# Mini-Invasive Osteotome Sinus Floor Elevation in Partially Edentulous Atrophic Maxilla Using Reduced Length Dental Implants: Interim Results of a Prospective Study

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## ABSTRACT

*Purpose:* The purpose of this prospective study was to investigate the clinical success of a treatment protocol for the rehabilitation of edentulous posterior maxilla consisting of the positioning of short implants in combination with transcrestal sinus lifting, with the adjunct of pure (leukocyte-free) platelet-rich plasma, in order to reducing the risk of membrane perforation and other surgical complications.

*Materials and Methods:* A total of 25 patients (65 implants) were treated. Pure platelet-rich plasma was used in the sinus membrane lifting procedure. Implants of 8.5 mm length or shorter were splinted through the prosthetic rehabilitation with one or more implants longer than 10 mm.

*Results:* After a follow-up period ranging from 12 to 19 months (mean 14.4 months) after prosthetic loading, 23 patients (60 implants) were evaluated. Overall implant success and survival rates were 100% at 1 year follow-up visit. All prosthetic rehabilitations were successful and in function. After 1 year of loading, peri-implant bone loss averaged $0.34 \pm 0.21$ mm for 8.5 mm or shorter implants ($n = 25$) and $0.36 \pm 0.30$ mm for longer implants ($n = 35$) (overall mean $0.35 \pm 0.25$ mm) without significant difference between the two groups ($p = 0.23$).

*Conclusions:* The proposed treatment protocol is a viable option for the rehabilitation of edentulous posterior atrophic maxilla.

KEY WORDS: atrophic posterior maxilla, osteotome sinus lift, platelet concentrates, short implants

## INTRODUCTION

Atrophy of the posterior maxilla is a relatively frequent condition in the population, which often compromises mastication function and esthetics. Maxillary sinus elevation is one of the most common preprosthetic techniques for increasing the available bone volume in order to place implants and restore function and esthetics.

While a lateral approach for sinus elevation is traditionally indicated in cases with less than 5 to 6 mm of residual bone height,[1–3] a transcrestal approach can be successfully adopted when residual bone height is at least 5 mm.[4–6]

Several types of complications may occur during and after the sinus elevation procedure with lateral approach. In fact, relatively frequent Schneiderian membrane perforations, nose bleeding, postoperative pain, and swelling could be considered as major drawbacks for this treatment option.[7,8] On the contrary, osteotome-mediated sinus elevation technique was proved to be more conservative and produced less complications.[5]

Platelet concentrates can be beneficial to transcrestal approach especially when sinus floor is elevated

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because of the capacity of lifting the sinus membrane safely, reducing the risk of perforation, and due to the excellent mechanical properties of the platelet gel.[9,10] Furthermore, the high content of growth factors may enhance the healing process.

As an alternative to sinus elevation procedures, the use of short implants (from 7 to 10 mm long) or extra-short ones (less than 7 mm long)[11] was proposed to support, alone or in combination with longer ones, partial or full maxillary restorations.[12–14]

To our knowledge, the association of osteotome-mediated sinus elevation technique with the use of platelet concentrates and short implants has not yet been reported in scientific literature. In this article, leukocyte-free platelet-rich plasma (or "pure platelet-rich plasma" [P-PRP]), according to a recently proposed definition,[15] was used as an adjunct to the surgical procedure in order to obtain a safe sinus membrane lifting and to reduce the risk of membrane perforations and related complications as well.

The aim of this preliminary report was to present the 1 year outcomes of a minimally invasive sinus lifting procedure in which P-PRP and short implants splinted with longer ones are used for the rehabilitation of posterior edentulous atrophic maxilla.

## MATERIALS AND METHODS

This prospective single-cohort study was conducted according to the principles embodied in the World Medical Association Helsinki Declaration of 1975 for biomedical research involving human subjects, as revised in 2000.[16] Ethical approval was obtained from the Review Board of the IRCCS Istituto Ortopedico Galeazzi. All patients gave their written informed consent.

Patients' inclusion criteria were the following:

- partially edentulous ridge in the posterior maxilla in which a site with residual bone height of less than 6.5 mm was adjacent to at least one candidate implant site with a residual bone height greater than 10 mm assessed through computerized tomography (CT) or cone beam CT scans;
- at least 18 years of age;
- absence of general medical contraindications for oral surgery procedures (American Society of Anesthesiologists ASA-1 or ASA-2);
- full-mouth bleeding score and full-mouth plaque score less than 25% at baseline;
- able to sign the informed consent form.

Patients were not enrolled in the study if they presented one of the following exclusion criteria:

- any disease, condition, or medication that might compromise healing or osseointegration;
- inability or unwillingness to return for follow-up visits;
- inability or unwillingness to maintain a good level of oral hygiene throughout the study.

Inclusion and exclusion criteria were checked after diagnosis and treatment planning. A single experienced surgeon (S.T.) performed all the surgeries.

A total of 25 patients (65 implants) were included and treated with the proposed protocol between February 2010 and January 2011 in a private dental practice and in a university clinic. Two patients failed to attend the 12 month follow-up visit and were excluded from the study. After a follow-up period ranging from 12 to 19 months (mean 14.4 months) after prosthetic loading, 23 patients (60 implants) were evaluated. Eight patients were females, while 15 were males with an age at recruitment ranging from 37 to 61 years (mean 55.8 ± 18.2 years). Implant characteristics were summarized in Table 1.

Implants of 8.5 mm long or shorter were all seated with a torque ranging from 25 to 30 Ncm (Figure 1), with the use of a manual torque-controlled wrench,

**TABLE 1 Implant Characteristics (Diameters and Lengths)**

| | 6.5 mm | 8.5 mm | 10 mm | 11.5 mm | 13 mm | Total |
|---|---|---|---|---|---|---|
| 3.75 mm | — | — | — | 3 | — | 3 |
| 4 mm | 18 | 1 | 17 | 4 | 3 | 43 |
| 4.5 mm | 5 | 1 | 14 | 3 | — | 13 |
| 5 mm | — | — | 1 | — | — | 1 |
| Total | 23 | 2 | 22 | 10 | 3 | 60 |

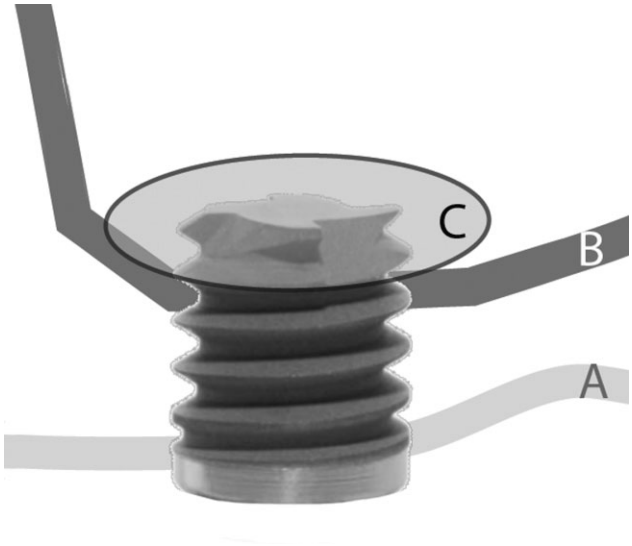


**Figure 1** Schematic representation of extra-short implant position. *A*, Sinus floor elevation; *B*, sinus floor; and *C*, bone crest.

while for longer ones, the seating torque ranged from 25 to 40 Ncm (Figure 2). After surgery, no complications were reported.

All prostheses were cement-retained. Reinforced composite crowns were used in 16 patients and metal-ceramic ones in seven subjects.

## Surgical and Prosthetic Procedure

One hour before surgery, 2 g of amoxicillin and clavulanic acid (Augmentin, Roche, Milan, Italy) were administered to patients as prophylactic regimen. Ten milliliters of peripheral blood was collected using two citrated tubes in order to prepare P-PRP. The tubes were centrifuged at 460 × g at room temperature for 8 minutes in a centrifuge unit specifically designed for use with this technique (PRGF System®, BTI Biotechnology Institute, Vitoria, Alava, Spain). After centrifugation, the plasmatic component is separated in two fractions, using a laboratory pipette. The lower fraction of about 1 $cm^3$, immediately above the buffy coat, is the plasma rich in growth factors, while the upper fraction (about 1 $cm^3$) is the plasma poor in growth factors. The two fractions are stored in a sterile glass container until use. The total preparation time for this technique is approximately 10 to 15 minutes.

Local anesthesia was obtained with articaine chloridrate 4% and adrenaline 1:100.000 (Alfacaina N, Weimer Pharma, Rastat, Germany).

After the elevation of a full-thickness flap, if needed a distal vertical incision was made in order to increase the mobility of the flap. The surgical site was prepared through standard technique with a 2 mm bur keeping intact 1 mm of cortical bone height of the floor of the sinus.

After this, the P-PRP clot was prepared through a standard procedure. A few minutes before use, 50 μL of 10% CaCl2 was added per cubic centimeter of platelet concentrate to enhance fibrin polymerization.

A P-PRP clot was then inserted in the site and carefully positioned with the use of a calibrated osteotome. The sinus floor was lifted by means of an osteotome with gentle hand pressure and rotation and, only when necessary, slight malletting to implode the sinus membrane in an apical direction was applied. Depending on implant diameter, a slightly different sequence of osteotomes was used: a 2 mm one followed by a 3 mm osteotome was used for 4 and 4.5 mm–diameter short implants. When necessary, the sinus floor was broken using a Partsch hammer and a 2 mm osteotome.

After the fracture of the sinus floor, a Valsalva maneuver was performed in order to verify the integrity of the sinus membrane.

Because of the associated use of implants of 6.5 mm length, it was aimed to lifting the sinus floor until a vertical dimension of about 7 mm was achieved. Through the application of P-PRP clot in the implant site and compression of the material, Schneiderian membrane was smoothly detached and lifted from the

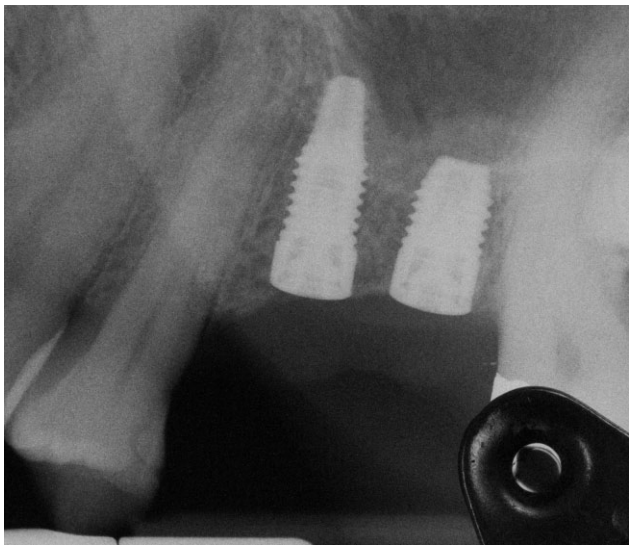

**Figure 2** Postoperative periapical radiograph showing sinus floor lifting apical to the extra-short implant.

sinus floor until the adequate vertical dimension was obtained. The extent of the elevation was checked through an intrasurgical periapical radiograph and the integrity of the membrane was assessed after each elevating maneuver.

The implant site was underprepared to achieve implant primary stability.

Each implant (BTI Biotechnology Institute) was inserted with the use of a torque-controlled handpiece with a torque of 25 Ncm. A manual placement should be avoided because of the increased risk of uncontrolled forces acting on the fixture during the insertion. Only for the final 1 mm, a manual torque wrench could be used to better control the position of implant neck up to a 40 Ncm torque. The achievement of a primary stability at medium insertion torques was considered mandatory for the success of the surgery.

After implant placement, the flap was repositioned and sutured with 5-0 (Ethicon Inc., Johnson & Johnson, Piscataway, NJ, USA) nonadsorbable sutures. Activated liquid P-PRP was sprayed onto or was injected at the suture site.[17] Postsurgical instructions were provided to control bleeding and to avoid the detachment of sutures during the first healing period. Sutures were removed after 10 days.

Provisional prosthesis (made by composite) was delivered after a 5 month healing period. After 3 months of progressive occlusal loading, provisional restorations were substituted with final ones made by reinforced composite or metal ceramic.

Follow-up visits were scheduled at 6 and 12 months after loading and then yearly up to 5 years.

### Clinical and Radiological Parameters

At each visit, the following variables were recorded.

Primary variables were the following:

- prosthesis success when the prosthesis was in function, without mobility, even in face of the loss of one or more implants. Prosthesis stability was tested by means of two opposing instruments' pressure;
- implant success according to conventional criteria[18,19];
- patients' satisfaction for mastication, function, phonetics, and aesthetics, evaluated by means of questionnaires based on a five-point Likert-type scale, ranging from 0 (fully unsatisfied) to 4 (fully satisfied) for each question.[20]

Secondary variables were implant survival, number and type of surgical or postsurgical complications, and marginal bone level change. The effect of implant location, residual bone height, smoking status, and bone density according to classification of Lekholm and Zarb[21] was based on the clinical and radiographic evaluation.

Radiographic evaluation was performed through standardized intraoral radiographs. Periapical radiographs were taken immediately after implant placement (at baseline), at the prosthetic phase, and at each follow-up visit (scheduled after 6 and 12 months of prosthesis function and yearly thereafter up to 5 years). Radiographs were taken using a long-cone paralleling technique and individual trays to ensure reproducibility. A dedicated image analysis software (UTHSCSA Image Tool version 3.00 for Windows, University of Texas Health Science Center, San Antonio, TX, USA) was used to perform measurements of marginal bone level around implants at both mesial and distal aspect. Implant neck was the reference for each measurement. Mesial and distal values were averaged so as to have a single value for each implant.

### Statistical Analysis

Data regarding bone level changes of short and extra-short implants were pooled together and compared with those of longer implants through Student's *t*-test. Level of significance was placed when $p < 0.05$. Cumulative survival and success rates for implants were calculated by means of Kaplan-Meyer analysis.

## RESULTS

Overall implant success and survival rates were 100%[18,19] at 1 year follow-up visit. All prosthetic rehabilitations were successful and in function.

After 1 year of loading, the peri-implant bone loss averaged $0.34 \pm 0.21$ mm for implants 8.5 mm long or shorter ($n = 25$) and $0.36 \pm 0.30$ mm for longer implants ($n = 35$) (the overall mean was $0.35 \pm 0.25$ mm). No significant difference was found between the two groups ($p = 0.23$). Implant location, bone density, and initial bone height were not statistically correlated to peri-implant bone loss.

Residual bone height before surgery at sites involved in sinus elevation was $5.8 \pm 1.10$ mm (Figure 3). After 1 year of loading, the same sites showed $8.5 \pm 1.20$ mm of bone height (Figure 4).

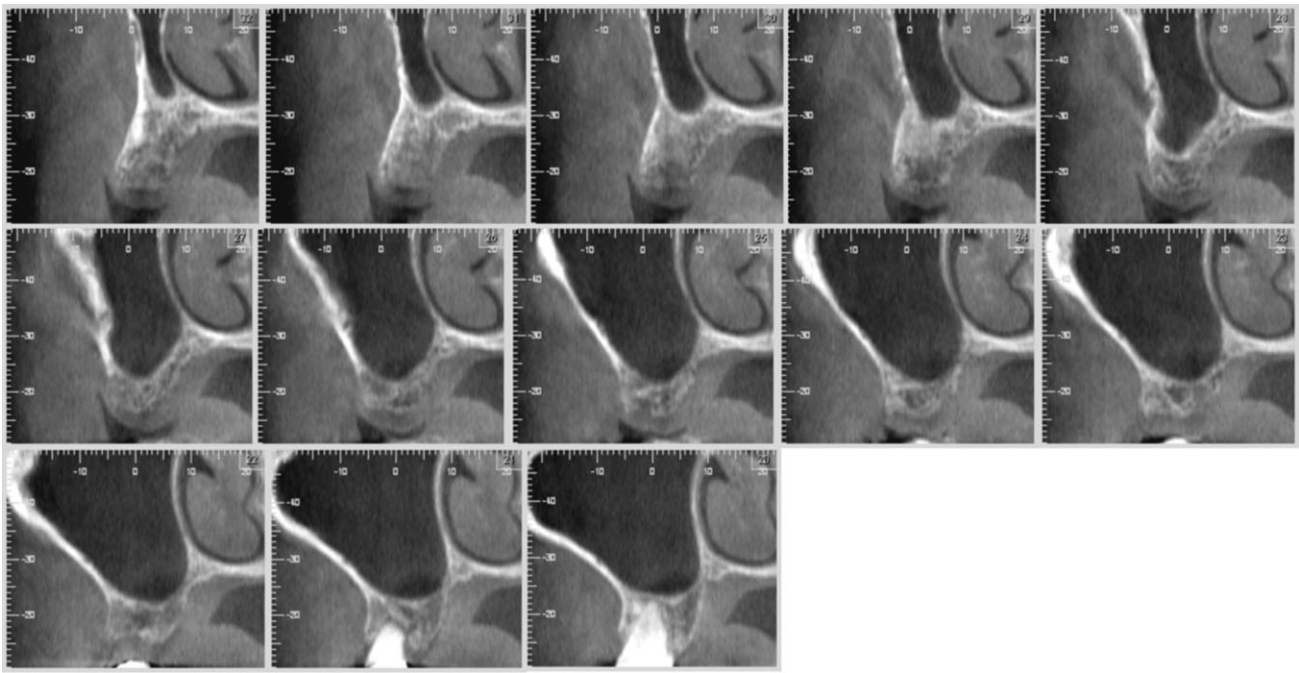

**Figure 3** Preoperative cone beam computed tomography scan showing the presence of atrophic edentulous area adjacent to a site with more bone volume.

All patients returned their questionnaires. All of them reported full satisfaction for function (chewing ability), phonetics, and aesthetics (Figure 5).

## DISCUSSION

The main objective of this single-cohort prospective study was to evaluate the outcome of prosthetic reconstructions supported by a combination of 8.5 mm long or shorter implants placed simultaneously with osteotome-mediated sinus lift and splinted with one or more longer fixtures after 5 years of prosthetic loading. This paper reports the interim 1 year results.

Recent systematic reviews of the literature showed that short implants can be a viable treatment alternative in cases of bone atrophy of both jaws even if a considerable heterogeneity among the selected articles was found regarding study design, treatment protocol, follow-up duration, and success criteria adopted.[12,14] Moreover, in vitro biomechanical and finite-element analysis studies reported that the most coronal 2 to

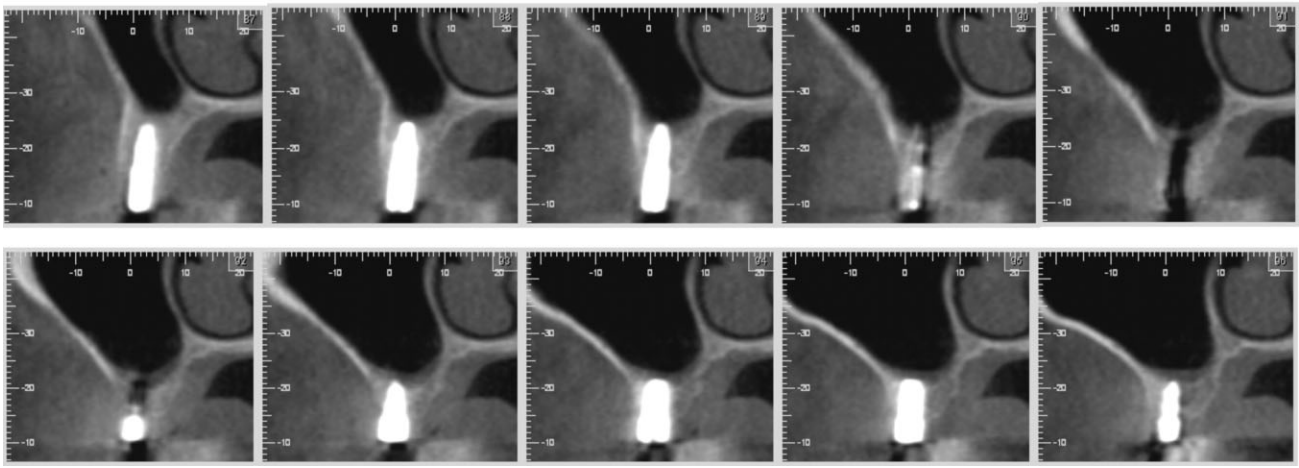

**Figure 4** Postoperative cone beam computed tomography scan.

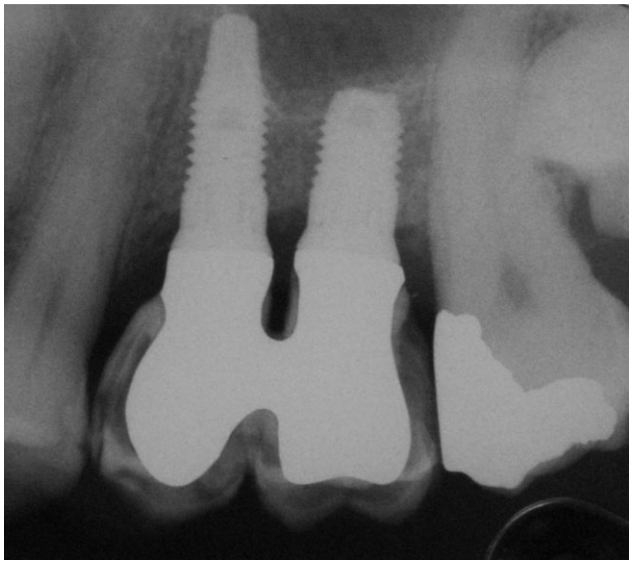

**Figure 5** Periapical radiograph after 1 year from prosthetic loading. Bone resorption appeared low and the stability of sinus lifting is observable.

3 mm of the implants carries the major load transfer, indicating that shorter implants did not transmit significant higher stress force to bone.[22] Earlier clinical studies reported that maxillary short implants can be more susceptible to failure than mandibular ones probably due to the lower bone density in the upper jaw, especially in posterior regions that would compromise implant stability.[23–26] Most recent studies reported that prosthetic reconstructions supported by short implants in the posterior maxilla may achieve excellent results.[22,27] This has been ascribed both to the improvement in the shape and surface over earlier implant systems and to the adoption of minimally invasive surgical techniques aiming at preserving as much as possible the residual bone.

In this study, during the placement of 8.5 mm long or shorter implants, extreme care was paid to maintain the integrity of the alveolar bone after extraction. Furthermore, it was decided to splint the shorter fixtures to longer ones both in order to allow a correct functional rehabilitation and to reduce the possibility of excessive occlusal stress to a short fixture, placed in an augmented site. Thus, from a prosthetic point of view, such splinting could be effective in reducing the occlusal stresses, otherwise supported only by the short implants.[28]

Osteotome sinus lift with transcrestal approach, as first described by Tatum[29] and then modified by Summers,[30] has been described to be a viable treatment alternative in the presence of at least 5 mm of residual bone height in the posterior maxilla.[6] The impossibility of visualizing the sinus floor is considered to be the major drawback of this approach.[5,6] However, a lower rate of intrasurgical complications, such as sinus membrane perforation, was reported as compared with the lateral approach.[7] Moreover, it was shown that perforation occurring during transalveolar sinus lifting procedure did not imply the abandon of the procedure and did not affect the success rate of the whole procedure even when no grafting material was placed.[31] It must be said, however, that a number of unnoticed perforations of the Schneiderian membrane should be reasonably taken into account due to the blindness of the procedure regarding this aspect. Therefore, such consideration should be interpreted cautiously and any expedient aimed at reducing the risk of membrane perforation is more than welcome.

Platelet concentrates can be beneficial to many regenerative oral surgery procedures as the treatment of periodontal intrabony defects[32] or maxillary sinus elevation.[16,17,33] Autologous platelet concentrates have the advantage of high biocompatibility and the capacity to reduce the anti-inflammatory responses through the suppression of pro-inflammatory chemokines as Interleukin-1 (IL-1).[16,34] An antimicrobial effect of platelet concentrates was also observed.[35]

In spite of a lack of evidence of beneficial effects on bone neoformation in the long term using platelet concentrates in sinus lift surgery, in part due to the relatively short-time effect of delivered growth factors on surrounding tissues,[33,36,37] in this study the use of platelet concentrate was mainly aimed at exploiting its mechanical properties during the sinus elevation maneuvers.

In this study, leukocyte-free PRP (P-PRP) was used without any bone substitute with the aim of allowing a better control of forces during sinus floor elevation and reducing the incidence of complications, as suggested by previous literature.[9,35]

Furthermore, platelet gel was used as a cushion in order to dampen the compressive forces during the lifting procedure and with the aim of using the hydraulic force transmitted by the P-PRP clot for a safer detachment of the sinus membrane reducing the stress. The use of platelet concentrates in cases of membrane perforation, due to the adhesive properties of the material, could also permit the obliteration of the perforation

during the surgical procedure, avoiding the occasional displacement of materials as bone particles in the sinus cavity during the site preparation.[18]

The preliminary results of this study showed that the proposed technique could be useful and effective for the treatment of maxillary partial edentulism in cases of reduced residual bone height. No differences in bone loss over time were found between short and longer implants, suggesting that splinting of the fixtures through prosthetic rehabilitation could be useful in reducing stresses at the bone-implant interface.

Furthermore, the absence of intrasurgical and postsurgical complications in the patients' cohort should be considered in the choice of treatment alternatives as sinus elevation through lateral approach, especially when only one site needs to be grafted.

Many advantages could be observed in this surgical protocol. First, the use of short implants required less bone volume than longer ones. Also, a recent literature review demonstrated a high success rate for implants shorter than 8 mm even though only short-term studies were considered.[12] Then, osteotome-mediated sinus lifting technique is easier and more conservative than lateral surgical approaches and could also be performed in postextractive sockets.[38] It was also demonstrated that the Schneiderian membrane has an osteogenic potential and may induce neo-osteogenesis through the stimulation of osteoprogenitor cells from the periosteum.[39] Such action may be further stimulated by the growth factors present in the P-PRP clot.

Some disadvantages have to be highlighted. The placement of extra-short implants in low-density bone could be challenging. In fact, because of their difficult handling, there is the risk of fixture displacement in the sinus cavity or the possibility of compromising the primary stability due to unintentional nonaxial forces during the insertion. Furthermore, the sinus lifting procedure must be delicate, favoring direct gentle compression through the osteotome and avoiding the application of other uncontrolled forces. Then, a minimum diameter of 4 mm for short implants, in order to maximize the surface available for bone contact, is considered mandatory as well as a sufficient bone height. Finally, during the prosthetic phase, a progressive occlusal load should be applied through the use of a sequence of provisional restorations avoiding excessive stresses and eccentric tooth contacts during the initial phases of loading.

## CONCLUSIONS

Despite the restricted anatomical inclusion criteria adopted in the present study, this procedure could be considered a viable alternative to more demanding surgical procedures for the rehabilitation of posterior atrophic maxilla.

Studies with wider sample sizes and a randomized design with longer follow-up are necessary to validate this technique.

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