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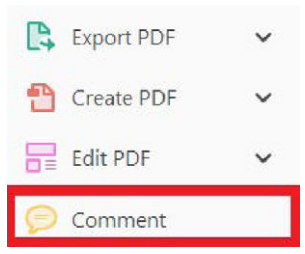

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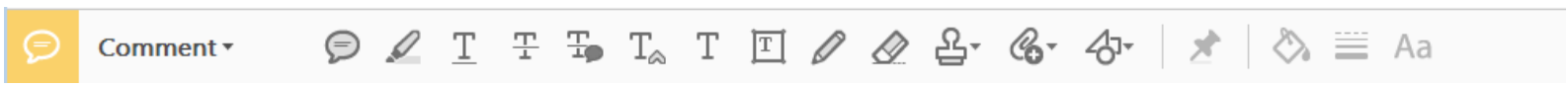

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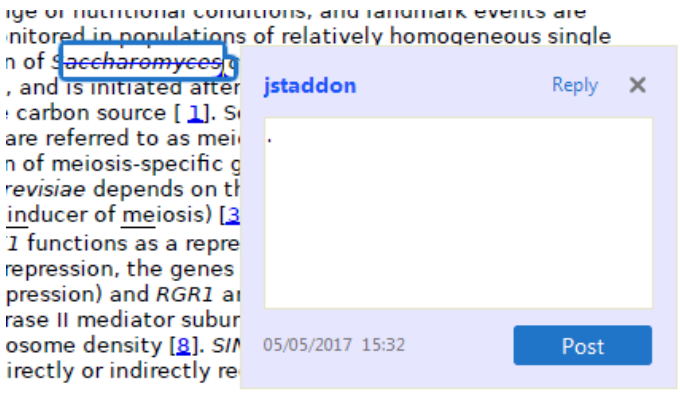

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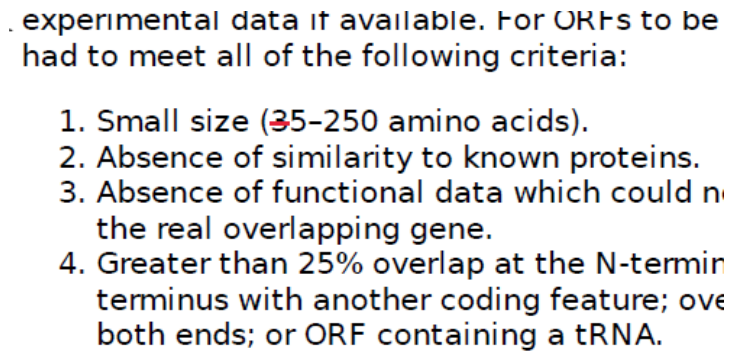
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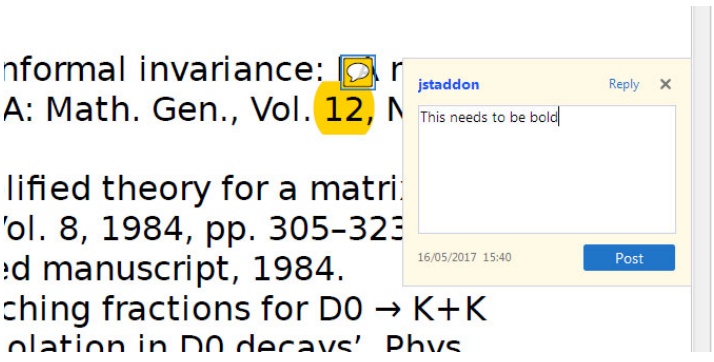

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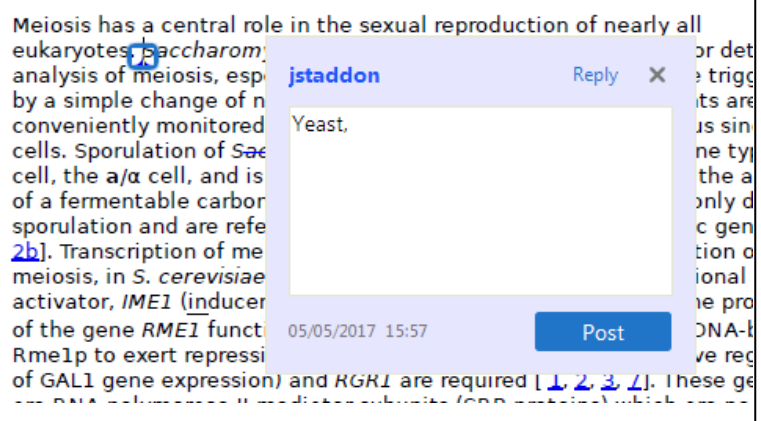

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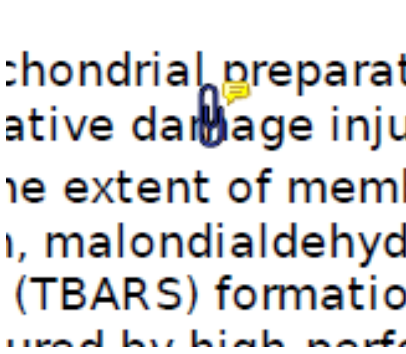

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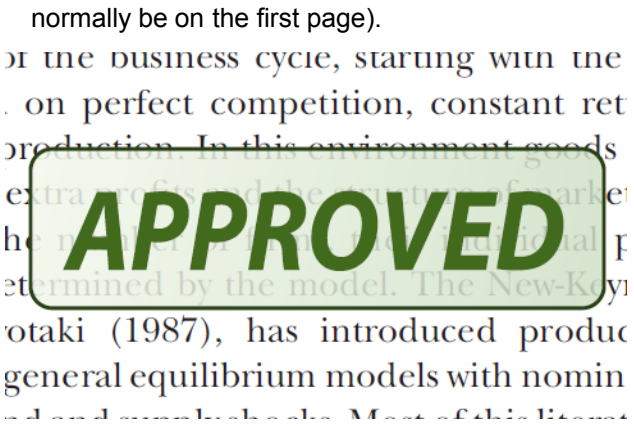

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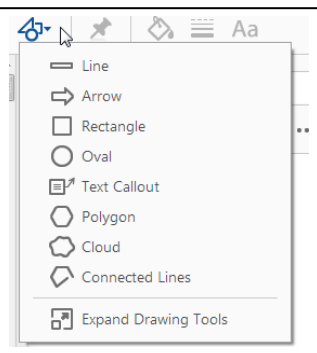

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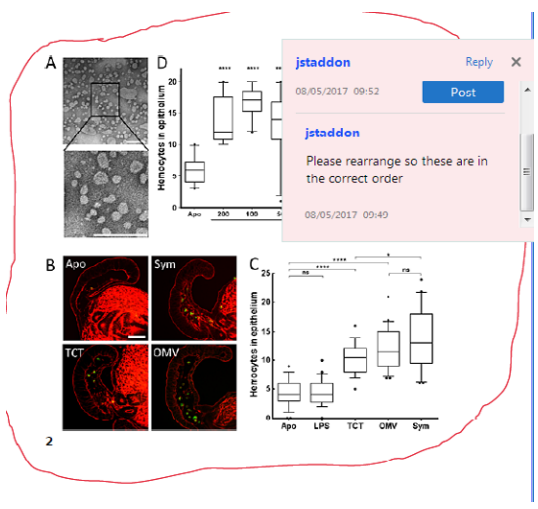

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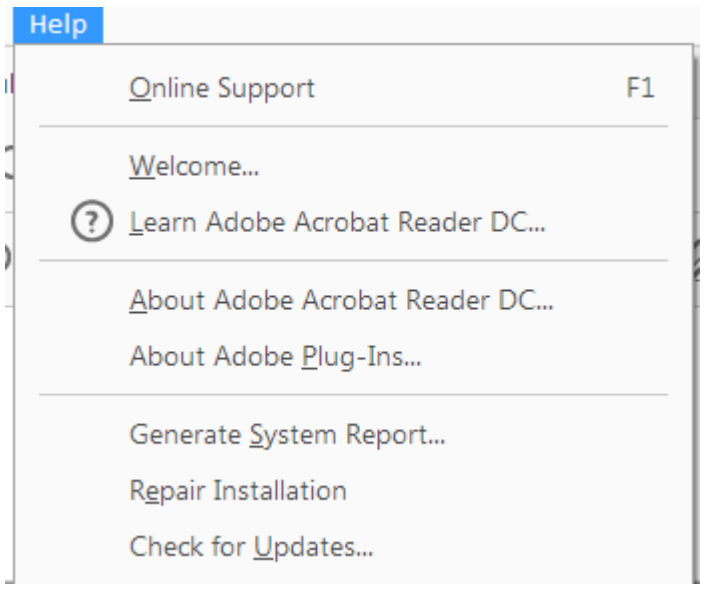

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ARTICLE

Long-term stability of autologous bone graft of intraoral origin after lateral sinus floor elevation with simultaneous implant placement

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Abstract

Background: Lateral approach to maxillary sinus floor elevation (LSFE) with autologous bone grafts and simultaneous implant insertion is a widespread technique for prosthetic rehabilitation of the atrophic maxilla.

Purpose: To analyze implant survival and autologous bone graft resorption after LSFE, in patients with at least 5 years follow-up.

Materials and Methods: Thirty-three patients (mean age 56 years, range 46-68 years) who had undergone LSFE with intraoral autologous bone graft from mandibular ramus and simultaneous implant insertion were included. A minimum of 5 years of follow-up was required. The total peri-implant bone height was measured at mesial and distal aspects of the implants immediately after surgery (T0) and after a period ranging from 5 to 11.5 years after surgery (mean 7.65 ± 1.80 years) (T1) on digital panoramic and periapical radiographs. Wilcoxon matched-pairs signed rank test was used to compare bone graft height at T0 and T1. The influence of patient-, surgery-, and implant-related factors on the outcomes was investigated.

Results: Of the 58 implants placed, no one was lost. All prostheses were in function, and no biological or mechanical complications occurred. The residual ridge height at the involved sites averaged 6.48 ± 1.72 mm. The mean bone height at grafted regions was 12.05 ± 2.47 mm at T0 and 12.13 ± 2.39 mm at T1 (not statistically significant). Marginal bone level change at T1 averaged −1.22 ± 1.60 mm. None of the evaluated factors significantly affected the results.

Conclusion: Autologous bone grafts from intraoral donor sites display excellent volume stability over time that may contribute to optimal outcomes of the procedure.

KEYWORDS

autogenous bone graft, autologous bone, bone resorption, implant survival, maxillary sinus floor elevation, radiographs, sinus augmentation, sinus lift procedure, survival rate

1 | INTRODUCTION

Rehabilitation of the atrophic posterior maxilla has been widely examined in the literature. Different types of studies, including systematic reviews of the literature and meta-analyses, have shown that implant survival rate tends to decrease when residual bone height decreases, and particularly if the latter is less than 5 mm.[1–5] This correlation requires further consideration when planning implant rehabilitation of the posterior maxilla. Residual bone height and width and even bone density may influence implant positioning in the posterior maxilla. In this anatomical region, in fact, inadequate bone quantity and quality often results in low primary implant stability and increased failure rates.[6–8] Advanced periodontal disease and long-term tooth loss further increase bone resorption in the posterior maxilla. In association

with those conditions, a downward pneumatization of the sinus due to increased activity of osteoclasts in the schneiderian membrane may further reduce bone height.[8]

Consequently, sinus floor elevation procedures have become increasingly common in cases of insufficient residual bone height for hosting dental implants.

The two most popular surgical approaches used to manage the atrophic posterior maxilla are lateral window technique, that is, lateral sinus floor elevation (LSFE) and transcrestal approach, that is, crestal sinus floor elevation.[9,10] The choice of the most appropriate surgical technique for sinus augmentation is mainly based on preimplant residual bone height. With a residual bone height greater than 5 mm, the transcrestal approach is usually preferred; otherwise, when the residual bone height is 5 mm or less, lateral window approach with or without the use of autologous bone is indicated.[9,11–14]

The use of autogenous bone grafts has a long history of clinical success in sinus augmentation procedures due to its unique osteoinductive, osteoconductive, and osteogenic properties.[15] Bone substitutes made of synthetic, allogenic, or xenogenic bone have also been widely used for sinus augmentation.[15] Although histomorphometric outcomes of various graft materials used for maxillary sinus augmentation have shown considerable differences,[16] there is no convincing evidence that either implant survival or marginal bone loss are strictly dependent on the type of bone graft used in sinus augmentation.[12–16] Longitudinal randomized controlled trials of large sample size for the evaluation of clinical outcome and efficacy of these different types of bone grafting materials used in sinus augmentation are still scarce, and according to many clinicians autogenous bone graft is still considered the "gold standard."[17,18] However, in addition to the need for an harvesting site, which increases the morbidity to patients, one of the possible drawbacks sometimes reported using autologous bone is its greater than average resorption rate, that could jeopardize the success of the procedure and the longevity of the implants.[19,20] On the other side, a recent systematic review reported that, in spite of a tendency toward greater resorption when using autogenous bone respect to bone substitutes, augmentation volume loss does not seem to compromise implant placement or survival in maxillary sinus augmentation.[21] It has also been pointed out that some features of the autologous graft may be relevant to the resorption process, for example, its form, (block vs particulate grafts[22]), microarchitecture (cortical vs cancellous grafts[23]) and the embryogenesis of the harvesting site (endochondral vs intramembranous grafts[23,24]). Regarding the latter, some studies suggested that intraoral autologous bone grafts (eg, from the ramus or the chin that have an intramembranous origin) have a greater dimensional stability as compared to extraoral autologous grafts (such as the tibia or the iliac crest, that have an endochondral origin), when the site receiving the graft is in the craniofacial region (which has an intramembranous origin).[23,24]

The aim of this retrospective study was to evaluate the dimensional stability of autologous bone grafts harvested intraorally, after at least 5 years of prosthetic function, using digital orthopantomograms and periapical radiographs, after LSFE and simultaneous implant placement.

2 | MATERIALS AND METHODS

2.1 | Patients

Thirty-three patients (20 males and 13 females, mean age 56 years, range 45-68 years) selected from a retrospective cohort of consecutive patients undergoing implant surgery from 2004 to 2010 in the Dental Clinic of the University of Milano Bicocca were included in this study. The study was conducted in full accordance with ethical principles included in the World Medical Association Declaration of Helsinki for biomedical research involving human subjects.[25] All patients had been carefully informed about the procedure and gave their written consent to participate.

2.2 | Selection criteria

The general inclusion criteria for sinus surgery were: patients older than 18 years, able to sign an informed consent form and in general good health (ASA 1-2 following the American Society of Anaesthesiologists classification); patients with posterior edentulous maxilla in need for augmentation of the maxillary sinus floor in order to be rehabilitated using fixed prostheses supported by standard size implants (≥10 mm length); residual bone height in the posterior maxilla region intended for implant placement ranging from 4 to 9 mm as determined by preliminary diagnostic CT evaluation. In case the residual bone volume and density was sufficient to provide optimal implant primary stability, implant placement was performed simultaneously to the sinus lifting procedure.

Patient exclusion criteria were: presence of active infection or inflammation (eg, maxillary acute sinusitis) in the area intended for sinus floor augmentation and implant placement; presence of systemic diseases such as uncontrolled diabetes or any disease affecting bone metabolism; patients immunosuppressed or immunocompromised; patients who underwent irradiation to the head and neck regions within 12 months before surgery; severe bruxism or clenching habits; pregnant or nursing women; inadequate oral hygiene (full-mouth plaque score and full mouth bleeding score >25%); and poor motivation to follow the protocol instructions and to regularly return at follow-up controls.

Only patients treated with LSFE using intraorally harvested autologous bone from mandibular ramus and simultaneous placement of dental implants for prosthetic rehabilitation of the posterior maxilla, and having performed the latest clinical and radiographic control visit at least 5 years after prosthesis delivery, were selected for the present study.

2.3 | Surgery and implants

All patients were given antibiotics prior to surgery (1 g of amoxicillin for 2 days). In brief, a mucoperiosteal flap was raised to expose the lateral wall of the sinus. A bone window was then opened into the sinus using a 1 mm cutter (Komet, Hannover, Germany) with a motor handpiece. After removal of the bone window, small elevators were used to carefully detach the sinus membrane and lift it from the sinus

floor. A resorbable membrane (Bio-Gide; Geistlich Pharma, Wolhusen, Switzerland) was placed to protect the sinus membrane.

In the residual alveolar ridge, implant positions were marked with a round bur and then 2.2 and 3.0 mm diameter twist drills were used to prepare the sites aiming at high primary stability. A total of 58 Neoss Proactive or Bimodal straight implants 13 × 4 mm (Neoss Ltd, Harrogate, UK) were used in all the surgical procedures independently of residual bone height. In all cases, the insertion torque was >30 N cm. The final insertion torque was measured using a calibrated digital torque wrench and annotated in the patients' record.

The sinus floor was grafted with particulate autologous bone obtained from the mandibular ramus with a trephine 4 mm diameter at low speed under irrigation. Harvested bone samples were then ground and mixed with a 1 g of ceftriaxone e.v. (Rocefin; Roche, Basel, Switzerland) solution in order to add bactericidal activity, and placed immediately after fixture insertion. In all cases, the bone window was repositioned before suturing.

The patients received postoperative antibiotics (1 g of amoxicillin three times per day for 8 days). Betamethasone sodium phosphate was administered after surgery (4 mg per day for 2 days).

2.4 | Prosthetic phase

The implant fixtures were uncovered 6 months after surgery with a crestal approach using a round blade punch. Provisional plastic healing abutments (Neoss Ltd) were connected to the fixtures, left in place for 2 weeks and then substituted with definitive titanium abutments (Neoss Ltd) previously adapted. Single crowns or multiple unit ceramic bridges were then attached.

2.5 | Outcome variables

2.5.1 | Radiographic and clinical evaluations

All patients were evaluated through clinical and radiographic assessment prior to surgery. Standard follow-up evaluation was scheduled 6 and 12 months after the surgical procedure and annually thereafter.

The main outcome variables were the following. Prosthesis failure: when the prosthesis cannot be placed as planned due to implant failure(s) or when loss of the prosthesis occurs after delivery, due to secondary implant(s) failure or prosthesis fracture. Implant failure: implant mobility due to lack/loss of osseointegration and removal of stable implants caused by progressive marginal bone loss or infection. Implant stability was clinically evaluated through the use of two metallic instruments, applying opposing forces to the implant-abutment structure. An implant was recorded as unstable if a clearly visible movement could be detected.

Secondary outcomes were: occurrence of any biological complications (such as peri-implant mucositis, peri-implantitis, fistula or abscess, sinus infection), or mechanical/prosthetic complications (such as fracture of the implant and/or of any prosthetic component, screw loosening); mesial and distal changes of marginal bone level, measured on panoramic radiographs or periapical radiographs as described later. At each follow-up visit, the following clinical parameters were assessed: presence of plaque and bleeding on probing at implants; presence of inflammation; presence of peri-implant radiolucency; and presence of prosthesis mobility. Plaque score was defined as the presence or absence of plaque on the abutment/restoration complex, evaluated on four sites around each implant, and scored by naked eye or by running a periodontal probe (PCP15; Hu-Friedy, Chicago, Illinois) around implants, parallel to the surfaces of the abutment. Bleeding of the peri-implant mucosa was evaluated on four sites around each implant by gentle probing with a periodontal probe. Prosthesis stability was tested using two opposing instruments' pressure. All these parameters were evaluated dichotomously as yes/no.

Digital panoramic radiographs (Sidexis; Sirona Dental Systems GmbH, Bensheim, Germany) taken immediately after surgery (T0) and after a period of at least 5 years of function (T1) were used for bone level measurements using a specific image analysis software (Sidexis; Sirona Dental Systems GmbH). Preoperative residual crestal bone height was measured. Total vertical bone height from the implant platform level, taken as the reference point, to the uppermost level of the sinus bone graft was calculated at mesial and distal aspects of each implant at T0 and T1. Each measurement was made following an axis parallel and tangential to the mesial and distal sides of each fixture. Implant survival and any type of mechanical and biological complication occurring in the postsurgical period were recorded.

2.6 | Statistical analysis

The data were analyzed with Prism 6.0 (GraphPad Software Inc, La Jolla, California). The D'Agostino-Pearson normality test was conducted on each data set, showing a nonnormal distribution ($P < 0.05$); therefore, a nonparametric Wilcoxon matched-pairs signed rank test was used to compare the measurements of the various parameters at T0 and T1. The significance level was set at a level of probability $P = 0.05$.

3 | RESULTS

Table 1 summarizes the features of the patients' sample. Although smoking was not a specific exclusion criterion, no patient with smoking habits was present in the study group. The mean follow-up duration was 7.65 ± 1.80 years and ranged from 5 to 11.5 years after loading surgery. During this observation period, no implants were lost leading to an implant survival of 100%. Table 2 is a life table analysis showing the distribution of patients and implants per follow-up duration. The distribution of implant location in the maxilla is shown in Figure 1.

A few intraoperative complications occurred. In four cases, a small tear of the schneiderian membrane occurred during the elevation phase. In these cases, a resorbable collagen membrane (Bio-Gide; Geistlich Pharma) was placed, allowing to conclude the surgical procedure without any further complication. No neurological complications arose in the donor sites. A significant bleeding from the donor site with hematoma formation was evident in eight patients for up to 10 days postoperatively. Five of these eight patients had used acetylsalicylic acid at the time of surgery. No inflammatory reactions of the schneiderian membrane were observed during clinical and

TABLE 1 Demographic details of the study population, implants, and prostheses

No. patients/dropouts	33/0
Age at surgery, mean ± SD (range) (years)	51.05 ± 10.64 (36-68)
Gender (male/female)	18/15
Residual ridge height, mean ± SD (range) (mm)	6.48 ± 1.72 (3.55-9.2)
Smoking status Nonsmokers/former smokers/smokers	30/3/0
ASA I/II	29/4
No. implants placed/lost	58/0
No. prostheses/lost	33/0
Implants per prosthesis	No. prostheses
1	20
2	6
3	6
4	0
5	0
6	1

Abbreviations: ASA, American Society of Anesthesiologists; SD, standard deviation.

radiographic follow-up examinations. Table 3 resumes the secondary outcomes assessed at the latest follow-up visit.

At the radiographic evaluation, all patients showed a good mineralization of the grafted autologous bone which resulted mostly indistinguishable from surrounding native bone, especially in cases followed for more than 3 years.

The mean height of the residual bone in the surgically involved region of the posterior maxilla was 6.54 ± 1.83 mm. Descriptive statistics of the measurements of the overall bone height (ridge height plus graft height) at the mesial and distal aspect at the time of surgery (T0) and at the latest follow-up (T1) are shown in Table 3. No statistically significant difference was found at the mesial and distal aspect between T0 and T1 measurements according to the Wilcoxon matched-paired signed rank test (Table 4). Also, no significant difference in bone height was found between mesial and distal aspect, at both T0 (P = 0.57) and T1 (P = 0.36).

Peri-implant bone loss at T1 averaged 1.13 ± 1.48 mm at the mesial side and 1.30 ± 1.71 mm at the mesial side, being the mesial and the distal measurements not significantly different (P = 0.28). When averaging mesial and distal measurements, the mean overall marginal bone level change resulted −1.22 ± 1.60 mm. Figures 2–10 illustrate two clinical cases followed up to 5 years follow-up. Some examples of the measurement of the sinus graft height and of the ridge-to-graft distance through the software at baseline and follow-up are shown.

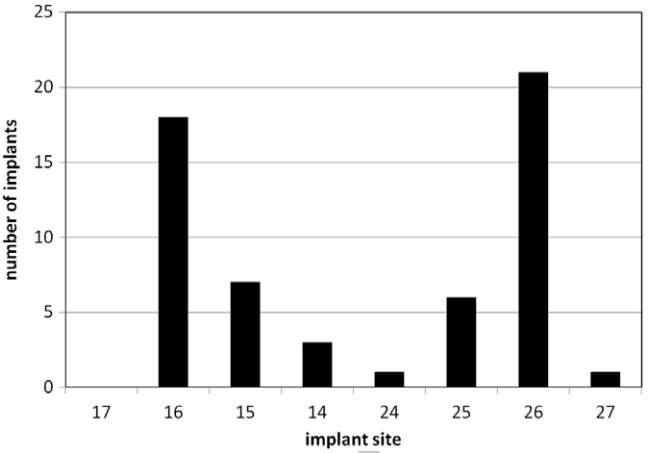

FIGURE 1 Distribution of the study implants in the upper arch

4 | DISCUSSION

This study showed that excellent long-term results may be achieved using autogenous bone harvested from the mandibular ramus as graft material for maxillary sinus augmentation. Different grafting materials have been successfully used in maxillary sinus lifting procedures achieving established and reliable results.[15,16,26,27] However, many clinicians still prefer autologous bone for sinus augmentation procedures, due to its osteogenic, osteoconductive, and osteoinductive properties, all required for proper bone neoformation.[28] The ready availability of all these properties is critical to graft survival, especially in a region with scarce regenerative potential, like the severely atrophic posterior maxilla. Likewise, for achieving the success of the implant-based rehabilitation treatment, it is important that the implants, once integrated in the graft, maintain their supporting function as long as possible. This is made easier if the augmented bone does not reduce significantly its volume over time. Because the use of extraoral autologous bone grafts has been associated with a greater than average graft resorption, other possible harvesting sites emerged, like intraoral regions. Intraoral autologous bone could be harvested from mandibular symphysis, mandibular ramus, retromolar trigone, and tuber maxillae. The mandibular symphysis provides excellent

TABLE 2 Life table analysis on patient and implant basis

Interval	No. patients/prostheses	No. implants	Failed implants	Dropouts	ISR %	CSR %
Loading to 5 y	33	58	0	0	100	100
5–6 y	33	58	0	0	100	100
6–7 y	29	51	0	0	100	100
7–8 y	23	39	0	0	100	100
8-9 y	17	28	0	2	100	100
9–10 y	10	20	0	0	100	100
>10 y	6	16	0	0	100	100

Abbreviations: CSR, cumulative survival rate; ISR, interval survival rate.

TABLE 3 Results of the secondary outcomes at the latest follow-up visit

Outcome	Yes	No
Sinus infection	0	33
Biological complications	0	58
Mechanical complications	0	58
Plaque score (yes/no)	10	48
Bleeding score (yes/no)	2	56
Soft tissue inflammation (	2	56
Radiolucency	0	58
Prosthesis mobility	0	33

quantity of bone, and generally is even able to offer a greater bone volume compared to the mandibular ramus. Nevertheless, bone harvesting in this area can sometimes lead to paresthesia of the lower lip and mental region.[28] Compared to the symphysis, the use of the mandibular ramus as donor site is normally associated with less postoperative morbidity and with a lower risk of complications such as dehiscence and infection of the surgical wound, gum recession, and especially neurosensory disorders, as reported by Clavero and Lundgren.[29] A systematic review assessing morbidity resorption and the performance of autogenous bone grafts of different origin for advanced jaw resorption, reported that the mandibular ramus was the harvesting site preferred by the patients.[30] Zins and Whitaker suggested that ossification of autologous grafts from membranous bone (like the bone found in intraoral regions) maintains its volume to a significantly greater extent than grafts from endochondral bone (like those harvested from the iliac crest) once transplanted in the craniofacial region.[24] In fact, the authors reported a loss of volume with endochondral bone grafts three times greater respect to membranous bone grafts.[24] Also, a higher tendency to resorption of iliac crest onlay grafts compared to calvarial onlay grafts has been reported, even though such tendency seems to decrease when increasing the follow-up duration.[31] However, when calvarial bone is involved, conflicting reports may be found. Chiapasco and colleagues in one study reported that graft resorption is more pronounced for calvarial grafts compared to bone grafts harvested from the mandibular ramus after a mean follow-up of 23.9 months.[32] However, in a subsequent study, the same group reported that calvarial bone shows less resorption than ramus bone, while both displayed a significantly lower resorption than iliac crest bone grafts.[33] Another clinical study comparing sinus grafts of intraoral and extraoral origin by microradiography of monocortical

TABLE 4 Total bone height data (ridge plus graft height) and results of the Wilcoxon match-paired signed rank tests

	Mean ± SD (mm)	Range (min-max)	95% CI	*P* value
Mesial bone height—T0	12.10 ± 2.40	6.66-20.58	11.46-12.74	0.7202
Mesial bone height—T1	12.20 ± 2.53	5.85-20.84	11.53-12.87	
Distal bone height—T0	11.99 ± 2.51	6.28-20.12	11.32-12.66	0.7153
Distal bone height—T1	12.05 ± 2.25	5.77-12.05	11.46-12.65	

Abbreviations: CI, confidence interval; SD, standard deviation.

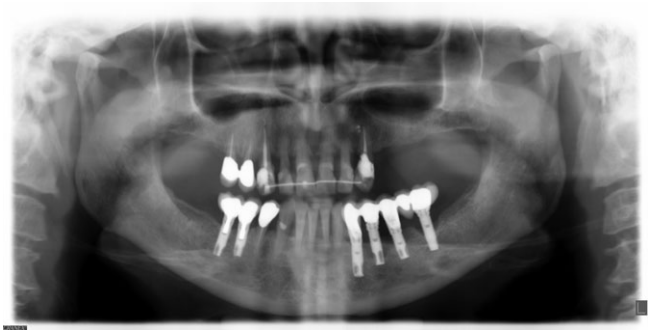

FIGURE 2 Case 1: preoperative panoramic radiograph of a female patient with edentulous left posterior maxilla scheduled for implant-supported full-arch rehabilitation and sinus augmentation. As there was sufficient residual ridge height, sinus grafting and implant placement were scheduled to be in the same surgical session

biopsies showed that the degree of mineralization of grafts harvested from the retromolar region remains significantly higher as compared to grafts from both anterior and posterior iliac crest up to 6 months after the grafting procedure.[34]

A study published by Khoury based on 467 implants placed in sinus lift procedures, has shown that the best clinical and radiographic results, the lowest bone resorption and the fewest complications occurred when graft material used was autologous bone.[35] Lundgren et al in a literature review published in 2008 reported higher survival

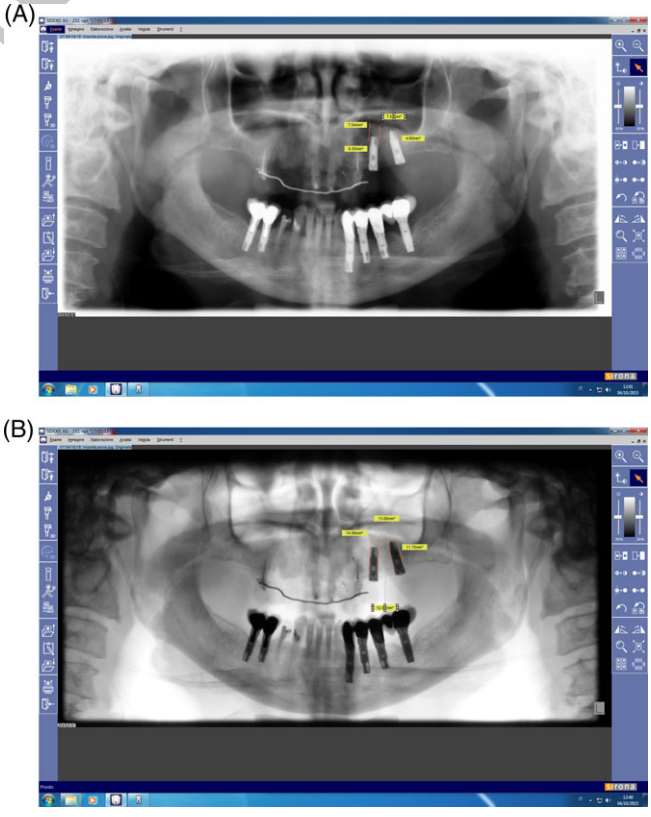

FIGURE 3 Panoramic radiograph after sinus augmentation with autogenous graft and implant placement. At this stage, a measurement of the baseline graft height (A) and of the distance between ridge and graft level (B, negative image) was performed mesial and distal to implant, as described in the text

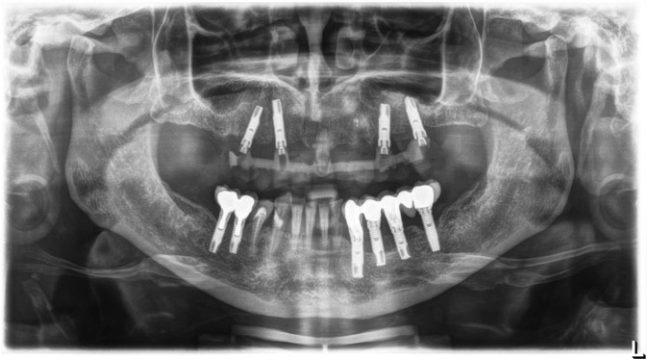

FIGURE 4 Panoramic radiograph taken 6 months later. Two implants were placed in the anterior maxilla, and a provisional prosthesis with 10 elements was attached

rates for implants placed in maxilla in a two-stage technique after lateral sinus augmentation procedure (90%), compared to those inserted simultaneously (79%), but we the authors considered mostly block bone grafts (either inlays or onlays) from several intraoral and extraoral sites.[36] It has been reported that bone grafts in block form tend to slow down the process of graft revascularization compared to particulate bone chips that naturally create the space for angiogenesis which is fundamental to successful osteogenesis.[36] On the other hand, another review by Pjetursson et al published in the same year, estimated a 3-year implant survival greater than 90% for implants inserted at the same time of bone graft.[37] Indeed, the Pjetursson review based on a meta-analysis of 48 studies and 12 020 implants inserted in combination with lateral sinus lift, estimated an annual failure rate of 3.48% on an implant basis and 6.04 on a patient basis. It appears difficult, however, to believe that such estimates may be valid in the long term, as the longest follow-up among the studies included averaged 6.1 years.[37] Pjetursson et al's review reported that all the implant failures were related to sinus membrane perforation.[37] Perforation of the schneiderian membrane is probably the most common sinus lift complication. A membrane perforation may affect sinus

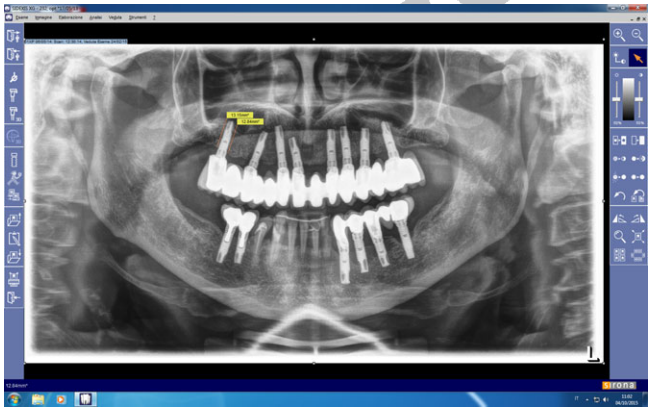

FIGURE 5 Panoramic radiograph taken 1 year after left sinus grafting. A further surgical session was performed to insert three more implants in the anterior maxilla and one in the right posterior maxilla simultaneous to sinus grafting, in order to support a full-arch prosthesis composed of 14 elements. At this stage, measurement of the baseline graft height and ridge to graft distance was performed at the level of the implant placed in the right posterior maxilla

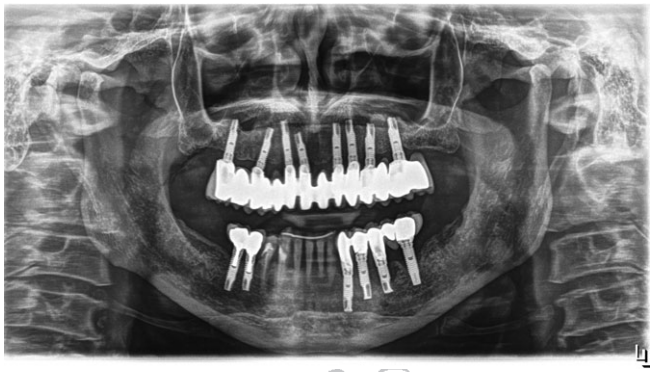

FIGURE 6 Panoramic radiograph taken 5 years after left sinus augmentation. The graft level appears well preserved

integrity, though it can be managed intraoperatively and generally does not require premature termination of the surgical procedure.[38,39] There is no evidence that such intraoperative complication compromises the success of the treatment nor that it is related to an increased implant failure rate.[40,41] Nevertheless, the correlation between intrasurgical perforation of the sinus membrane and the occurrence of postoperative complications and negative graft outcomes is controversial in the scientific literature.[42,43] In a recent retrospective study of 359 sinus lift procedures, 7 out of every 10 failed sinus grafts were accompanied by a perforated schneiderian membrane during sinus lift surgery.[44] The sinus membrane perforation markedly increased the risk of sinusitis or infection in that study. [44] In our study, all lifting procedures were accompanied by the placement of an absorbable membrane made of bovine collagen onto the schneiderian membrane. The barrier membrane isolated the area of the graft from the maxillary sinus, also limiting the bacterial contamination that could result in case of small incidental laceration during surgery, an event that occurred in four cases. The resorbable barrier membrane may also prevent laceration of the schneiderian membrane using the apex of implants or due to the sharp edges of the bone graft particles. In the present study, the use of disodic ceftriaxone, which has a direct bactericidal activity against gram positive and negative bacterial strains, aimed to further reduce the possibility of graft contamination. Even if the use of consistent bone grafts may prove effective acting

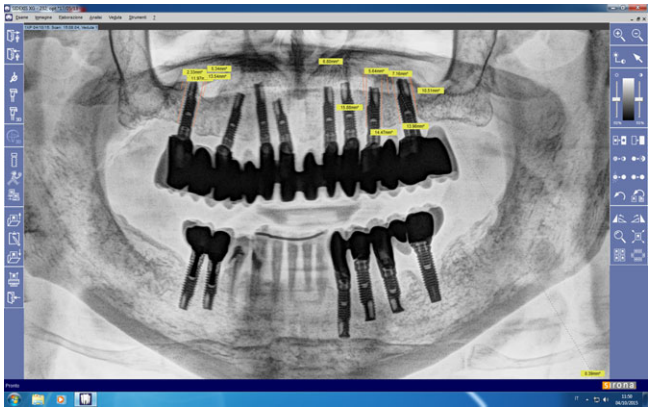

FIGURE 7 Negative image of the radiograph in Figure 6. Measurement of the graft height and ridge to graft distance were repeated at the level of each implant involved with the graft

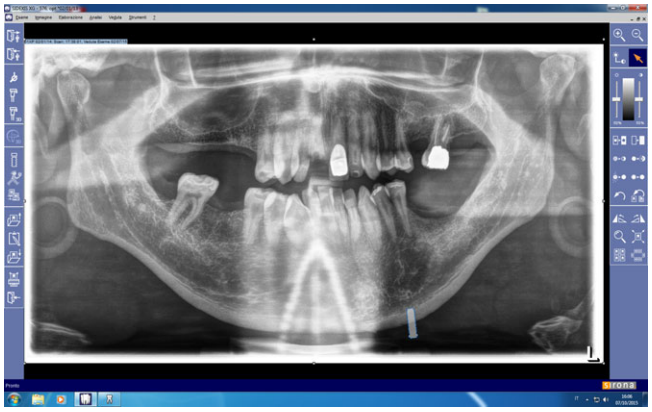

FIGURE 8 Case 2: preoperative panoramic radiograph of a male patient with partially edentulous right posterior maxilla scheduled for implant-supported single-tooth rehabilitation and sinus augmentation. As there was sufficient residual ridge height, sinus grafting and implant placement were scheduled to be in the same surgical session. In addition, the corresponding missing mandibular molar site was scheduled for insertion of one implant supporting a single tooth reconstruction, to work as antagonist

as a space keeper, ensuring preservation of an adequate volume, several recent studies discuss over the necessity of bone grafting after sinus lift because once a compartment between the elevated schneiderian membrane and the osseous floor of the sinus is created, new bone formation will spontaneously fill this space.[45–47] The bone measurements of our study sample were carried out by following the

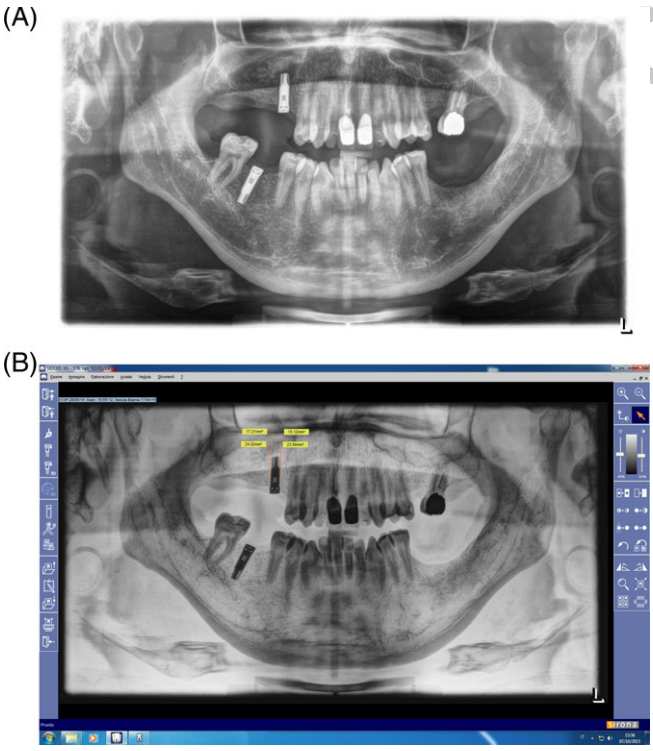

FIGURE 9 (A) Panoramic radiograph after sinus augmentation with autogenous graft and implant placement. An implant was also inserted in the antagonist site in the same session. (B) Measurement of the baseline sinus graft height and of the distance between ridge and graft level was performed on the negative image, as described in the text

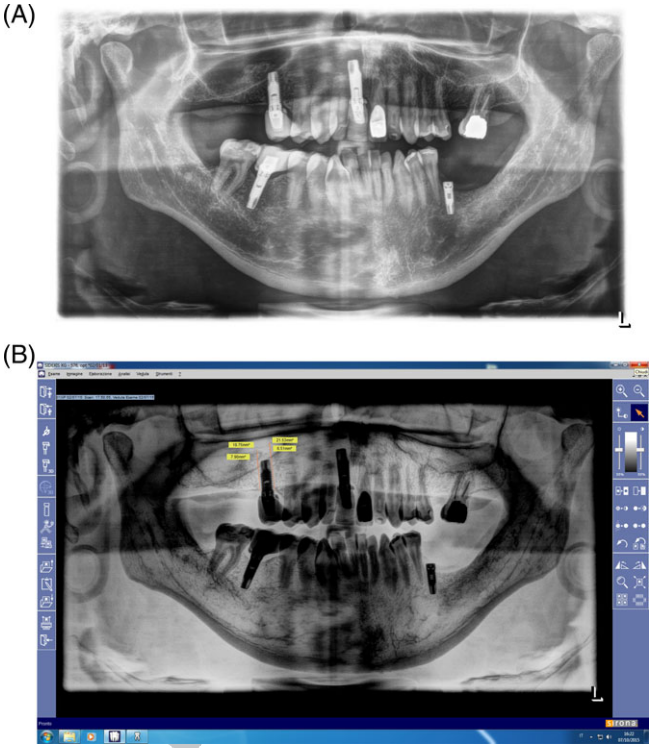

FIGURE 10 (A) Panoramic radiograph taken at the 5-year follow-up. The graft level in the right sinus appears well preserved. (B) Measurement of the sinus graft height and of the distance between ridge and graft level was performed on the negative image, as described in the text

guidelines proposed by Heinemann et al to evaluate the effectiveness of implants placed in the posterior atrophic maxilla rehabilitated through a lateral sinus floor augmentation.[48] This simple technique allows to accurately assess the presence of bone around the implants and the success of osseointegration. We used in addition a support that guarantees a negligible digital radiographic image distortion, thereby enabling precise visualization and measurement. In particular, the use of specific digital imaging software allowed us to work on a negative image, useful to accurately see the bone graft respect to the residual alveolar bone. In fact, usually the recognition of the border between alveolar native bone and grafted one is not easy, unlike the above mentioned study in which it was used hydroxyapatite as graft material. For the above-mentioned reasons, in our study, we evaluated the total bone height available after grafting procedures, since during healing a bone graft becomes indistinguishable from the native alveolar bone. Thus, focusing on the total bone height obtained after sinus augmentation procedure, our report shows a fairly stable grafted bone volume after longer than 5 years of follow-up. A study of Hatano et al based on panoramic radiographic images for the evaluation of sinus lifting procedures with a 2:1 mixture of autologous bone and bovine xenograft with simultaneous implant placement reported a significant decrease in total bone height during the first 3 years after grafting procedures, and after then only minor changes occurred.[49] However, the total bone height up to 96 months of follow-up resulted higher than preoperative bone height, probably because implant loading promotes osteogenesis and thus the maintenance of bone graft over time.[49] Conversely, our findings did not show a significant

variation in the first years after sinus grafting, resulting in a bone height constantly stable over time. Also a study of Kim et al reported a significant loss of vertical bone volume of more than 1.5 mm 1 year after sinus augmentation.[50] Similar to our results, instead, Heinemann et al reported a bone height stable throughout the entire 3-year follow-up period.[48] None of patients included in our study were smokers. This is an important indicator of success since, as defined by Herzberg et al, smoking contributes to reduce the success of implant therapy and causes bone loss around implants.[51] Even if a study of Takamiya et al stated that smoking is not an absolute contraindication to implant therapy, the authors specified that the cigarettes, containing more than 4000 toxic substances for the body, may seriously damage most tissues, including bone, drastically reducing the immune defense and the healing potential.[52] Cigarette smoking affects the process of revascularization and wound healing becoming extremely harmful and dangerous for implant therapy especially when it is associated with lateral sinus lift.[52] The 100% survival rate reported in our study could be partially favored by the fact that there were no smoker patients included in the sample.

5 | CONCLUSIONS

The use of autologous bone grafts from intraoral donor sites for LSFE and simultaneous implant placement allows dimensional graft stability in the mid-long term. Further prospective studies are needed to confirm the present results.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest with the contents of this article.

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