

# Maxillary sinus augmentation using sinus membrane elevation without grafts - A Systematic Review

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## Abstract

Implants have a predictable outcome and are the foremost treatment modality for prosthetic rehabilitation of edentulous patients. Due to loss of bone after extraction and pneumatization of maxillary sinus, there is insufficient bone volume for implant placement. The direct maxillary sinus lift procedure has been performed with different grafting materials (autogenous bone grafts, alloplasts, allografts, and xenografts) and without grafting material, having new bone formation around the implant. There is no evidence to prove the need for grafting material in all direct sinus lift procedures, hence the need for this review. Previous meta-analysis showed that survival rates of implants placed in grafted maxillary sinuses had similar survival rates whether autogenous, allogeneous, or alloplastic grafts were used. This paper aims to review scientific data on the direct sinus elevation technique without use of any grafting material, volume of new bone formed, and also mechanism behind this technique. Articles were searched from 1997 to October 2014 in PubMed, Google Scholar, and Cochrane CENTRAL. The study eligibility criteria were (1) direct sinus lift procedure without any graft material during implant placement and (2) human or animal studies with a minimum follow-up of 6 months or more. Two authors independently scrutinized the literature and if any controversy was raised, third author's opinion was sought to arrive at a mutual consensus for including the study in the review. Due to the heterogeneity across all studies in all study designs, the data were not pooled and a meta-analysis was not performed. Taking into consideration all factors reviewed in this regard along with the outcomes, the direct sinus lift technique without grafting can be suggested as a viable treatment option keeping in mind the limitations involved. The average bone gain was seen across all studies ranging from 2.37 to 10 mm and with an implant survival rate ranging from 79.9% to 100% across studies.

**Key Words:** Dentistry, implants, maxillary sinus lift, systematic review

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## INTRODUCTION

Osseointegrated implant prosthesis has evolved over the years. Continuous residual ridge resorption is seen after tooth loss.

In the maxillary posterior region, the residual ridge resorption is accompanied by pneumatization of the maxillary sinus. This leads to lack of adequate bone height, and implant placement

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without bone regeneration is not possible. Implant stability is also higher in the mandible than in the maxilla, which further causes unfavorable conditions for implant placement.<sup>[1]</sup> The most commonly used technique to overcome these problems is sinus membrane lift procedure and augmentation of maxillary sinus floor, which was first introduced by Tatum<sup>[2]</sup> and further modified by Boyne and James.<sup>[3]</sup> A 3-year implant survival rate was reported as 90.1% after lateral approach sinus augmentation using a meta-analysis of 48 studies with 12,020 implants in 4000 patients.<sup>[4]</sup>

The alternative method of indirect sinus membrane elevation also known as transalveolar technique was first introduced by Summers.<sup>[5,6]</sup> A set of osteotomes was used to form, shape, and lift the sinus membrane. The maxillary sinus lift procedure has been performed using different grafting materials, mainly involving autogenous bone grafts;<sup>[7-12]</sup> further, a large variety of other grafting materials such as alloplasts, allografts, and xenografts have been used.<sup>[13-15]</sup> The direct sinus lift procedure has also been performed with grafting. There is inconclusive evidence to prove the need for grafting material in direct sinus lift procedures, hence the need for this review. The survival rates of implants placed in grafted maxillary sinuses using meta-analysis showed similar survival rates whether autogenous, allogeneous, or alloplastic grafts were used.<sup>[16]</sup>

### Objective

- To review the scientific data of patients treated with implants using direct sinus elevation technique without the use of any grafting material and evaluate the volume of new bone formed, implant survival rate, implant stability, and complications encountered
- To review the scientific data of animals treated with implants using direct sinus elevation technique without the use of any grafting material and evaluate the volume of new bone formed, implant stability, and complications encountered.

### Primary outcomes

- Height of new bone formation
- Implant survival rate.

### Secondary outcomes

- Implant stability
- Complications encountered
  - a. Presence of bony septae
  - b. Schneiderian membrane perforation.

## METHODOLOGY

Criteria for considering studies for this review are given below.

### Inclusion criteria

- Direct sinus lift procedure without any graft material prior to implant placement

- Human or animal studies with a minimum follow-up of 6 months or more
- Articles in English language – study designs included in this review are animal studies, case report, case series, and experimental studies.

### Exclusion criteria

- Articles having studies done with <6 months follow-up
- Direct sinus lift procedure done other than the lateral window approach.

The PubMed, Google Scholar, and Cochrane were searched, which included human and animal studies till October 2014; a total of 1333 articles were found. Based on the inclusion criteria, a total of 18 articles were identified and included in this review. Only English-language literature was searched.

The search terms used were “sinus,” “implant,” “maxillary sinus augmentation,” “maxillary sinus augmentation without grafts,” and “blood,” “no graft,” “venous blood,” “without biomaterials.”

The included studies based on the inclusion criteria and exclusion criteria are animal studies - 3, experimental study- randomized control trial - 1, observational-descriptive-case report - 1, and case series - 13.

### Study selection and data management

The authors selected the articles that matched the inclusion criteria of the review. The title and abstract of each article were assessed to make this inclusion. If the information present in the abstract was inadequate in making a decision, then the entire article was downloaded and reviewed and a decision for inclusion was finalized. The selected abstracts were then again examined reading the full text and a final decision for inclusion was taken by the authors. Any difference of opinion was discussed and the authors arrived at a common consensus. Data collection of the included studies was done without blinding to the authors. Due to the heterogeneity across all studies in all study designs, the data were not pooled and a meta-analysis was not performed.

## DISCUSSION

### Animal studies

An experimental study conducted by Boyne on *Macaca fascicularis* monkeys showed that when implants were left 5 mm protruding into the sinus, there was bone formation around the implants when observed histologically. The implants were in function for a period of 14 months during which there was no observed mobility of the implants.<sup>[17]</sup>

Palma *et al.* conducted an experimental study on primates where the sinus elevation procedure was done on both sides with and

without graft material and the stability of the implants was also assessed. The results showed no difference between the bone formation and implant stability. Another important observation was that oxidized implant surfaces showed better integration than the turned implants by the better bone implant contact.<sup>[18]</sup>

In another similar animal study, Schweikert *et al.* performed sinus membrane elevation procedure and placed a titanium device. Mineralized bone formation was seen after 6 months, but the amount of bone formation had reduced compared to the initial lift in the membrane. Further, in seven out of the eight cases, the sinus mucosa was perforated by the device. The cause for this could be due to the function of the space maintaining device.<sup>[19]</sup>

### Observational studies

Ellegaard *et al.*, in 1997, placed 38 implants in 24 periodontally compromised patients.<sup>[20]</sup> A fenestration of 10 mm in diameter was prepared in the lateral sinus wall about 5 mm above the anticipated bottom of the sinus. The membrane was lifted and the implants were placed conventionally. The membrane was allowed to settle on the implants, thus forming a secluded space in the sinus. There was no membrane used to cover the lateral sinus opening. Out of the 38 implants, three had failed during the study. Radiographic evaluation revealed some new bone formations above the apex of the implants in most of the cases.

Further, Ellegaard *et al.* carried out a follow-up of their initial study,<sup>[21]</sup> in which a total of 131 implants were placed in the sinus. During their long follow-up of about 10 years, they concluded that implants can be placed successfully in the maxillary sinus in patients who are periodontally compromised.

Lundgren *et al.* conducted a study where 19 implants were placed in 12 maxillary sinuses.<sup>[22]</sup> A reciprocating microsaw was used to prepare the window, and the window was dissected from the sinus membrane and placed in saline. The sinus membrane was then elevated and the implants were placed. The osteotomy for the implant was underprepared in cases where the bone was extremely soft to achieve primary stability. The bony window was then replaced and the flap sutured. After a 12-month postloading follow-up, new bone formation was seen in all cases and the implants were clinically stable.

Chen *et al.*, in 2007, placed 47 implants in 33 patients using the lateral trap door window approach.<sup>[23]</sup> A 2-year follow-up of all the implants showed clinical stability, and radiographically, an increase in average bone height of 4.5 mm was seen.

Thor *et al.* placed 44 Astra Tech implants in the maxillary sinus of twenty patients.<sup>[24]</sup> The surgical procedure done was similar to that of Lundgren. During the follow-up period of about

4 years, only 1 out of the 44 implants failed. Radiographically, a mean bone height gain of 6.5 mm was observed.

Sohn *et al.* placed 21 implants in ten patients.<sup>[25]</sup> Patients were divided into two groups, one placed the bony window back and the other used a nonresorbable membrane to close the lateral window. The results showed new bone formation in all the cases, both in histologic and radiographic evaluations.

Balleri *et al.* conducted a study on 15 patients, in which 28 implants were placed.<sup>[26]</sup> A 1-year postloading follow-up showed a mean bone gain of 5.5 mm which was lesser when compared to the mean initial membrane lift of 8.2 mm.

Lin *et al.*, in 2011, presented a study in 44 patients with eighty implants in the maxillary sinus which was followed for a period of 5 years postloading.<sup>[27]</sup> All implants were clinically stable during the follow-up period, and a mean bone height gain at the end of 5 years was 7.44 mm.

Furthermore, Cricchio *et al.* placed 189 implants in the maxillary sinus in 84 patients and a follow-up of 1–6 years was done.<sup>[28]</sup> At the end of the follow-up period, the survival rate was 98.7%. New bone formation of an average of 12.2 mm was observed in all cases after 6 years.

Moon *et al.* placed 31 implants in the maxillary sinus in 14 patients, with an average of 6.8 months follow-up.<sup>[29]</sup> The lateral window was created using a piezoelectric saw, and after sinus membrane elevation and implant placement, venous blood was injected into the secluded sinus space. New bone formation was seen radiographically, and 38.7% vital bone formation was seen histologically.

In 2012, Kaneko *et al.* placed 21 implants in 11 patients in the maxillary sinus, with an additional titanium bone fixation device.<sup>[30]</sup> New bone formation was seen in all cases with a 95.2% survival rate of the implants.

de Oliveira *et al.*, in 2013, presented a study on ten patients where the unilateral sinus lift procedure was performed.<sup>[31]</sup> In the first-stage surgery, the membrane was lifted and stabilized using a 12 or 14 mm osteosynthesis screw. During the second-stage surgery, implants were placed if adequate bone formation was observed. In 7 out of the 10 patients, it was not possible to place the implants due to the lack of bone quantity or quality. An average bone gain of 2.37 mm was obtained. It was noted that patients who had teeth present close to the sinus lift area showed higher bone formation compared to completely edentulous patients.

A case series presented by Hatano *et al.* on six patients requiring a sinus membrane elevation procedure.<sup>[32]</sup> A standard one-stage

Table 1: Summary of published articles reviewed

Study	Study design	Human/animal	Number of patients	Number of implants	Implant type	One-stage/two-stage	Follow-up (months)	Residual alveolar height (mm)	New bone gain height	Perforation of sinus membrane (%)	Implant survival (%)
Ellegaard et al. (1997)	Case series	Human	24	26/12	Astra/ITI	Two-stage	29.9/25.3	≥3	Bone gain in most of the implants	In a few cases	95/86
Lundgren et al. (2004)	Case series	Human	10	19	TiUnite	Two-stage	12	7 (range 4-10)	Bone gain in all patients	Perforation is described but not specified	100
Ellegaard et al. (2006)	Case series	Human	68	59/72	Astra/ITI	Two-stage/one-stage	64.2 (0-128)/57.5 0-143	≥3	Not specified	Not specified	85.4/79.9
Palma et al. (2006)	Case series	Animal	4	16	Mk III and Mk III TiUnite	Two-stage	6	Not specified	Bone gain seen in both groups	2	100
Chen et al. (2007)	Case series	Human	33	18/29	ITI and SwissPlus/Frialit-2	One-stage/two-stage	24	7.5±2.1	4.5 (range 3-9)	0	100
Thor et al. (2007)	Case series	Human	20	44	Astra	Two-stage	14-45	Range 2-9	6.51 (range 4-10)	41	97.7
Hatano et al. (2007)	Case series	Human	6	14	TiUnite	Two-stage	12.0-34	Range 2-10	Not specified	0	92.9
Sohn et al. (2008)	Case series	Human	10	21	Seven	Two-stage	8.5 (range 6-12)	5 (range 1-9)	Bone gain in all cases	Perforation is described but not specified	100
Balleri et al. (2010)	Case series	Human	15	28	Astra	Two-stage	12	6.2 (range 4-10)	5.5 (range 3-8.2)	Three cases unknown number of sinuses	100
Lin et al. (2011)	Case series	Human	44	80	ITI, SwissPlus and Frialit-2	Both	60	5.1 (range 4.6-6.6)	7.4 (range 5.7-9.1)	Not specified	100
Cricchio et al. (2011)	Case series	Human	84	179	TiUnite	Two-stage	12.0-72	5.7 (range 3.4-8)	5.2 (range 3-7.4)	11	99
Moon et al. (2011)	Case series	Human	14	31	Titanium device	Two-stage	6-8	1.0-8	Bone gain in all cases	2	93.5
Schweikert et al. (2012)	Case series	Animal	4	-	Titanium device	Two-stage	6	Not specified	Bone gain in all cases	3	95.2
Kaneko et al. (2012)	Case series	Human	11	21	SLA	Two-stage	32.5±8.4 (range 24-46)	4.7±1.4 (range 2.5-7.5)	Bone gain in all cases	4	100
Altintas et al. (2013)	RCT	Human	14	24	SLA	Two-stage	6	4-6 mm	Bone gain in all cases	0	100
de Oliveira et al. (2013)	Case series	Human	10	-	Osteosynthesis screw	Two-stage	13-14	3.18	Bone gain in all cases	-	-

RCT: Randomized control trial

surgical protocol was followed, and the membrane was elevated up to 10 mm to accommodate the implants. The elevated sinus space was then filled with venous blood, and the bone window was replaced using tissue glue to stabilize it. One out of the 14 implants failed to integrate in a follow-up period of 6 months. New bone formation was observed in all patients.

In a case letter by Dikicier *et al.*, placement of two implants in the maxillary sinus was studied.<sup>[33]</sup> After the sinus membrane elevation, venous blood was injected into the cavity. Results showed new bone formation around the implants and clinical stability of the implants.

### Prospective clinical studies

Altintas *et al.* conducted a comparative study to view the new bone formation in the maxillary sinus with and without bone grafting. A total of 24 implants was placed in 14 patients.<sup>[34]</sup> All implants were clinically stable over a period of 6 months. At 6 months, new bone formation was observed, but the density of bone in the nongrafted group was higher than in the grafted group.

Bone gain was seen across all studies with a bone gain ranging from 2.37 to 10 mm with an implant survival rate ranging from 79.9% to 100% across studies [Table 1].

### Potential complications

The most common problems encountered during a direct sinus elevation procedure include the presence of a septa or the perforation of the membrane. Septae in the maxillary sinus are more commonly seen in partially edentulous patients than in dentate and completely edentulous patients. In addition, the location of septae in the maxillary sinus is more frequent in the middle region.<sup>[35]</sup>

The presence of a single septum was much more common. Mediolaterally (transversely) oriented septa was a more frequent finding than anteroposteriorly (sagittally) oriented septa.<sup>[36]</sup> The surgical protocol should be modified depending on the site and the size of the septa, two lateral windows can be created on either side of the septa, and the membrane can be elevated separately on each side. Care should be taken while dissecting the membrane adjoining the septa as it can be fragile.

Maxillary sinus membrane perforation is another common complication encountered during surgery. If the tear in the sinus membrane is <5 mm, then extended elevation of membrane in all directions is done until it is possible to lift the membrane without tearing and the perforation is allowed to close on itself. In cases where the perforation is more than 5 mm, then, one or two small holes are drilled with a round bur above the window and the lifted membrane is then sutured to the holes close to

the perforation.<sup>[22,24,29]</sup> Another method to close a tear in the sinus membrane was by gently placing a resorbable membrane over the perforation.<sup>[27]</sup>

### CONCLUSION

Although limited literature is available on this topic, from the literature reviewed, it suggests that this treatment modality is a viable option. This technique has its unique advantages over the conventional treatment option. The technique of maxillary sinus elevation without the use of graft material might be a predictable option in the near future.

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### Conflicts of interest

There are no conflicts of interest.

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