

# Simultaneous sinus lift and implant placement using lateral approach in atrophic posterior maxilla with residual bone height of 5 mm or less. A systematic review

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## ABSTRACT

**Aim** To test both success and survival rate of implant placed simultaneously with sinus lift in atrophic posterior maxilla with a residual bone height of less than 5 mm.

**Materials and methods** A computer search strategy was developed for the following electronic databases: MEDLINE/ PubMed and EMBASE. All the relevant articles were screened involving controlled clinical trials, randomized clinical trials, prospective cohort studies.

**Results:** The selection process yielded 12 studies, published between 1999 and 2016, 6 of which were prospective, 1 was a randomized controlled trial, 5 were controlled studies.

**Conclusions:** Within the limitation of this systematic review, the qualitative data analysis revealed that the survival rate of implants placed in grafted sinus ranged from 61% to 100%; on the other hand, the success rate ranged between 75.3% to 94.8%. No significant differences were detected regarding different grafting materials used. In order to understand if the one-stage procedure is an effective and predictable surgical alternative in critically resorbed maxillae, larger and well designed clinical trials are needed.

**KEYWORDS** Dental implants; Maxillary floor elevation; Survival rate; Success rate.

## INTRODUCTION

The rehabilitation of partially or totally edentulous patients with implant-supported prostheses has become a common practice in dentistry; the posterior maxilla frequently represents a challenging clinical situation caused by the lack of bone due to alveolar ridge resorption and maxillary sinus pneumatization (1). Thus, several surgical options have been proposed to establish an adequate bone volume for implant placement. The sinus floor elevation, using the standard lateral procedure, to allow implant placement in the severely atrophic posterior maxilla was first presented in the late 1970s: the technique was introduced by Tatum and modified by Boyne and James and Wood and Moore (2,3). This procedure has been extensively used during the last 20 years to successfully increase the dimension of the posterior maxilla for implant placement; according to this technique the access to the maxillary sinus is obtained by drilling a bone window in the lateral sinus wall using a small round bur, while ensuring that the sinus membrane remains intact. The sinus membrane is then carefully elevated, mobilised together with the attached bone window and rotated medially. This procedure is usually performed in conjunction with a variety of bone grafting material, including autogenous bone from the iliac crest, the mandibular chin, the mandibular ramus or the calvarium, but also with bone substitutes used alone or in combination with autogenous bone. For this protocol, several studies have claimed success rates >90%, with control periods ranging from 1 to 9 years of follow-up (4,5).

Nowadays two main techniques of sinus lift for dental implant placement are in use: a two-stage protocol with a lateral window approach, followed by implant placement after a healing period; or a one-stage technique using either a lateral or transalveolar approach. The decision making process is mainly based on the amount of residual bone available and the possibility of achieving

primary stability for the inserted implants. Evidence from the literature suggests that the minimum bone height needed to install the implants in the same surgery is 4–5 mm (6,7,8,9). Several clinical studies confirm these data: in a study published by Geurs et al. in 2001 (10) a statistically significant difference in implant loss was demonstrated, where residual bone height was 4 mm or less, when compared with 5 mm or greater original bone height.

Various systematic reviews have recently reported that simultaneous and delayed implant placement have displayed similar survival rates (11); however it must be highlighted that these studies involved many factors that may create a bias, such as the type of graft used for augmentation, the surgical technique and the type of implants (12). A recent prospective study evaluated survival and success rates of the implants simultaneously placed into grafted sinus using rough-surfaced implant (13); a total of 217 consecutive sinus lifting through lateral approach and 462 simultaneous implants were installed. Of the 462 implants, 262 implants were installed in posterior maxilla less than 4mm RABH and two hundred implants were placed in over 5mm RABH. The cumulative survival and success rates were 98.91% and 96.54%; no statistically significant differences were observed in success rate between group 1 and group 2 ( $P=0.3135$ ). The Authors concluded that sinus lifting with simultaneous implant placement could be used to treat atrophic maxilla in patients with minimal RABH when initial stability could be obtained by using taper designed implants. However even if a good success rate is shown, in patients having residual bone height between 1 to 3 mm below the maxillary sinus there might still be a slightly higher risk for implant failures when performing a 1-stage lateral sinus lift procedure. Therefore, the aim of the present systematic review was to assess both survival and success rates of implants placed in grafted sinus, with an average residual bone height of 5 mm or less, when performing a 1-stage surgical procedure.

## MATERIALS AND METHODS

### Protocol

A detailed protocol was designed according to the PRISMA-p (Preferred Reporting Items Systematic review and Meta-Analyses) statement (14,15,16,17) for reporting systematising reviews and AMSTAR checklist (18), in order to improve the quality of the search. Moreover the methodology of this review was performed according to the Cochrane Handbook for Systematic Reviews of Interventions (19). The focus question was: What is the survival rate of dental implants inserted simultaneously with maxillary sinus lift, in atrophic posterior maxilla showing a residual bone height of 5mm or less?

### Types of publications

The present review searched for prospective cohort studies, controlled clinical trials (CCTs) and Randomized controlled clinical trials (RCTs) that analyzed both survival and success rate of implants inserted with simultaneous sinus floor elevation, with a residual bone height of less than 5 mm.

### Study variables

The primary outcome measure selected for this review was the survival rate of the dental implants inserted simultaneously with the maxillary sinus floor elevation in the posterior region of the maxilla with a residual bone height of 5 mm or less; this variable included the following.

1. Survival of implant: implant mobility, persistent pain, presence of continuous peri-implant radiolucency, followed by implant removal due to progressive marginal bone loss and infection were considered as biological failure.
2. Survival of implant prosthesis: any mechanical complications such as implant fracture or platform deformation (mechanical failure) were included.

### Source of information and search strategy

for the identification of studies to be involved in this review, a computer search strategy was developed for the following electronic databases: PubMed/ MEDLINE, EMBASE and Cochrane Library. The search was limited to studies involving human subjects, published in English from January 1998 to October 2017. A further manual search was performed on the following journals: The International Journal of Oral and Maxillofacial Implants, Implant Dentistry, The international journal of oral and maxillofacial surgery, The International Journal of Periodontics and Restorative Dentistry, Clinical Oral Implants Research, Clinical Implant Dentistry and Related Research, Journal of Dental Research, European Journal of Oral Implantology, Periodontology 2000, Journal of Periodontology, Journal of Clinical Periodontology. The search was completed by adding a manual review of the references of the included studies.

The following search string was applied: ("residual bone height" OR "atrophic maxilla" OR "atrophic posterior maxilla" AND "sinus lift" OR "sinus floor elevation" OR "maxillary sinus augmentation") OR ("lateral window" OR "maxillary sinus grafting" OR "lateral approach" OR "sinus graft" AND "dental implants" OR "one stage sinus elevation") OR ("maxillary sinus lift" OR "sinus lift" AND "implant placement" OR "immediate implant placement") OR ("dental implant survival rate" OR "dental implant failure").

### Study selection

Two authors (CD and NN) independently screened the titles derived from the extended search, based on the inclusion criteria; disagreements between the two examiners

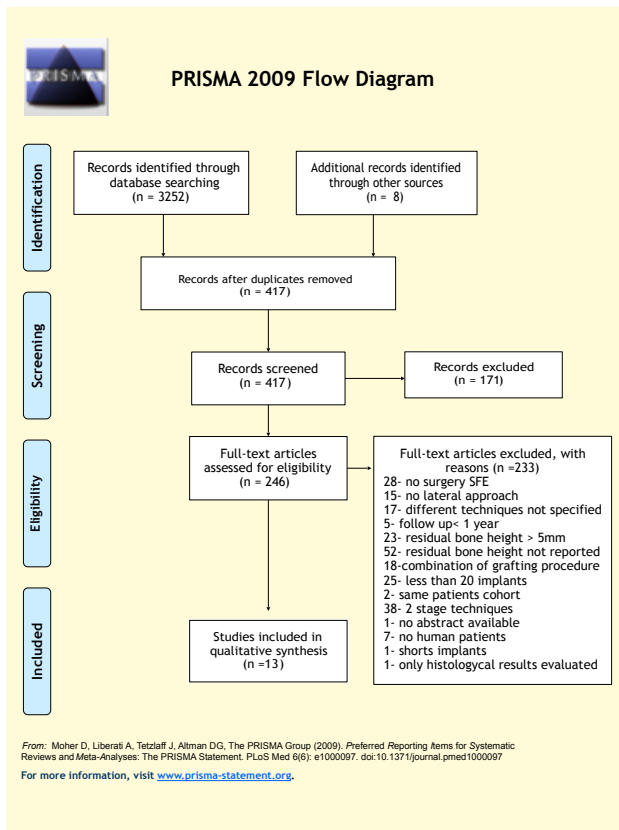


FIG. 1 The PRISMA flow diagram of the selection process.

were resolved through discussion and a Cohen's Kappa coefficient was calculated as a measure of agreement between them. As described in Figure 1, the PRISMA flow diagram shows an overview of the selection process: on the whole 3252 titles were screened; furthermore, an additional hand search, included 8 articles. Following this, all the abstracts of the titles selected by both authors, were searched and screened to ensure they met all the inclusion criteria; again disagreements were resolved by discussion between the two readers. Finally the selection of all the articles, based on the inclusion/exclusion criteria, was made for the full text articles. The screening of each section of the paper (materials and methods and results) was again carried out independently by the two examiners. All the rejected studies (independently of the selected step) were recorded in the "Excluded studies" table and the reasons for exclusion were then described. All disagreements between the two reviewers were resolved by discussion, and Cohen's Kappa coefficient was used as a measure of agreement between them: the K value was 0.66 at title level and 0,76 at abstract level, respectively. Finally, 12 studies were included in this review, as described in Table 1.

### Inclusion criteria

The review of the articles was accomplished in two consecutive screening steps. In the first screening, two

independent review authors screened all the titles and abstracts to eliminate the irrelevant articles or reviews. While, the second screening was aimed at collecting only the pertinent papers: each examiner reviewed the complete text of all articles that passed the first screening, using the following including criteria: human trials with a minimum amount of 20 patients; studies describing at least 15 immediate implants inserted simultaneously to the sinus for elevation, with a residual bone height of a maximum of 5mm; access to the sinus antrum by the lateral window procedure; trials with a follow up interval of at least 1 year after functional loading of the implant placed in the region of the grafted sinus; clearly defined survival or success rate for the implants placed in the region of the sinus floor augmentation; trials describing both the type of grafting material used and the implant surface features.

### Exclusion criteria

Publication concerning *in vitro* studies or animal studies were excluded. All the human studies not fulfilling all the above inclusion criteria, were also excluded. In addition, trials were eliminated if: the publications did not clearly report the baseline residual bone height amount; the papers were narrative reviews; personal communication was included in the paper. Moreover studies with inadequate description of surgical procedure or length of the follow up period were excluded.

### Data extraction and management

For each trial, the following informations from the included articles were collected: author(s), year of publication, study design, details of participants including demographic characteristics, number of inserted implants, residual bone height, surgical procedure details (implant type, graft type), follow up period, outcomes (survival/success rate) description, number and type of complication. Particularly, Schneiderian membrane perforation, infection and graft loss resulting in implant positioning inability were specifically considered as possible complications.

### Quality assessment and risk of bias

The methodological quality of all the included studies was independently evaluated, in duplicate, by the two reviewers; the Cochrane Collaboration's tool for assessing risk of bias was applied for RCTs and CCTs. The following criteria were considered: sample size determination, randomization sequence (selection bias), allocation concealment (selection bias), operators and participant blinding (performance bias), incomplete outcome data (attrition bias), selective outcome reporting (reporting bias), group imbalance and follow up duration. A judgement as to the possible risk of bias on each domain was made from the extracted information, rated as "high risk" or "low risk", when

Author, year	Study design	Implant system	implant design	Group treatment	Number of patients	Number of implants	Survived implants	Failed implants	loading protocol (month)	Mean age	Grafting material	Mean follow-up	Success/survival rate	evaluation method
Simonpiet et al, 2011	PROSPECTIVE COHORT STUDY, single centre	ASTRA-TECH INTRA-LOCK	conical-inter-analhexagn intern hex connection	SFE and simultaneous implant placement	20	52	52	0	6	59,8	L-PRF CLOTS	72 (24-72)m	survival 100% (Misch)	opt
Peleg et al, 1999	PROSPECTIVE COHORT STUDY, single centre	nr		SFE and simultaneous implant placement	63	160	160	0	9	57,5	50% ABG + 50% DFDBA	31 (23-48)m	survival 100% (self defined)	opt
Kahnberg et al, 2001	PROSPECTIVE COHORT STUDY, single centre	branemark systemm, nobel biocare	Conical, external hexagon connection	SFE and simultaneous implant placement	26	93	64	29	6	56	ABG BLOCK (ILIAC)	48 (36-60)m	survival 61,2 % (self defined)	opt
Canullo et al, 2010	PROSPECTIVE COHORT STUDY, multi centre	sweden &martina	conical, internal connection	SFE and simultaneous implant placement	30	67	65	2	3	58,3	HA + SILICE GEL (nanobone)	24 m	survival 97,01 % (self-defined)	
Manso et al, 2010	PROSPECTIVE COHORT STUDY, single centre	STERI-OSS SYSTEM; BRANEMARK SYSTEM MK-III; 3i-OSSEOTITE	Conical, external hexagon connection	1 group: autogenous bone and bioactive resorbable graft	45	160	158	2	3	nr	autogenous (retromolar)+ SBRB (syntetic bioactive resorbable graft)	61,7 (20-132)m	survival 98% success 94,8% (Albrektsson)	ct scans
Cha et al, 201213	CCT, single centre	IMPLANTIUM, DENTIUM Co, Seoul Korea	conical, internal connection	RBH < 5 mm RBH > 5 MM	217	262 200	255 191	7 9	6	NR	BIOSS	57±15,6 (36-98)	CRS 97,3% / (Albrektsson) / 98,91% CRS 95,5% / (survival rate)	opt and periapical
Johansson et al., 1999	CCT, single centre	NOBEL BIO CARE	Conical, external hexagon connection	inlay - block no bone grafting	39 37	131 +123 206	110 200	21 6	6	56	ABG BLOCK (iliac)	36	success 75,3 % (CRS) success 93.1% (CRS) (Albrektsson)	opt
Khour, 1999	CCT, single centre	nr	nr	bone graft from retro molar area bone graft from symphysis	69 147	467	439	28	9	45,5	autogenous (retromolar or symphysis)	49	success 94 % (Albrektsson)	opt
Rodriguez et al, 2003	PROSPECTIVE COHORT STUDY, single centre	nr	nr	SFE and simultaneous implant placement	15	70	65	5	4	nr	DPBB+ PRP	6-36	92,9	ct scans
Mendonca-Caridad et al, 2013	CCT, single centre	STRAUMANN SLA	conical internal connection	SFE and simultaneous implant placement HSB <5mm vs HSB >5mm	15	46	44	2	4-6	53,4	calvaria+ PRP+B-TCP	12,8 mon	95,7% /97,8%	opt
Di Lallo et al, 2014	CCT, single centre	Neoss Proactive	conical, internal connection	1-stage+SFE 3mm 2-stage +SFE <3mm	13	9 10	9 10	0	6	59	Bioss + ABG 50+50	1y	100%	nr
Felice et al, 2014	RCT muticentre	GEASS	conical internal connection	1-stage+SFE 2-stage+SFE	30 30	66 69	63 68	3 1	4	56 54	BIOSS + MEMBRANE	1y	95,45% 98,5%	opt and periapical

TABLE 1 Study and patient characteristics of the included studies.

they met all or all but one or more criteria respectively. Table 2 summarises the results of the quality assessment estimated for the involved studies. While prospective studies were analysed using the NOS (Newcastle Ottawa scale), as illustrated in Table 3.

## RESULTS

### Study selection

As the number of randomized controlled clinical trials (RCTs) was found to be numerically limited (only

		Felice et al	Cha et al	Johansson et al	Khoury
random sequence determination ( selection bias)	1	low risk	high risk	high risk	high risk
	2	a computer a generated restricted random list was created	no randomisation: group 1 included patient with RABH <5mm; group 2 included patients with RABH >5mm	no randomisation: the donor site was established with preoperative radiographs	no randomisation
allocation concealment (selection bias)	1	low risk	high risk	high risk	high risk
	2	after flap elevation, the sequentially numbered opaque sealed envelope containing the group allocation code was opened	-	-	-
blinding of participant and researchers	1	high risk	high risk	high risk	high risk
(performance bias)	2	both patient and surgeon were aware of the allocated arm and would know the randomised type of performed treatment	both patient and surgeon were aware of the allocated arm	both patient and surgeon were aware of the allocated arm	both patient and surgeon were aware of the allocated arm
blinding of outcome assessment	1	low risk	high risk	high risk	high risk
(detection bias)	2	One dentist not involved in the treatment of the patients, made all clinical assessments without knowing group allocation, therefore outcome assessor was blind.	not reported	no	not reported
incomplete outcome data ( attrition bias)	1	low risk	low risk	low risk	low risk
	2	losses to follow up were reported and specified	losses to follow up were reported and explained	losses to follow up were reported and specified	losses to follow up were reported and specified
selective reporting (reporting bias )	1	low risk	low risk	low risk	low risk
	2	all selected outcomes were reported	all selected outcomes were reported	all selected outcomes were reported	all selected outcomes were reported
group imbalance	1	high risk	high risk	high risk	high risk
	2	implant of different type were used	implant of different type were used	implant of different type were used	implant of different type were used
sample size	1	high risk	high risk	high risk	high risk
	2	no sample size calculation was performed	no sample size calculation was performed	no sample size calculation was performed	no sample size calculation was performed
follow up time	1	low risk	low risk	low risk	low risk
	2	patients were recalled every 6 months for 1 year	the mean duration of follow up was 36-98 months.	the mean duration of follow up was 3 year	the mean follow up time was 6 years
clinician bias	1	low risk	low risk	high risk	low risk
	2	the study addressed and specified each of the 3 surgeon performed the interventions; the same for the prosthetic treatment	one surgeon performed all the interventions	one or two surgeons treated the patients	one surgeon performed all the interventions
radiographic outcome	1	low risk	low risk	high risk	high risk
	2	the independent investigators performed the radiographic measurements	an independent examiner interpreted all radiographs	not specified	not reported
1: authors' judgement 2: explanation for judgement					

TABLE 2 Risk of bias assessment for RCT and CCT (Cochrane Scale).

		selection		comparability					total
authors , years	Representativeness of the exposed cohort	Selection of external control	Ascertainment of exposure	Outcome of interest not present at start	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	was follow-up long enough for outcomes to occur ?	adequacy of follow-up of cohorts	
Manso et al,2010	*	*	*	*	*	*	*	*	8/9
Simonpieri et al,2011	0	*	*	*	* 0	*	*	*	7/9
Peleg et al,1999	*	*	*	*	* 0	*	*	*	8/9
Kahnberg et al, 2001	*	*	*	*	**	0	*	*	8/9
Canullo et al,2010	*	0	*	*	* 0	*	*	*	7/9
Rodriguez et al,2003	*	*	*	*	0	*	*	*	7/9

TABLE 3 Newcastle- Ottawa quality assessment scale.

one), different levels of evidence including controlled clinical trials (CCTs), prospective cohort studies (CS) were involved. The electronic search identified a total of 3252 titles; Figure 1 describes the workflow process of identifying the 12 articles included in the study: one randomized controlled clinical trial (20), 5 controlled clinical trials (13,21,22,23,24), and 6 prospective cohort studies (25,26,27,28,29,30). All the selected studies features are shown in Table 2. The first article was published in 1999; the median year of publication is 2001. The overall amount of the implants inserted in these studies is 1777, including 796 patients between 18 and 80 years of age; all the involved trials were mainly conducted in institutional environments such as universities or specialist clinics.

### Included studies

The 12 studies that met the inclusion criteria are illustrated in Table 1; due to the absence of appropriate RCTs, controlled clinical trials and prospective cohort studies were included in the present systematic review. The results were analysed separately for different groups of studies. However, the annual failure rate did not reveal statistically significant differences between the groups, thus displaying a minimal study design effect.

### Exclusion of studies

The main reasons for excluding studies (reference list in Figure 1), after the full text was obtained, were as follows.

1. No information regarding residual bone height.
2. Sample size <20 inserted implants.
3. Only implants placement according to the 2-stage protocol.
4. Combination of grafting techniques.
5. Not reporting on sinus floor elevation procedure.
6. Sinus augmentation via transalveolar approach.
7. Residual bone height > 5mm.
8. No described survival data or no distinction of

survival data between implants placed in sites treated with different grafting techniques.

9. Mean follow up period <1 year.

### Characteristics of the studies

Table 1 describes the most important characteristics of the included studies. On the whole, 796 partially or totally edentulous patients showing a severely resorbed posterior maxilla (less than 5mm) were involved in the included studies. The mean size of the study samples was 128 implants and ranged from 9 to 467 inserted implants; the mean age of patients was 41.9 years (SD= 23.6) and none of the studies focused on the smoking habits of patients. The loading protocol was 6 months in 6 studies, 9 months in 2 studies; only in 2 studies the waiting time before loading the inserted implants was 3 months and 4 months respectively. Dealing with the radiographic evaluation method, in 2 studies (13,20) both periapical radiographs (long-cone paralleling technique) and panoramic radiographs were taken; only 2 studies performed CT scans at follow up visits (25,30). Conversely all the remaining studies used only panoramic radiographs.

### Statistical analysis

For descriptive statistics, the average of implant survival were calculated using the data extracted from the selected studies; data were analysed using SPSS version 18 for Windows (SPSS Inc., Chicago, IL, USA).

For each study, the estimated failure rate and implant survival rate after 1 year (%) were assessed. In this systematic review, an implant failure was defined as each implant from a cohort that was removed because of loss of integration, implant mobility, symptoms as pain, neuropathies, paraesthesia (31). Failures were directly extracted from the publications, as well as the mean follow-up time, supplemented as adjunctive information from the author of the original papers or calculated from the original database.

### Quality assessment and risk of bias of the included studies

Risk bias and quality were assessed by using two different analysis scales, according to the study design, as described in Table 3 and 4. The included randomized controlled trial was well conducted regarding randomization, allocation, data collection, blinding of outcome assessment reporting a low risk of bias. On the other hand the study showed an high risk in the blinding of participant and surgeon (performance bias) and for the group imbalance. Instead none of the included prospective cohort studies achieved the highest score on the NOS; however all studies scored 7 or 8 points, revealing an overall low risk of bias.

### Grafting material

Data from all the included studies could be allocated to at least one of 3 subgroups:

- 1) autogenous bone alone;
- 2) autogenous bone in combination with bone substitutes (alloplasts or xenografts);
- 3) bone substitutes alone.

Within the first subgroup, both block and particulated grafts harvested from different donor sites were included. Autogenous bone has long been considered the gold standard (32), due to its osteoconductive, osteoinductive and osteogenic properties. Intraoral donor sites (chin and ramus) are convenient but yield limited volume; whereas extraoral donor sites (iliac crest, tibia, ulna, rib and calvarium) increase surgical complexity and are associated with significant and often under-reported morbidity and scarring. In 2 studies autogenous bone graft harvested from the iliac crest was used (23,28); the mean survival rates assessed for this subgroup was 77.1 (SD=14.9). In two studies the autograft was harvested along the external oblique line of the mandibular ramus and then particulated using a manual milling machine (24,25). In the subgroup using a combination of grafts, 2 different bone substitutes were used as grafting materials to reduce the volume of bone harvested from different donor sites: SBRB, Syntetic bioactive reservable graft (25), DFDBA, demineralized freezedried bone allograft (27) and Beta-tricalcium-phosphate(32); particularly in this study a laminated calvaria scaffold was used as autogenous grafting material. This group showed a mean success rate of 99%. In the subgroup using only bone substitutes, 2 different grafting materials were applied: DBBM deproteinised bovine bone material (13,20), L-PRF leucocyte and platelet rich fibrin clot (26) and HA and silice gel (nanocrystalline hydroxyapatite granules embedded in a silica gel matrix) (29). In this group the assessed mean survival rate was 95%. It must be highlighted that long term reports are more numerous for autogenous bone graft than for other subgroups; conversely, long term studies using bone substitutes alone are still scarce.

### Survival rate of implants

In this review, all the selected studies reported the survival rate of the implants. We directly used the data of survival rate that was defined as the implant remaining in situ during the overall observation period. 35 The reported survival rate for all the included studies ranged between 96% and 100% after a mean observation period of 12–18 months; in this review a critical source of heterogeneity was the criteria used to describe implant survival/ success rate, which differs from paper to paper. Furthermore, some articles did not clearly report those criteria, so the amount of failure data was directly extracted without attempting to unify the overall success and survival criteria. However, the most important parameters considered as acceptable according to Albrektsson and colleagues' (31,34) success criteria were the following: marginal bone loss, implant mobility, peri-implant infection with suppuration, persistent pain. In one study (26) the survival rate of the inserted implants was evaluated by using the clinical and radiographic evaluation parameters of Misch et al. (34). Instead, one paper (13) clearly declared that the survival rate calculation was performed according to the Kaplan-Meier survival analysis: implant survival was defined as the length of time of implant survival from the date of implant installation to the date of implant failure. Furthermore, implant failure rates were also calculated according to the performed surgical procedure (one stage or two stage): in 1 study 20 patients were allocated into two groups, comparing the one stage technique with the 2-stage technique, with implant placement delayed by 4 months. In all other studies the implants were inserted only according to the one stage technique; implants inserted with a one stage technique showed a slightly higher failure rate, even if there were no statistically significant differences. Several clinical studies showed similar results, confirming that immediate implant placement demonstrated a successful surgical approach, when the bone residual height is moderate, but adequate in order to achieve primary stability (36,37,38). Particularly, in a 1 to 6 year follow up study (39) the authors suggested that the one stage protocol results in a predictable bone formation with a high implant survival rate of 97.6%, even without using bone graft.

### Biological and technical complications

Biological complications were classified as intrasurgical (membrane perforation) or post-surgical complication (acute sinusitis). No biological or technical intrasurgical complication were described or specified in 4 studies (21,23,28,30). Perforation of the sinus membrane was the mostly reported intraoperative complication, although none of the studies showed any correlation between the complication and the implant treatment outcome. Particularly in one study, a total of 35 of

two 217 sinus membranes were perforated and 68 of 462 implants were inserted in perforated sites: only 3 implants of these failed; according to chi square test with Fisher's exact test, there were no statistically significant differences in success rate between implants inserted in perforated or non-perforated sinuses ( $p=0.7162$ ) (13). All the perforated membranes were sealed by using a collagen membrane, as a coverage. Only in one study this kind of complication was related to a graft infection (20); dealing with post surgical complication, one study reported 5 sensory disturbances due to injury of incisive nerve branch, during graft harvesting stage (27); in addition one study reported sinusitis (22).

## DISCUSSION

The purpose of this systematic review was to evaluate survival and success rates of implants simultaneously placed in grafted sinus, with an original residual bone height of less than 5mm. Studies with similar design were compared and in the overall survival rate, no statistically significant differences were found, with regard to the evidence level; these data are consistent with previous reviews (40,41); it must be noted that this systematic review, due to the absence of appropriate RCTs, also involved articles of lower evidence levels, such as controlled trials. The comparison of data from different surgical approaches, varying follow up times, dissimilar success and survival criteria, different grafting materials and implant macro and micromorphologies always affects the validity of the statistical evaluation. For this reason, the main aim of this review was to select the most significant variables, evaluating their effect on the overall database.

Only studies with at least 10 patients monitored at least for 12-month follow up after implant loading were included; regarding the surgical procedure, only studies based on lateral window approach to enter the maxillary sinus were selected; different surgical procedures, such as osteotome sinus elevation, were excluded because they might have represented an important source of bias. Furthermore, studies that did not report the residual bone height or studies with an initial residual bone height, at implant site, of more than 5 mm were not included. In evaluating the factors mainly involved in affecting survival or success rate of implants, it should be noted that only 4 studies (13,21,25,29) reported data regarding the insertion torque and the crown/implant ratio, as a potential risk factor for failure rate. Particularly one study (20) reported that in the 2 stage procedure group, more implants were inserted with a torque higher than 30cmN (97.9% versus 18.2%) while more sites were characterized by soft bone quality at stage-1 implants (81% versus 0%). Conversely, the controlled clinical

trial by Cha et al. (13) reported that, if the initial stability of 15 Ncm was not gained by the torque gauge, a larger diameter implant was used. No other studies report any information regarding the insertion torque. In one study (29) resonance frequency analysis (RFA) was performed to monitor implant stability changes over time: the implant stability quotient (ISQ) was measured at the first surgery (T0), at the abutment connection (T1) and after 2 year follow up (T2). Data analysis showed statistically significant differences ( $P<0.005$ ) regarding ISQ mean values, between T1 and T0, as well as T1 and T2; after 24 months of prosthetic loading, only 2 implants were lost. Particularly, both insertion torque and RFA are considered predictive methods when assessing implant osseointegration at implant placement, as shown in a recent study. (40). None of the selected studies emphasised the importance of the crown/implant ratio, as possible factor affecting the success or survival implants rate. This prosthetic parameter is considered by clinicians as a potential risk factor for biomechanical complication and higher failure rate in areas with soft bone, even if a potentially greater C/I ratio has not yet been demonstrated to result in increased biological complication (41). Furthermore, longer dental implants inserted in augmented and grafted sinus may have an increased failure rate (up to 17%, within 3 years of follow up) when compared to implants placed in native bone (36). In a recent review (42) the calculated mean survival rate of shorter implants was 99% (95% CI 96.4-99.8%) and therefore similar to the mean survival rate of longer implants in the augmented sinus (99.5%; CI 97.6-100.0%). One must consider the important limitations of these findings that still include: the relatively short follow up period; the lack of studies specifying the prosthetic reconstruction type: in all but one clinical study, shorter dental implants were splinted and not restored by single crowns.

A positive or negative influence of splinting implant prosthetic reconstructions has not yet been still demonstrated, even if splinting adjacent implants may improve the stability of the implant at osteotomy site, thus controlling all the micromovements at the interface (43). Finally, regarding the surgical procedure, only one study (20) reported the comparison between the 1-stage and the 2-stage technique, while all other studies involved only the one stage technique. It should be noted that, even in one stage procedure studies, the failure rate is influenced by different variables: the main potential disadvantage is the possibility of not being able to stabilise the inserted implants in a minimal bone height; however in these cases, it is always possible to shift during the surgery to a 2-stage procedure, or the insertion of implants of greater diameter (13), even if higher implant failure probability may be expected (20). On the other hand, the most important advantage of the 1-stage procedure is the



possibility of shortening the healing time by at least 50%. Implant survival rates reported in this systematic review are favourably comparable with data obtained according to the 2-stage procedures: the study by Felice et al. (20) suggested that in patients having a residual bone height between 1 to 3 mm, there might be a slightly higher risk of implant failure when performing the 1-stage procedure. Nevertheless, there is a small quantity of trials comparing the 2-stage surgical procedure, as reported in a recent systematic review by Esposito et al. (44). A study by Wannfors et al. (45) evaluated this comparison at 3-years after loading; 40 edentulous patients with more than 2 mm but less than 7 mm of residual bone height were involved in the study. In the first group, the 1-stage sinus lift was performed, using monocortical iliac bone blocks fixed with 2 implants; in the control group, patients underwent the 2-stage procedure, with particulate bone from the iliac crest. The following outcome measures were studied: implant failure, prosthesis failure, marginal bone level changes and complications (intra-operative sinus membrane perforation). Data analyses showed no statistically significant differences between the 2 groups. A systematic review by Wallace and From (46) identified 8 clinical trials focusing on the comparison between the 2 procedures: the implant survival rate for the combined simultaneous implant placement and delayed placement studies were 89.7% and 89.6% respectively. In evaluating these data, it must be kept in mind the large amount of multiple confounding variables affecting the results of non controlled clinical trials: used biomaterial, type of inserted implant (machined versus rough surface) and presurgical residual alveolar bone height (RABH). It is reasonable to consider the RABH as a key factor for clinicians in choosing a simultaneous or delayed implant placement, because it allows for implant primary stability; however the relevance of the initial residual bone height is a controversial question. Peleg et al. (47) reported 96.4% of survival rate for simultaneous placement of implants in sinus grafts with a 1 to 2mm RSBH and 98.9% for implants inserted >5 mm bone, thus confirming previous reports (27, 48).

## CONCLUSION

The most significant limitation of this systematic review is the different evidence level of the involved studies; particularly, the absence of appropriate randomized controlled clinical trials provided a lower level of evidence, thus requiring the inclusion of prospective and retrospective cohort studies. Within these limitations, the following conclusions can be drawn. The survival rate of implants placed in grafted sinus ranged from 61% to 100%; instead the success rate varied between 75.3% to 94.8%. Nevertheless it must

be highlighted that both success and survival rate have been described using different criteria, thus providing a source of heterogeneity; furthermore some articles did not clearly report the criteria used to describe the implant survival rate.

No significant differences were detected about groups, regarding used grafting materials; these data are consistent with results obtained in a recent review by Esposito et al. (42). In order to understand if the onestage procedure is an effective and predictable surgical alternative in critically resorbed maxillas, larger and well designed clinical trials are needed.

## Conflict of interest

Authors declare that there was no conflict of interest during the elaboration of this paper.

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