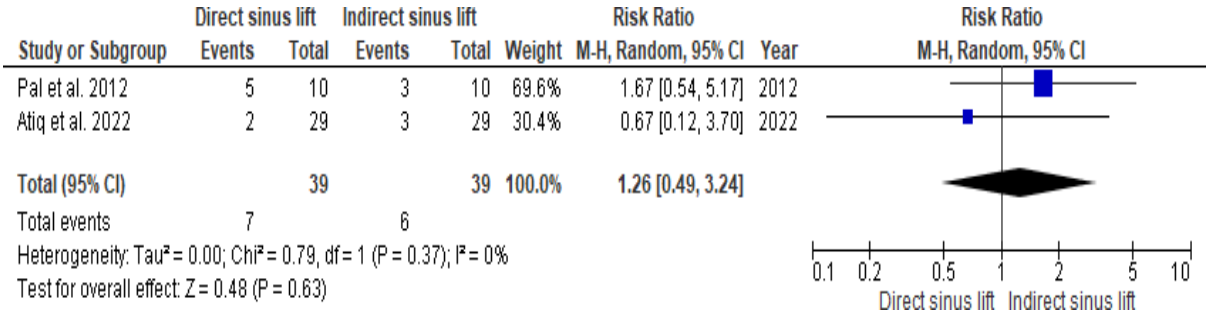

Fig 10: swelling between direct and indirect sinus lift procedure

The funnel plot did not show significant asymmetry, indicating absence of publication bias as shown in **Figure 11.**

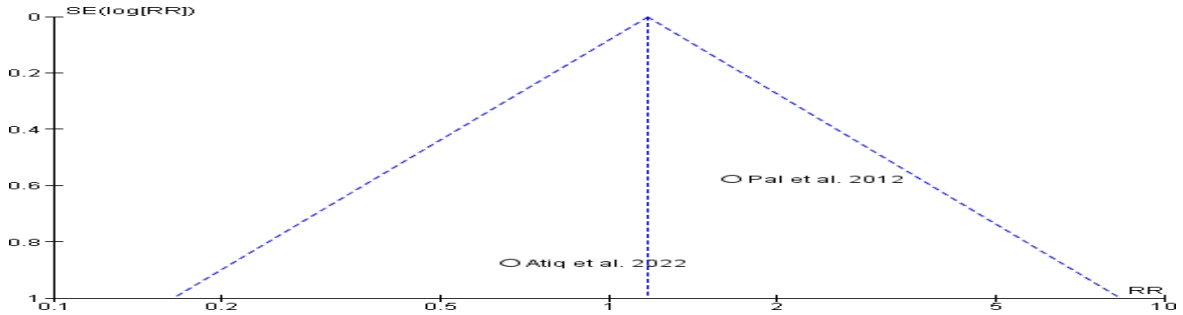

Figure 11: showing Begg's Funnel plot demonstrating absence of publication bias.

DISCUSSION

Wallace et al., 2003 [24] conducted a systematic review on evaluating the effect of maxillary sinus augmentation on the survival rate of dental implants and comparing the results with other surgical techniques, grafting materials and implants. Databases were searched till April 2003. 43 studies, (3- RCTs, 5 controlled trials (CS), 12 case series (CS) and 23 retrospective studies fulfilled the eligibility criteria and were included in review. Among the included studies, 34 were lateral window technique, 5 were osteotome intervention, 2 were local management of sinus floor and 2 were crestal core technique. From the results of the study, it was found that the survival rate of implants placed in augmented sinus with lateral window technique was between 61.7% and 100% with a mean survival rate of 91%.

Potdukhe et al., 2023 [25] conducted a systematic review and meta-analysis to evaluate the difference in primary implant stability and bone height increase in indirect sinus lift using osseo-dentification and osteotome technique. Databases were searched from 2000 to 2022 for RCTs, non-randomized clinical trials and cross-sectional studies, yielding nine studies for systematic review and five studies for meta-analysis. From the results, of the study it was found that for bone height, no significant difference was seen Mean Deviation (MD=0.30 (-0.11 – 0.70)) and for primary implant stability, osseo-densification group was superior to osteotome group with MD=10.61 (7.14 – 14.08). It was concluded that overall osseo-densification was superior to osteotome group ($p<0.05$).

We conducted this systematic review and meta-analysis to analyze on effectiveness between direct sinus lift and indirect sinus lift procedure for implant stability. Databases were searched till December 2023 for randomized controlled trials, comparative and prospective studies comparing these two procedures and reporting outcomes in terms of increase in bone height and development of pain, gingival inflammation and swelling. Five studies[21-25] were included in review and data was taken from 330 implants of which 149 implants were placed by direct sinus lift procedure and 168 implants by indirect sinus lift procedure. All the included studies had presence of moderate to low risk of bias. Meta-analysis was performed to assess these outcomes quantitatively. Through the pooled estimate of SMD, mean bone height was 0.31 (- 2.26 – 1.63) times greater in indirect sinus lift procedure while pooled estimate through RR reported that pain 0.72 (0.46 – 1.13) and gingival swelling was 0.97 (0.51 – 1.84) lesser in direct sinus lift procedure while swelling was 1.26 (0.49 – 3.24) times higher in indirect sinus lift procedure. Funnel plot did not reveal any significant asymmetry indicating absence of possible publication bias in meta-analysis.

The adherence to the PRISMA guidelines, the thorough unrestricted literature search, utilization of reliable methodology with regard to the qualitative synthesis of data, the quality assessment of evidence with the Cochrane ROB -2 tool for included RCTs and comparative studies strengthens this systematic review. The quality assessment of all the included studies showed low-moderate risk of

bias whereas overall quality was high, specifying lack of potential and inevitable sources of bias with limited variability and reporting deficiencies.

However, there were also some limitations. A review of the evidence shows that the literature on comparative evaluation of direct and indirect sinus lift procedure is sparse when evaluating outcomes such as bone height, pain, gingival swelling and pain. Even after an unlimited search and eligibility criteria, there were very few studies with qualitative synthesis and quantitative synthesis. Only five studies were included in the final assessment. More randomized controlled

Trials, prospective or follow-up studies comparing these two surgical procedures are needed to evaluate the above-mentioned results to show a better effectiveness between the two procedures.

In the current systematic review, included studies had a brief observation period and a known risk of bias was taken into consideration. It was found that greater increase in bone height was seen with indirect sinus lift procedure as compared to direct sinu lift procedure. Hence, based on the findings of the included studies, it can be concluded that indirect sinus lift provides better implant stability and increase in alveolar bone height. However, indirect sinus lift procedure was associated with higher incidence of development of subjective symptoms like pain, swelling and gingival inflammation during the 1st week after the procedure. Hence careful planning and decision making plays an important role in long term survival and stability of implants.

CONCLUSION

Direct and Indirect sinus lift has been an important advanced surgical technique for augmentation of alveolar bone height to enhance implant stability and long term survival. From present systematic review, it was found that greater increase in bone height was seen with indirect sinus lift procedure. However, indirect sinus lift procedure was associated with higher incidence of development of subjective symptoms like pain, swelling and gingival inflammation during the 1st week after the procedure. Furthermore, clinical studies with greater follow up period and sample size should be conducted to validate our study findings and to obtain an overall good quality evidence.

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