Shortened Treatment Time for Maxillary Sinus Grafting with Simultaneous Implant Placement: Retrospective Analysis with 10-Year Follow-Up

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Purpose: The aim of the present retrospective clinical study was to evaluate the outcome of a maxillary sinus lateral window augmentation protocol, which sought to shorten the treatment time. ***Materials and Methods:*** This protocol entailed sinus augmentation with deproteinized bovine bone minerals (DBBM) and simultaneous implant placement in patients with minimal residual bone height. A total of 89 sinus augmentation procedures were performed in 74 patients, in whom 160 implants were placed between 2005 and 2013. The mean residual bone height was 2.6 ± 0.6 mm. The healing time before loading was 4.18 ± 0.63 months. ***Results:*** In a first evaluation in 2014 the early implant survival rate (EISR) was 96.8% after a mean period of 5.4 ± 2.2 years. A second evaluation in 2019 after a mean period of 10.4 ± 2.2 years showed a late implant survival rate (LISR) of 83.1%. The failures after 2014 were all caused by peri-implantitis, which affected 14.6% and 16.8% of patients and implants, respectively. This prevalence of peri-implantitis does not appear to be higher than that usually observed in nonaugmented sites. ***Conclusion:*** This reduction in the duration of treatment compared to the usual duration of 9 to 12 months does not seem to affect the predictability of the technique. *Int J Oral Maxillofac Implants 2022;37:722–730. doi: 10.11607/jomi.9413*

Keywords: atrophic sitres, lateral approach, long-term complications, maxillary sinus augmentation, reduction treatment time

Maxillary sinus grafting using a lateral approach is now recognized as being very effective in the treatment of the atrophic posterior maxilla.[1–4] Regardless of the technique, one- or two-stage, and the grafting material used, the survival rate of the implants is comparable to that observed in nongrafted sites.[5] The typical treatment time has varied from 9 to 12 months, depending on whether a one- or two-stage technique was used.[3] The duration of treatment is often perceived as inconvenient by patients. In order to resolve this issue, ways to shorten this duration without impairing the efficacy of the technique have been considered. There are several ways to reduce this time. A first way would be to reduce the healing time of the graft. We can also imagine placing the implants at the same time as the graft, even with a limited residual bone height. This has been reported with good results after a healing period ranging from 6 to 9 months before the implants are loaded.[6–8] These two possibilities can finally be combined by placing the implants at the same time as the graft, even if the bone height under the sinus is less than 4 mm. The implants would be exposed and loaded after 4 months of healing. In this report, the latter option was used in order to determine if the reduced healing period, the limited residual bone height (RBH), and long-term complications such as peri-implantitis are likely to impair the implant survival rate.

MATERIALS AND METHODS

Study Population

This report follows the STROBE recommendations for observational studies.[9] The patients were treated according to the ethical principles of medical research involving human subjects as laid down in the Declaration of Helsinki in 1975 and modified in 2000. It also complies with the amendments made in Seoul in 2008. The opinion of an ethics committee was not necessary because all patients were treated with a conventional surgical technique. The patients selected met the inclusion and exclusion criteria of the study. The inclusion criteria included: *(1)* RBH inferior to the maxillary sinus of 1 to

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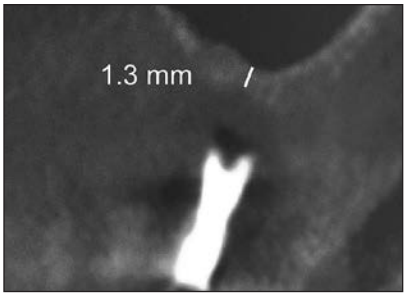

Fig 1 *(Left)* The residual bone height is limited.

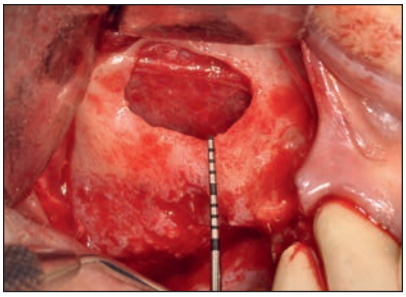

Fig 2 *(Right)* The inferior limit of the window is about 10 mm from the crest of the ridge.

4 mm; *(2)* patients were asked to undergo lateral window maxillary sinus augmentation surgery and simultaneous implant placement and gave informed consent for this; and *(3)* the surgical procedure performed was between 2005 and 2013. Exclusion criteria were *(1)* sinus pathology contraindicating sinus augmentation; *(2)* cigarette smoking, and *(3)* lack of adequate records for a minimum of 5-year and 10-year postoperative follow-ups.

Surgical Procedure

CBCT 3D imaging was conducted to rule out potential sinus pathology, including ensuring the patency of the sinus ostium. Those with substantial pathology were referred to an otorhinolaryngologist to manage any sinus diseases prior to sinus augmentation. The RBH in the planned implant sites was measured in cross-sectional views of CBCTs as the linear distance from the alveolar crest to the floor of the sinus using a surgical template (Fig 1). When several implants were planned, the RBH was expressed as the mean of all implants sites. For all the selected patients, the RBH was less than or equal to 4 mm. All implants were 11 mm in length with a diameter of 4.5 or 5 mm, and all the surgeries were performed by the same surgeon (P.V.).

The patients received amoxicillin plus clavulanic acid starting the day before the surgery and continued for 7 days. Those allergic to penicillin were prescribed clindamycin (600 mg per day) combined with metronidazole (500 mg per day) for the same period of time. In order to reduce postoperative edema and the risk of blocked sinus drainage in cases of sinus ostium stenosis,[10] corticosteroids were prescribed systemically (prednisolone 1 mg/d/kg) and locally[11] (budesonide twice a day in each nostril) from the day before the surgery for 4 days in a single shot and for 2 weeks starting 2 days before the surgery, respectively. Acetaminophen with codeine was used for analgesia. Mouthwash with chlorhexidine 0.12% was recommended from the day after surgery until the removal of the sutures 10 days later. Local anesthesia was administered to address the sources of innervation to the sinus, ie, the infraorbital nerve, posterior superior alveolar nerve, and greater palatine nerve.

The incision design included a crestal incision over the edentulous space, slightly palatal to the crest. An oblique vertical incision was typically placed in the posterior region and another one in the anterior region. A mucoperiosteal flap was elevated to expose the lateral alveolar wall.

The lateral window location was approximately 1 cm in height. Anteriorly, the window was positioned approximately 3 mm posterior to the anterior wall of the sinus. The window was not necessarily extended beyond the position of the last implant to be placed except in the presence of septa. The window dimensions were kept as small as possible to provide more bony walls for graft stability and blood supply. At the same time, adequate dimension of the window was provided to ensure effective maneuvers to dissect the Schneiderian membrane as well as graft insertion using a 1-mL syringe.

Antrostomy was accomplished by removal of the lateral alveolar wall outlined for the window through systematic abrasion of the bone with Piezosurgery (Mectron). In case an alveolo-antral artery with an intraosseous course was detected and the risk of hemorrhage was high,[12] it was dissected using Piezosurgery. The membrane dissection was performed with hand curets. The presence of septa often complicated elevation of the sinus membrane because dissection was performed in a more blind manner in an inferior direction because of the more superior position of the window in order to prevent any bone fracture at the time of implant placement as described below.

In case of perforation of the sinus membrane, the tear was sealed with a collagen membrane (Bio-Gide, Geistlich) stabilized with titanium tacks (Tack System, Geistlich) internally and/or externally, depending on the location of the perforation.[13] All the perforations were recorded and classified according to the RBH. The sinus membrane dissection was continued until it reached the medial and anterolateral walls.

Because minimal residual alveolar bone height was present in all cases, osteotomy for implant site preparation was undersized to obtain adequate primary stability of the implants. The implant system used (Astra Tech, Dentsply Sirona) specified a 0.3- to 0.5-mm differential between the osteotomy and implant diameter. The osteotomy performed in the sites reported here typically had a 1.0-mm differential between osteotomy and implant diameter. In order to minimize the risk of fracturing the bone between the implant osteotomy site and lateral window, at least 8 to 10 mm of distance (Fig 2) was

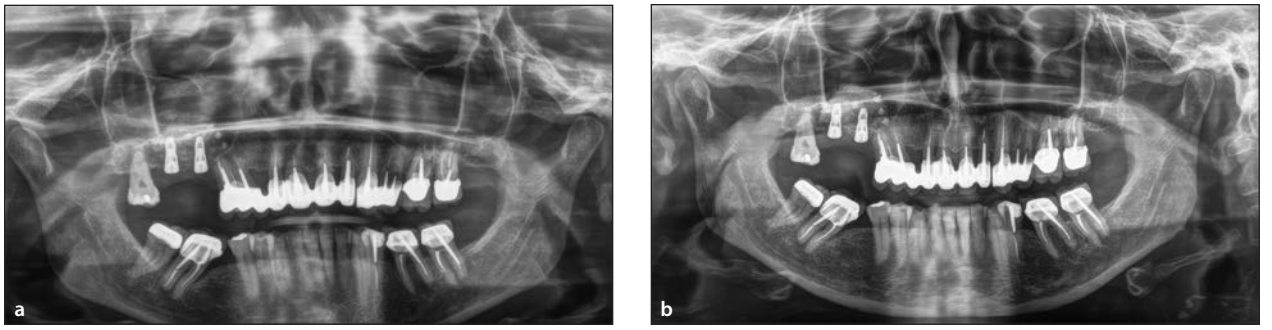

Fig 3 *(a)* Radiopacity of the graft immediately after the surgery. *(b)* Increased radiopacity of the graft after 3 months of healing.

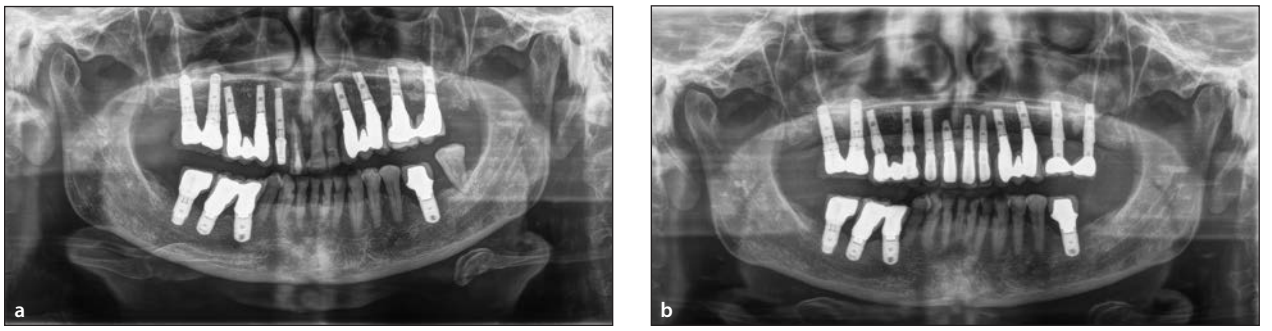

Fig 4 *(a)* Two years after implant loading peri-implantitis has already been established at the maxillary right canine site. *(b)* Peri-implantitis has evolved despite the modification of the prosthesis.

allowed between the antrostomy window and implant site. Large-particle (1.0- to 2.0-mm) anorganic bovine bone mineral (ABBM) graft material (Bio-Oss, Geistlich) was placed using a modified 1-mL syringe beveled at the tip. In order to avoid the collapse of the sinus membrane and its interposition between the bone wall and the graft, the patient was asked to breathe in as the material was injected. The graft was placed layer by layer in order to have a better impregnation by the blood. The material was slightly compacted always toward the bone plate to eliminate any gaps. Once the internal two-thirds were filled, the implants were inserted using the motor and stabilized with the ratchet wrench. Implant macrogeometry selected for cases with minimal residual bone was important. Implants used in the present report had a slight taper at the platform with micro-threads of 0.2-mm pitch. This meant that five micro-threads engaged every 1.0 mm of the osteotomy site.

Finally, the grafting procedure was completed externally, and a collagen membrane was applied above. The crestal incision was approximated with horizontal nonresorbable mattress sutures and sealed with resorbable interrupted sutures. The releasing incision was sutured with resorbable interrupted sutures. The posterior releasing incision was not sutured in order to provide space for drainage. Immediately after the surgery, a panoramic radiograph was taken in order to obtain the starting radiopacity of the graft (Fig 3a). After the procedure, patients were instructed to avoid excessive pressure within the sinus, including refraining from blowing their nose for 2 weeks and sneezing with their mouths open. They were also advised not to perform any Valsalva maneuver if they flew during the month following the operation. After 3 months, a new panoramic radiograph was taken, and the radiopacity was compared with the initial one (Fig 3b).

The implants remained submerged for 4 months and then were uncovered to attach abutments and take an impression for prosthetic fabrication. Two weeks later, the prosthesis splinting the implants was placed. The patients were not monitored on a regular basis after the placement of the prostheses, and no specific periodontal maintenance protocol on a regular basis was implemented.

Implant Outcomes

The survival rate of implants was defined as follows: An implant was considered as "surviving" if there was no mobility and if it was not affected by peri-implantitis, which was diagnosed when there was bleeding on probing accompanied by significant vertical or horizontal bone loss on radiographs compared to baseline levels at prosthesis connection[14] (Fig 4). The following parameters were evaluated at the end of 2014 and 2019: The implant survival rate and the presence of peri-implantitis according to the RBH and the type of edentulism. The soft tissue conditions have not been considered.

Table 1 Study Population Characteristics

Patients, n	74
Female, n (%)	41 (55.4)
Male, n (%)	33 (44.6)
Age, y [mean (±SD)]	59.55 (±10.02)
Preoperative bone height, mm [mean (±SD)]	2.66 (±0.85)
Healing time, mo [mean (±SD)]	4.18 (±0.63)
Early follow-up, y [mean (±SD)]	5.4 (±2.2)
Late follow-up, y [mean (±SD)]	10.4 (±2.2)
Edentulism, n (%)	
Complete	7 (9.5)
Partial	47 (63.5)
Single	20 (27.0)
Grafts, n	89
Perforations (graft-related), n (%)	36 (40.4)
Implants, n	160
Early implant survival (%)	96.9
Late implant survival (%)	83.1
Patient-related peri-implantitis, n (%)	11 (14.6)
Implant-related peri-implantitis, n (%)	26 (16.2)

Table 2 Grafts, Implants, and Edentulism Stratified by Preoperative Bone Height (h, in mm)

	h ≤ 1	1 < h ≤ 2	2 < h ≤ 3	h > 3	*P* value*
Patients, n (%)	7 (9.45)	14 (18.92)	33 (44.59)	20 (27.02)	
Grafts, n (%)	9 (10.11)	17 (19.10)	40 (44.94)	23 (25.84)	.88
Implants, n (%)	19 (11.9)	27 (16.9)	73 (45.6)	41 (25.6)	.521
Edentulism, n (%)					.418
Complete	1 (14.3)	1 (7.1)	5 (15.2)	0 (0.0)	
Partial	5 (71.4)	7 (50.0)	20 (60.6)	15 (75.0)	
Single	1 (14.3)	6 (42.9)	8 (24.2)	5 (25.0)	

*Fisher test for statistical significance, $P < .05$.

Table 3 Number of Grafts and Perforations Stratified by Preoperative Bone Height (h, in mm)

	h ≤ 1	1 < h ≤ 2	2 < h ≤ 3	h > 3	*P* value*
Grafts (patient-related), n (%)	9 (10.1)	17 (19.1)	40 (44.9)	23 (25.8)	.88
Perforations (graft-related), n (%)	1 (11.1)	7 (41.2)	17 (42.5)	11 (47.8)	.619

*Fisher test for statistical significance, $P < .05$.

Table 4 Patient- and Implant-Related Early Failures Stratified by Preoperative Bone Height (h, in mm)

	h ≤ 1	1 < h ≤ 2	2 < h ≤ 3	h > 3	*P* value*
Patient-related early failures, n (%)	0 (0.0)	2 (14.3)	0 (0.0)	0 (0.0)	.034*
Implant-related early failures, n (%)	0 (0.0)	6 (18.5)	0 (0.0)	0 (0.0)	< .001*

*Fisher test for statistical significance, $P < .05$.

Statistical Analysis

Univariate analyses were performed for categorical variables (Fisher tests). Then, multivariate analyses were performed with diagnosis of peri implantitis and failure due to peri implantitis as outcomes. Since several implants were often placed in the same patient, mixed logistic regression models were used with a patient random effect. Dependent variables were introduced in the models when the *P* values were inferior to 0.2 in univariate analysis. Then, covariable selections were made with backward selection of 100 bootstrap samples as already described to determine their inclusion frequencies. The inclusion threshold of 60% kept two covariates in the reduced models. Statistical analyses were performed with R version 4.0, with packages table on, final fit, and Bootstrap AIC.[15]

All associations were considered significant when $P < .05$

RESULTS

Clinical Characteristics of Study Patients

Between 2005 and 2013, a group of 76 patients who wanted a shorter treatment duration were treated with this protocol. There were 43 female and 33 male patients. Two female patients (one fully edentulous and one partially edentulous), representing three sinuses and six implants, were lost to follow-up and therefore have been withdrawn from the study. As a result, the group of patients included in the study thus gathers 74 patients representing 89 sinus grafts and 160 implants (OsseoSpeed, Dentsply) placed simultaneously. The mean age was 59.6 ± 10.0 years. The selected patients were all nonsmokers. The clinical data on study patients are provided in Table 1.

Grafts, implants, and the type of edentulism were divided into four groups based on the residual bone height. They were homogeneous regardless of the height of residual bone under the sinus (Table 2).

During these 89 surgeries, 36 Schneiderian membrane perforations occurred (Table 3). For all patients, the implants were exposed after an average healing period of 4.2 ± 0.6 months (range, 2.6 to 6.9 months; see Table 1), and the prosthesis was placed within the 2 following weeks. The early implant failure rate, as the incidence of peri-implantitis, was evaluated according to residual bone height at the end of 2014 (Table 4). Two patients developed infections within 3 weeks after the procedure. Both had blown their nose at the second postoperative day. This led to graft dislodgment and an

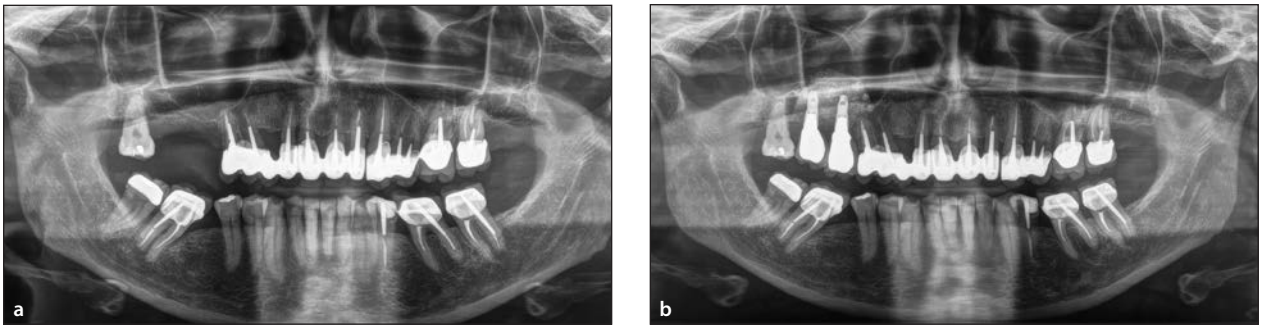

Fig 5 *(a)* Preoperative radiograph. *(b)* Five-year follow-up.

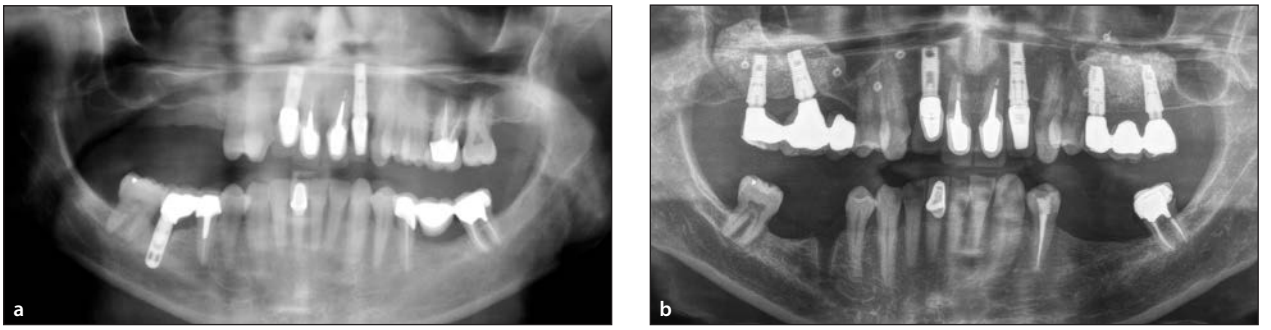

Fig 6 *(a)* Preoperative radiograph. *(b)* Eleven-year follow-up.

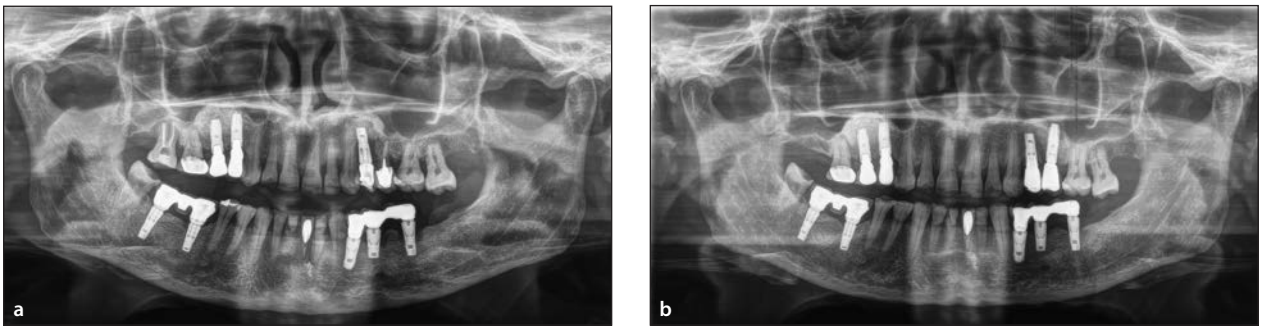

Fig 7 *(a)* Peri-implantitis before treatment at the maxillary left first premolar site. *(b)* After treatment by guided bone regeneration.

acute infection, necessitating removal of grafts and six implants from two sinuses. These were the only implant failures recorded during that period, and no cases of peri-implantitis were diagnosed. This corresponds to an average loading time of 5.4 ± 2.2 years (range, 1.7 to 9.4 years) and a 96.9% of implant survival rate that can be described as the "early implant survival rate" (EIsR; Fig 2; see Tables 1 and 4). In the following period, until the end of 2019, some patients were reviewed because they presented implant infections that turned out to be peri-implantitis, which was diagnosed according to Zitzmann and Berglundh's criteria.[14] During that period, 26 implants were affected by peri-implantitis. At that date, which corresponds to an average period of loading of 10.4 ± 2.2 years (range, 6.7 to 14.3 years), the late implant survival rate (LIsR) was 83.1% (Fig 6; see Table 1). Between 2014 and 2019, all late implant failures were attributed to peri-implantitis. Three manifestations of peri-implantitis were noted: *(1)* limited bone loss that was amenable to regenerative therapy (Fig 7); *(2)* extensive bone loss, confined to the alveolar bone (Fig 8a); and *(3)* large-scale bone loss, with the inflammatory manifestation extending to the sinus with blockage of the sinus ostium (Fig 8b). The implants with limited bone loss (n = 4) were treated with guided bone regeneration[16] and retained. The implants with extensive and large-scale bone loss (n = 22) were removed due to the amount of bone loss. Those associated with sinusitis and ostiomeatal complex blockage required a meatotomy prior to implant removal in order to reduce the risk of an oroantral fistula. The prevalence of peri-implantitis and implant failure is expressed at both the implant level and patient level (Tables 5 and 6). At the implant level, there was no significant association between the prevalence of peri-implantitis and the preoperative residual bone height (see Table 6). When the data were

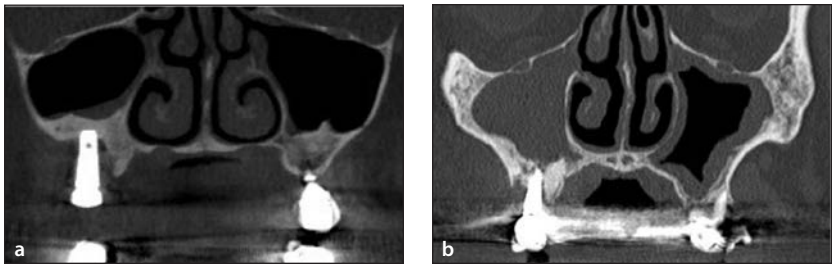

Fig 8 *(a)* Bone defect caused by peri-implantitis without sinusitis prior implant removal. *(b)* Peri-implantitis within the graft with acute sinusitis before meatotomy and implant removal.

Table 5 Patient-related Peri-implantitis (PIp) and Failure Due to Peri-implantitis (PIFp) Stratified by Preoperative Bone Height (h, in mm)

	h ≤ 1	1 <h ≤ 2	2 < h ≤ 3	h > 3	Total (%)	*P* value*
PIp, n (%)	3 (42.9)	3 (25.0)	9 (27.3)	1 (5.0)	16 (22.2)	.127
PIFp, n (%)	2 (28.6)	3 (25.0)	6 (18.2)	1 (5.0)	12 (16.7)	.344

*Fisher test for statistical significance, $P < .05$.

Table 6 Implant-related Peri-implantitis (PIp) and Failure Due to Peri-implantitis (PIFi) Stratified by Preoperative Bone Height (h, in mm)

	h ≤ 1	1 <h ≤ 2	2 < h ≤ 3	h > 3	Total (%)	*P* value*
PIi, n (%)	4 (21.1)	6 (27.3)	14 (19.2)	2 (4.9)	26 (16.8)	.092
PIFi, n (%)	3 (15.8)	6 (27.3)	11 (15.1)	2 (4.9)	22 (14.2)	.107

*Fisher test for statistical significance, $P < .05$.

stratified into four categories according to the initial residual bone height, the risk of peri-implantitis was significantly lower when the residual bone height was greater than 3 mm. However, there was not a significant correlation with implant failure (Tables 7 and 8).

The results of the univariate and multivariate associations of peri-implantitis prevalence and implant failure are presented in Tables 7 and 8. Peri-implantitis and implant failure occurred in younger patients (respectively, OR = 0.96; 95% CI = 0.91 to 1; $P = .049$ and OR = 0.95; 95% CI = 0.90 to 1; $P = .038$). Late failures were more frequent when two sites were involved (n = 12 failed implants [54.5%], OR = 3.11; 95% CI = 1.24 to 7.98; $P = .016$). Peri-implantitis prevalence and late failure were strongly associated with the number of implants (OR = 1.78; 95% CI = 1.27 to 2.57; $P = 0.001$ and OR = 2.14; 95% CI = 1.47 to 3.25; $P < .001$, respectively), the length of follow-up (OR = 1.24; 95% CI = 1.03 to 1.52, $P = .029$ and OR = 1.27; 95% CI = 1.04 to 1.58; $P = .024$, respectively), and complete edentulism (OR = 3.26; 95% CI = 1.23 to 8.37; $P = .015$ and OR = 4.42; 95% CI = 1.62 to 11.84; $P = .003$, respectively). However, in the full mixed models, no significant association was found either with peri-implantitis or late failure. Bootstrap stepwise regression analysis selected the time of follow-up and the number of implants as covariate in the reduced models. In those models, the number of implants was positively associated with the risk of peri-implantitis (OR = 1.84; 95% CI = 1.83 to 1.84; $P < .001$ and with the risk of failure due to peri-implantitis (OR = 2.51; 95% CI = 2.50 to 2.53; $P < .001$).

DISCUSSION

Simultaneous maxillary sinus augmentation and implant placement has been demonstrated to be highly predictable for the treatment of the severely atrophic posterior maxilla.[6,7] However, many clinicians have extended the healing period of these implants by loading them after 6 to 12 months. The aim of the present study was to present the outcome of implants placed simultaneously in conjunction with maxillary sinus augmentation and loaded in less than 6 months. Implant outcomes were reported at 5 and 10 years after implant placement. It is often implied in the literature that the quality and quantity of vital bone obtained by osteoconduction depends on the healing time, potentially influencing the success of osseointegration. However, the literature has not clearly established whether

Table 7 Univariate and Multivariate Association of Peri-implantitis

	Univariable OR (95% CI)	Multilevel OR (95% CI)	Multilevel Reduced Model OR (95% CI)
Age, y	0.96 (0.91 to 1), *P** = .049	0.96 (0.88 to 1.05), *P* = .410	–
Two operative sites	2.13 (0.89 to 5.05), *P* = .085	0.69 (0.07 to 6.53), *P* = .745	–
Preoperative bone height > 3 mm	0.19 (0.03 to 0.69), *P** = .030	0.18 (0.02 to 2.09), *P* = .171	–
Number of implants	1.78 (1.27 to 2.57), *P** = .001	2.10 (0.89 to 4.93), *P* = .089	1.84 (1.83 to 1.84), *P** < .001
Healing time in months	0.61 (0.29 to 1.22), *P* = .177	0.58 (0.17 to 2), *P* = .384	–
Time of follow-up in years	1.24 (1.03 to 1.52), *P** = .029	1.13 (0.78 to 1.62), *P* = .520	1.25 (1.24 to 1.25), *P** < .001
Complete edentulism	3.26 (1.23 to 8.37), *P** = .015	0.67 (0.04 to 9.94), *P* = .768	–

Logistic regression with mixed models for multivariate analysis (patient random effect).
*Fisher test for statistical significance, *P* < .05.

Table 8 Univariate and Multivariate Association of Failure Due to Peri-implantitis

	Univariable OR (95% CI)	Multilevel OR (95% CI)	Multilevel Reduced Model OR (95% CI)
Age, y	0.95 (0.90 to 1), *P** = .038	0.95 (0.84 to 1.06), *P* = .358	–
Two operative sites	3.11 (1.24 to 7.98), *P** = .016	0.89 (0.05 to 15.15), *P* = .938	–
Preoperative bone height > 3 mm	0.24 (0.04 to 0.88), *P* = .063	0.33 (0.01 to 8.67), *P* = .503	–
Number of implants	2.14 (1.47 to 3.25), *P** < .001	2.36 (0.78 to 7.13), *P* = .129	2.51 (2.50 to 2.53), *P** < .001
Healing time in months	1.27 (1.04 to 1.58), *P** = .024	1.18 (0.73 to 1.89), *P* = .498	1.37 (1.36 to 1.38), *P** < .001
Time of follow-up in years	4.42 (1.62 to 11.84), *P** = .003	0.85 (0.03 to 25.16), *P* = .926	–

Logistic regression with mixed models for multivariate analysis (patient random effect).
*Fisher test for statistical significance, *P* < .05.

percentage of vital bone is correlated with implant outcomes and what amount of vital bone is the minimum necessary for successful osseointegration.[17] This point was illustrated by the current data, since no osseointegration failure was observed, despite a reduced healing time, with a 5-year implant survival rate equivalent to that reported with a longer healing time. The primary failures were caused by infections due to baro-trauma. Although those early failures occurred in a case with an initial alveolar bone height less than 2 mm, it is difficult to correlate them with this anatomical particularity. It has been reported in the literature that the quality of bone obtained by osteoconduction using an allograft[18] depends on bone height and sinus width. This does not seem to be the case with a xenograft.[19] Indeed, in this sample, no osseointegration failures were found with single implants in the molar region, where the sinus is particularly wide. The perforation rate of 40.6% is relatively high, without correlation with residual bone height (see Table 3). This high percentage can be explained by the fact that in order to avoid bone fracture during implant placement, the windows were more superiorly positioned. The increased distance between the window and the sinus floor made sinus membrane dissection more challenging, particularly in the presence of septa or sinus floor irregularities. However, the fact that these perforations did not correlate with implant survival may be attributed to proper repair and management of the membrane perforation.

The reported 10-year implant survival rate is lower (83.1%) because of peri-implantitis, whose prevalence has not always been cited after a maxillary sinus graft.[6,7] On the other hand, in a recent study,[8] which compares the one-stage approach to the two-stage one, with a bone height of less than 4 mm, the result is identical for both techniques after an average period of 5 years, but failures due to peri-implantitis were observed for cases beyond 5 years, despite a healing time of about 1 year. It is therefore difficult to conclude that a reduced healing time increases the risk of peri-implantitis. Neither residual bone height nor patient age was correlated to patient-related risk (see Table 5). On the other hand, as in other recent studies,[20,21] an implant-related tendency to peri-implantitis appears when the residual bone height was less than 3 mm (see Table 6). This is confirmed in the univariate analysis (see Table 7). The relationship between residual bone height and the occurrence of peri-implantitis can only be speculated at the present time. In cases with limited alveolar bone height, remodeling is likely to lead to the resorption of the remaining host bone and exposure of grafted bone. It is possible that the presence of nonresorbable

graft material within grafted bone may be more susceptible to peri-implantitis, but this remains to be proven. In the same way, caution should be used in situations with thin mucosal phenotype and a removable interim prosthesis at the graft site. These may lead to early native bone resorption and early exposure of the grafting material to bacterial contamination. But, again, this remains to be proven.

With the multivariate analysis, the risk of peri-implantitis was also associated with the number of implants placed and the degree of edentulism, as well as the duration of follow-up.[22] The possibility of successfully treating peri-implantitis does not depend on the residual bone height (see Table 8). The prevalence of peri-implantitis, either at the patient level (14.6%) or at the implant level (16.2%), was not higher than that found in native bone.[22–25] Thus, it cannot be concluded that a sinus graft is a risk factor for peri-implantitis. Moreover, if we compare these results with those of Stacchi et al,[20] they are much better because in that study, contrary to what was done in the present article, the author used the stricter criteria proposed by Berglund et al[26] in 2018 to define peri-implantitis. This influences the outcome significantly, as demonstrated in a recent study by French et al.[27] The bone lesions resulting from peri-implantitis are often more extensive in the graft site than in the native bone. This is confirmed by one experimental animal study researching the prevalence of peri-implantitis in grafted sites,[28] but this study only considers peri-implant bone defects treated by guided bone regeneration.

It is clear from the present data that it is not loss of integration that is the main cause of implant failure in sites with minimal residual alveolar bone height but rather peri-implantitis, which can lead to the creation of extensive defects that can cause sinusitis that may require graft removal.[29] It will first be necessary to take the same measures[30,31] as for native bone by selecting periodontally stable patients who adhere to a well-structured maintenance program. Other risk factors, such as smoking or diabetes mellitus, with poor metabolic control may also constitute contraindications for this protocol. Other considerations include mucosal phenotype, which may be augmented to allow adequate peri-implant keratinized mucosa. In this study, the soft tissue phenotype was not taken into consideration; therefore, it is not possible to draw conclusions. This is a weak point of this study. Perhaps the prevalence of peri-implantitis would have been reduced if the nature of the soft tissue had been considered and modified accordingly.

Screw-retained prostheses with physiologic contour are also important to consider. Early diagnosis, prevention, and treatment of peri-implant mucositis is an effective strategy in the prevention of peri-implantitis, hence the importance of strict follow-up to diagnose and treat mucositis, which is the only reversible stage of the peri-implant disease. This is even easier with easily removable prostheses such as a screw-retained prosthesis.

As with any study, there are limitations in the present report, which are important to be mentioned: *(1)* the retrospective nature of the study; *(2)* the lack of control to which to compare the outcome; *(3)* one implant design and surface was used; *(4)* only one graft material was used; and *(5)* the lack of consideration of the nature of the soft tissue to be correlated with the prevalence of peri-implantitis. To further validate the protocol proposed in the present study, it will be necessary to design a prospective randomized controlled clinical trial to compare the shortened protocol to the conventional protocol. In addition, it is not known whether the prevalence of peri-implantitis is in any way related to the implant surface or the type of graft used in the present study. Future studies are merited to clarify these questions.

CONCLUSIONS

The present retrospective study serves as proof-of-principle evidence for a shortened treatment protocol in the management of the highly atrophic posterior maxilla. This entailed simultaneous implant placement and sinus graft followed by approximately 4 months of healing time before loading, regardless of the degree of edentulism. The reduced healing time and the limited residual bone combined with the simultaneous implant placement do not negatively influence the implant survival rate after 5 years. The main risk associated with negative outcome was the long-term occurrence of peri-implantitis and subsequent implant failure. This new approach appears to be effective in the midterm but requires an appropriate patient selection and preparation for the prevention of peri-implantitis.

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