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PRF versus xenograft in sinus augmentation in case of HA-coating implant placement: A 36-months retrospective study

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Advances in Clinical and Experimental Medicine, ISSN 1899–5276 (print), ISSN 2451–2680 (online) *Adv Clin Exp Med*. 2021;30(6)

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Funding sources
None declared

Conflict of interest
None declared

Received on January 3, 2021
Reviewed on February 28, 2021
Accepted on March 11, 2021

Published online on May 13, 2021

Abstract

Background. Sinus lift with a simultaneous implant placement in the residual maxilla is a common technique used worldwide. Nevertheless, choosing an ideal grafting material remains an object of dispute. The use of an autologous blood-derived graft, known as platelet rich fibrin (PRF), has not yet been recognized to be as good as xenografts and alloplastic materials. However, initial results have been promising.

Objectives. To conduct a clinical and radiological comparison of implantation with a simultaneous sinus lift using xenograft or PRF clots.

Materials and methods. Thirty sinus lifts with simultaneous implantation were conducted using a lateral window approach and the tent pole technique, with xenograft (group 1 (G_1)) or PRF (group 2 (G_2)) as a filling material. To be included in the study, patients must have had an alveolar ridge height of 4–5 mm, no signs of inflammatory processes, good oral hygiene, and no other grafting procedures performed in region of implant insertion. In each case, the measurements taken were probing pocket depth (PPD), height of keratinized tissue (HKT), clinical attachment level (CAL), recession depth/width (RD/RW), and, on panoramic X-rays, marginal bone loss (MBL), grafted sinus high (GSH), and bone gain (BG). Pre- and post-operative treatment was applied to reduce the chance of infection.

Results. During the study, 30 implants (hydroxyapatite-coated implants manufactured by SGS – 10 mm in length and 4.2 mm in diameter) were placed. The survival rate of implants in both groups was 100% with no implant mobility, pain, paresthesia, or inflammatory processes in the direct vicinity of the implants observed, except in 1 patient. After 36 months of follow-up, the radiological assessments for G_1 were: GSH 4.5 mm, MBL 0.46 mm and BG 4.53 mm; and for G_2: 3.4 mm, 0.6 mm and 3.4 mm, respectively. Results of the clinical measurements were for G_1: HKT after 36 months (HKT_{36}) 2.46 mm, CAL 0.47 mm and PPD 2 mm; and for G_2: HKT_{36} 3.13 mm, CAL 0.6 mm and PPD 2.07 mm.

Conclusions. After 3 years of follow-up, the results of sinus lifting solely using PRF with simultaneous implantation were promising, especially in terms of soft tissue management. Therefore, PRF can be regarded as an alternative to previously used materials.

Key words: implant, PRF, sinus lift, growth factors, hydroxyapatite-coated implants

Cite as
Dominiak S, Karuga-Kuźniewska E, Popecki P, Kubasiewicz-Ross P. PRF versus xenograft in sinus augmentation in case of HA-coating implant placement: A 36-months retrospective study [published online as ahead of print on May 13, 2021]. *Adv Clin Exp Med*. 2021;30(6). doi:10.17219/acem/134202

DOI
10.17219/acem/134202

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Background

Implant treatment for patients with edentulous maxilla can only be performed when there is an adequate amount of good-quality bone tissue. Following tooth extraction, the bony socket undergoes a series of adaptive changes, in both the vertical and horizontal dimensions, in an attempt to reduce bone height. It has been previously documented that the main result of alveolar bone resorption after tooth loss is the pneumatization of the maxillary sinus.[1,2] Implant-supported rehabilitation in such cases remains a challenge. However, the treatment of choice in these cases is sinus augmentation.

The sinus augmentation procedure was first described by Tatum and was subsequently redesigned by Boyne and James.[3,4] Depending on the clinical situation, such as the height and width of the alveolar ridge, different types of the procedure can be pursued. For example, in cases with a height over 6 mm, transcrestal techniques can be conducted.[5] In contrast, when the bone level is insufficient, procedures with an approach from the lateral side of the sinus cavity are most commonly used. This technique creates space between the maxillary alveolar process and the elevated Schneiderian membrane, which is filled with various grafting materials to maintain adequate space for new bone formation.[3–5]

Various materials, including freeze-dried bone allograft, β-calcium phosphate tribasic (β-TCP) and xenografts, such as deproteinized bovine bone mineral (DBBM), have been proposed as bone substitutes that can be applied during the sinus augmentation procedure.[6] However, due to their lack of progenitor cells and growth factors, these materials allow for potential osteoconductive growth only. In order to improve the osteoinductivity of alloplastic materials and xenografts, the use autologous growth factors has been proposed.[7]

Platelet-rich plasma (PRP) was initially used for this purpose.[8] However, there are potential risks associated with usage of this material, as PRP contains synthetic anticoagulant materials (e.g., sodium citrate, ethylenediaminetetraacetic acid, or anticoagulant citrate dextrose solution A).[8–10] Other limitations of PRP application include a more time-consuming preparation and a rapid degradation of platelets that can result in a reduced release of growth factors. Because of these reasons, PRF (platelet-rich fibrin) was substituted for PRP in guided bone regeneration procedures.[9]

The PRF process, first described by Choukroun et al.[10] in 2001, begins with blood being centrifuged immediately after collection without anticoagulants. With this procedure, coagulation starts during centrifugation. Centrifugation divides the blood sample into 3 parts: a red blood cell base at the bottom, an acellular plasma as a supernatant and a PRF clot in between. The PRF clot is transformed into a membrane through compression, and contains the highest concentration of the platelets and more than half of the leukocytes from a 9-mL blood harvest. Within the PRF membrane, the platelets are tightly merged together within a fibrin mesh, and the enmeshed leukocytes remain alive and functional in the dense fibrin network.

The PRFs release a high amount of growth factors including transforming growth factor-β1 and β2 (TGFβ-1 and TGFβ-2), platelet-derived growth factor (PDGF), vascular endothelial growth factor (VEGF), insulin-like growth factor 1 and 2 (IGF-1 and IGF-2), fibroblasts growth factor (FGF), and matrix glycoproteins (such as thrombospondin-1) for at least 7 days in vitro.[10–12] The PDGF occurs in the form of both homodimers (PDGF-AA and PDGF-BB) and heterodimers (PDGF-AB), and influences the synthesis of DNA strains, inducing angiogenesis, chemotaxis, and mitogenesis of fibroblasts, osteoblasts and monocytes. It cooperates with IGFs, which, in turn, leads to the differentiation of fibroblasts into osteoblasts, further increasing the amount of bone collagen in osteoblasts. In turn, TGF-β1 and TGF-β2 stimulate the production of connective tissue, synthesis and maturation of the collagen fibers, angiogenesis, and cell differentiation. The TGF-β1 has an impact on the mineralization of regenerating cells, influencing the speed and quality of the process. In turn, VEGF influences the synthesis of DNA strains, impacting the differentiation of endothelial cells, while simultaneously activating the healing process. During the early stages of healing (1–2 weeks), PDGF-BB and IGF-1 play a key role by stimulating and accelerating the gathering of fibroblasts. Later on (2–3 weeks), inflammatory tissue is replaced by connective tissue and induces production of the collagen fibers, where EGF and FGF lead the way. The last part of healing, when cells differentiate into osteoblasts and their maturation occurs, is once again induced by IGF-1.[12,13]

In recent years, researchers have paid increased attention to the clinical results of PRF application in sinus augmentation procedures. However, a general consensus pertaining to the use of this material has yet to be reached.[14,15]

Objectives

The main aim of this study was to evaluate if PRF, used solely as a grafting material in sinus lifting procedures, is a reliable alternative to xenografts.

Materials and methods

The data used in this study were collected via retrospective evaluation and were obtained through a well-known treatment. Thus, this study did not require approval of the bioethical committee.

Patient selection

Thirty generally healthy patients (14 men, 16 women), aged 30–64 years, with atrophic maxilla due to missing teeth in the lateral aspects, and previously treated with

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implant-supported oral rehabilitation, were included in the study. Other inclusion criteria included a apico-coronal height of 4–5 mm for the alveolar ridge in the region of the implant insertion during pre-surgical qualification, a minimal width of 7 mm for the alveolar ridge in the region of interest, approximal plaque index (API) ≤35, and plaque index (PI) ≤25. The exclusion criteria were previous grafting procedures in the area of interest and systemic or local diseases that could affect the healing or osteointegration processes. Smokers and patients with bruxism were excluded from the study as well.

Patients were randomly divided into 2 equal-sized groups. The 1st group (G_1) consisted of patients in whom the sinus lift was augmented with xenograft (Cerabone®; Botiss Biomaterials GmbH, Zossen, Germany). The 2nd group (G_2) consisted of patients solely receiving PRF as a grafting material.

Implants

In both groups, electrochemically hydroxyapatite-coated implants SGS (SGS Dental Implant System Holding, St. Gallen, Switzerland) of the same size (10 mm in length, 4.2 mm in diameter) were used.

PRF preparation

The PRF was prepared in accordance with Choukroun's protocol.[10] First, venous blood samples were collected from the patient into 10-mL tubes. Next, the samples were placed in a centrifuge (PRF PROCESSTM (CHOUKROUN DUO, Nice, France) and spun for 10 min at 3000 rpm. The PRF clot was then isolated from the erythrocytes fraction, 2 mm below platelets-rich layer. In order to obtain the desired PRF membrane, the PRF clots were put into a A-PRF™ box (Fida Tech, Copenhagen, Denmark) without any pressure applied.

Surgical technique

In order to aid the procedure and successfully identify patients who needed sinus augmentation, preoperative cone-beam computed tomographic (CBCT) images were used to carefully measure the residual bone volume. All patients were given premedication for antibiotic prophylaxis (Augmentin; GSK, Brentford, UK; 2.0 g), and implants were placed on the day of sinus augmentation surgery as a one-stage procedure. The position of the implant insertion was within the premolar and molar region.

Sinus augmentation with PRF

Under local anesthesia (4% articaine, 1 : 200000 Ubistesin; 3M, St. Paul, USA), a full-thickness mucoperiosteal flap with 2 releasing incisions was made. After creating an approach to the buccal wall of the maxillary sinus, the smallest possible window was created with piezosurgery® white (Mectron Carasco, Genova, Italy) and constant water-cooling. The bone window was used as a new sinus floor, as it remained partly attached to the membrane. Next, the Schneiderian membrane was carefully elevated from the bottom of the sinus. The implant was then inserted into the alveolar arch with a low rpm rate to use tip of the implant as a tent pole to elevate the sinus sealing membrane, and an extra layer of the A-PRF was placed underneath. These latter procedures were carried out under constant eye control through created window, and the autogenous membranes were used to prevent perforations. The PRF membrane was applied to prevent further complications. When primary stabilization of the implant was satisfactory, PRF clots were placed around it to fill up the residual space completely. The PRFs were also positioned to cover the bony window, and the flap was sutured back with resorbable, monofilament 5-0 sutures (Monosyn B/Braun, Tuttlingen, Germany). The primary closure without tension was achieved by using horizontal mattress or continuous sutures. Postoperative treatment consisted of Eludril Classic® (Pierre Fabre, Paris, France) mouthwash for 2 weeks, 2 times per day, and an antibiotic cover (Augmentin; GSK; 2.0 g per day). If no complications were observed, the sutures were removed after 7–10 days.

Sinus augmentation with xenograft

The operating procedures for creating access to the maxillary sinus were as described above. The procedure started to differ after the bone window was made. Here, the Schneiderian membrane was elevated, and the freshly created subsinus cavity was filled with xenograft. Implantation in this group was also conducted simultaneously. After obtaining primary stabilization in the residual alveolar arch, the approach to the sinus was closed with resorbable, monofilament 5-0 sutures. The full-thickness flap was sutured back without tension using horizontal mattress or continuous sutures. Postoperative management also included Eludril Classic® mouthwash for 2 weeks (2 times per day) and an antibiotic cover (Augmentin; GSK; 2.0 g per day). Sutures were removed after 7–10 days if there were no complications.

Implant loading

All implants were non-submerged. After 6 months, loading of the implants was carried out. All implants were loaded with a splinted or non-splinted screwed restoration.

Clinical evaluation

The assessment was based on a clinical examination, including probing pocket depth (PPD) measured around the implants in 4 measurement points, height of the keratinized tissue (HKT), clinical attachment level (CAL), and the recession depth/width (RD/RW). The evaluation

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of HKT was performed on the day of surgery (HKT_0) and after 36 months from the implant loading (HKT_{36}). To calculate implant survival rate, criteria suggested by Albrektsson et al.[16] (individual unattached implant that is immobile when tested clinically; no evidence of peri-implant radiolucency; bone loss that is less than 0.2 mm annually after first year of service of the implant) and Buser et al.[17] (the absence of implant mobility; no pain or any subjective sensation and peri-implant infection; the absence of continuous radiolucency around the implants) were used.

Radiological evaluation

At least 3 digital panoramic X-rays were taken for evaluation: 1st immediately after sinus augmentation, 2nd during the follow-up visit after 6 months after sinus augmentation and prior to loading the implant, and 3rd 36 months after implant loading. The X-rays were performed using Galileos® D3437 software (Sirona Dental, Erlangen, Germany). Radiological evaluation allowed for the assessment of 3 main parameters: marginal bone loss (MBL), grafted sinus high (GSH) and bone gain (BG).

To calculate MBL, the dimensions were first calibrated using the known parameters of implant, including diameter and length. Starting from the implant shoulder, distances were measured to the mesial and distal points of bone-to-implant contact, parallel to the implant axis. Both distal and mesial measurements were averaged. To report the change in the height of the grafted sinus, the lowest point of the original sinus floor (OSH) was calculated. The BG was finally calculated at 36-month follow-up based upon panoramic X-ray examination as a distance between OSH and the highest point of bone structure – GSH. All measurements were done by S.D., a junior member of the study team who was not involved in performing the implant surgeries.

Statistical analysis

Statistical analysis was carried out using SPSS v. 25 (IBM Corp., Armonk, USA) In order to check the distribution of the examined variables and to test their compliance with the normal distribution, basic descriptive statistics were calculated and Shapiro–Wilk distribution normality tests were performed. Ultimately, the nonparametric Mann–Whitney U test was used to detect differences between groups in the following measurements: MBL, BG, PPD, HKT (measured immediately after surgeries, and after the 36-month follow-up period), CAL, RD, and RW. The global significance level for the study was $\alpha = 0.05$.

Results

The implant survival rate in both groups was 100% at 36 months. For 1 case in the PRF group, PPD for 4 mm with accompanying bleeding was reported, although the implant was stable. Mechanical and chemical debridement was applied in this case as a first option for peri-implantitis management. In the rest of the cases, implant mobility, pain, paresthesia, and inflammatory processes in the direct vicinity of the implants were not reported in either group. Thus, the cumulative success rate was calculated as 100% according to Albrektsson et al.[16] and 93% according to Buser et al.[17]

The mean GSH value was 3.4 mm for the PRF (G_2) group and was lower than that observed for the xenograft (G_1) group (4.5 mm). These findings were accompanied by poorer results for MBL and CAL in G_2 (0.6 mm and 0.53 mm, respectively) relative to G_1 (0.46 mm and 0.4 mm, respectively). In contrast, the initial HKT in G_2 was 3.4 mm, while in G_1 the pre-surgical HKT level was 2.93 mm. Detailed results from the clinical and radiological evaluations are reported separately for each group in Tables 1 and 2.

As the Shapiro–Wilk tests indicated that the variables were not normally distributed and exhibited kurtosis values usually surpassing the absolute value of 2, it was decided to use the nonparametric Mann–Whitney U test to examine group differences in site, PPD, HKT_0, HKT_{36}, CAL, RD, RW, MBL, and BG. The rank-biserial correlation (r) was used as a measure of the effect size. The results of Mann–Whitney U tests for each of the variables are reported in Table 3.

Three of the 9 conducted tests turned out to be statistically significant. The HKT_{36} value in the G_1 group was significantly lower than that observed for G_2, and the effect factor r indicated a large effect. The RW value in the G_1 group was also significantly lower as compared to G_2, and the effect factor indicated a large effect. However, the BG value in G_2 was much lower than that observed in G_1, and the effect factor r also indicated a large effect.

Discussion

The issue of maxillary sinus grafting is not new and has been evaluated by many authors before. Previously, using bone-substituting materials, xenografts have mostly proved effective. However, application of a xenograft in the sinus lifting procedure requires a long follow-up period due to relatively slow resorption of the biomaterial. Another disadvantage of using heterogenic or allogenic materials in this procedure is the necessity for evacuation in the case of complications. The ethical concerns associated with the aforementioned materials also cannot be depreciated. On the other hand, the alveolar recess of the maxillary sinus, due to sufficient blood supply and other anatomical properties, possesses a high osteoconductive potential. Thus, a sinus lift without grafted bone material or with an autologous graft is a very natural and attractive approach.[16]

The existing evidence-based literature is scarce in terms of the sole use of platelet concentrates in maxillary sinus augmentation. Evaluation of this procedure is hampered also by the fact that the majority of the existing studies

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Table 1. Clinical and radiological results of patients included in group 1 (G_1)

G_1	Age/sex	Splinted or non-splinted	Site (tooth number)	PPD	HKT_0	HKT_{36}	CAL	RD	RW	MBL	BG
1	45/M	N	16	2	3	2	0	0	0	0	4
2	30/F	N	16	2	2	3	1	1	0	1	5
3	66/M	N	15	2	3	3	0	0	1	1	4
4	64/M	S	25	2	4	3	0	0	0	0	5
5	48/F	S	15	1	4	3	1	0	0	0	5
6	59/F	N	16	2	3	2	0	0	0	0	5
7	52/F	S	25	3	2	2	1	1	2	1	5
8	41/M	N	26	2	2	2	1	1	1	1	4
9	48/F	S	26	2	3	2	0	0	0	0	5
10	**35/M**	**N**	**15**	**3**	**3**	**3**	**1**	**1**	**0**	**1**	**4**
11	48/F	S	16	3	3	3	1	1	0	1	5
12	59/M	S	26	2	4	3	1	0	0	0	5
13	56/F	S	16	2	3	2	0	0	0	0	6
14	61/F	N	15	1	3	2	0	0	0	0	3
15	38/M	N	16	1	2	2	0	0	0	0	3
Average	–	–	–	2	2.933333	2.466667	0.466667	0.333333	0.266667	0.4	4.533333

G_1 – group 1; PPD – probing pocket depth; HKT – height of the keratinized; CAL – clinical attachment level; RD – recession depth; RW – recession width; MBL – marginal bone loss; BG – bone gain.

Table 2. Clinical and radiological results of patients included in group 2 (G_2)

G_2	Age/sex	Splinted or non-splinted	Site (tooth number)	PPD	HKT_0	HKT_{36}	CAL	RD	RW	MBL	BG
1	45/F	N	16	3	4	4	1	1	2	1	3
2	57/M	N	16	1	3	3	1	1	1	1	4
3	60/M	S	26	1	4	3	1	1	2	1	5
4	55/M	N	26	2	4	3	0	0	2	0	3
5	53/F	S	25	2	3	3	0	0	2	0	4
6	63/F	S	27	2	3	3	1	1	1	1	3
7	47/M	S	26	2	3	3	0	0	2	0	2
8	41/F	N	16	3	3	3	1	0	2	1	6
9	58/F	S	15	2	4	4	0	0	2	0	4
10	55/M	S	16	4	3	3	3	1	1	2	4
11	38/F	N	16	2	4	3	0	0	2	0	3
12	60/M	S	16	2	4	4	0	0	2	0	3
13	44/F	S	26	2	3	3	0	0	2	0	3
14	49/M	S	25	1	3	2	1	1	1	1	2
15	59/F	N	26	2	3	3	0	1	1	0	2
Average	–	–	–	2.066667	3.4	3.133333	0.6	0.466667	1.666667	0.533333	3.4

Bold – patient with bleeding; G_2 – group 2; PPD – probing pocket depth; HKT – height of the keratinized; CAL – clinical attachment level; RD – recession depth; RW – recession width; MBL – marginal bone loss; BG – bone gain.

included only small cohorts of patients and short-term follow-up periods (6–12 months). Another difficulty in the assessment of platelet concentrate applications is the lack of control groups in the previous work.[18]

Anitua et al. were one of the first to conduct a retrospective study of platelet concentration application in maxillary sinus grafting with a long (36 months) follow-up period. When using short implants and a transcrestal approach, the alveolar bone height increased by 3.7 ±1.7 mm and 4.2 ±2.0 mm at 12 ±3 months and 35 ±11 months after surgery, respectively.[14] Previously, most studies included a shorter observation period. Toffler et al.[19] in a study

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Table 3. Mann–Whitney U test results for each of the variables

Variable	G_2 (n = 15)				G_1 (n = 15)				Z	p-value	R
	medium range	Me	SD	IQR	medium range	Me	SD	IQR			
Site	17.90	25.00	5.20	10.00	13.10	16.00	4.91	10.00	–1.56	0.118	0.29
PPD	15.60	2.00	0.80	0.00	15.40	2.00	0.66	0.00	–0.07	0.944	0.01
HKT_0	18.20	3.00	0.51	1.00	12.80	3.00	0.70	1.00	–1.89	0.059*	0.35
HKT_{36}	19.70	3.00	0.52	0.00	11.30	2.00	0.52	1.00	–3.00	0.003*	0.55
CAL	15.73	0.00	0.83	1.00	15.27	0.00	0.52	1.00	–0.17	0.868	0.03
RD	16.50	0.00	0.52	1.00	14.50	0.00	0.49	1.00	–0.73	0.464	0.13
RW	22.00	2.00	0.49	1.00	9.00	0.00	0.59	0.00	–4.32	<0.001*	0.79
MBL	16.20	0.00	0.64	1.00	14.80	0.00	0.51	1.00	–0.50	0.616	0.09
BG	11.10	3.00	1.12	1.00	19.90	5.00	0.83	1.00	–2.83	0.005*	0.52

Asterisks indicate significant results; G_1 – group 1; G_2 – group 2; PPD – probing pocket depth; HKT – height of the keratinized; CAL – clinical attachment level; RD – recession depth; RW – recession width; MBL – marginal bone loss; BG – bone gain; Me – median; SD – standard deviation; IQR – interquartile range.

on SLA implants with a 3-month follow-up reported a mean increase in the height of implant sites of 3.4 mm (range: 2.5–5 mm), while Diss et al.[20] in a 12-month follow-up on Astra Tech implants reported a mean endo-sinus BG of 3.2 ±1.5 mm. Aoki et al.[21] also reported a statistically significant mean BG in sandblasted acid-etched implants compared to hydroxyapatite implants, and Molemans et al.[22] reported a higher mean BG (5.4 ±1.5 mm) with the lateral sinus floor elevation approach compared to the transalveolar technique (3.4 ±1.2 mm).

The superiority of the lateral window technique was once again confirmed in a study by Mazor et al.,[23] where implants were placed in residual bone with heights between 1.5 mm and 6 mm (mean ± standard deviation (SD): 2.9 ±0.9 mm). The final bone gain with this procedure was very significant (between 7 mm and 13 mm (mean ±SD: 10.1 ±0.9 mm) at 6-month follow-up. In a similar study with a 6-month follow-up, Tajima et al.[24] observed a lower gain in mean residual alveolar bone height after the sinus floor elevation from 4.28 ±1.00 mm (range: 1.9–6.1 mm) prior to surgery to 11.8 ±1.67 mm (range: 9.1–14.1 mm) after surgery. The results of the sinus-lift procedure combined with PRF application also appear to remain stable with a longer follow-up. Simonpieri et al.[25] conducted a retrospective study with 2–6 years of observation and reported very stable results with between 8.5 mm and 12 mm of bone gain (mean ±SD: 10.4 ±1.2 mm) observed. These findings of very stable results for crestal bone height were confirmed by Pichotano et al.[26] In this study, 20 patients treated with SLA implants placed immediately with PRF sinus-grafting showed a bone gain of 8.5–12 mm (mean ±SD: 10.4 ±1.2 mm). Another study, including 27 patients who received 2 types of implants during the sinus-lift procedure, with PRF used solely as the grafting material, reported a bone gain of 4.38 mm and 4.00 mm for SLA and HA implants, respectively. The observation period in this latter study was 12 months.[27]

Similar to the abovementioned studies, the current work evaluated maxillary sinus grafting by radiographic assessment using pre- and post-surgical panoramic X-ray. In this study, a comparison of the effectiveness of solely used xenograft or PRF was carried out. However, some authors have suggested that PRF could be combined with xenograft to improve the osteoconductive properties of the graft. This combination may accelerate bone formation and promote wound healing. The mechanism that underlies both events could be the ability of PRF to increase blood flow in the sinus cavity and osteoblast formation via the release of growth factors. Pichotano et al.[28] showed that the addition of PRF to xenograft improves resorption rates when compared to xenograft alone (22.25% and 8.95%, respectively). Histomorphometric analysis showed an increased amount of newly formed bone when PRF was used compared with xenograft alone, and allowed, in turn, faster implant loading. However, Nizam et al.[29] reported no qualitative difference in histological analyses among groups of patients receiving xenograft alone or in combination with PRF. In all samples, a newly formed bone was in direct contact with the residual material. Similar radiographic bone height was observed in the augmented area, and the implant survival rate was 100% for both groups.

Retrospective studies based on clinical evaluations of sinus floor augmentation are even less common. Hadzik et al.[30] reported that the HKT value changed from 2.7 ±1.64 mm to 1.73 ±1.1 mm at 36 months following the direct-placing of similar-sized SLA implants with sinus floor lifting + xenograft usage, a much bigger decline in comparison to the current results.

None of the implants were lost during the current study, including during the initial-surgical phase and over a 36-month follow-up period. According to the criteria proposed by Albrektsson et al.[16], the success and survival rate was 100%, as no mobility of the implant or radiolucency was observed. Unlike the criteria proposed by Albrektsson et al.[16], the criteria proposed by Buser et al.[17] include vertical bone loss and the presence of infection (peri-implantitis). This latter clinical evaluation allows for a more stringent assessment of the peri-implant hard

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and soft tissue condition, which explains the lower success rate according to Buser et al.[17] For 1 case in G_2, PPD for 4 mm with accompanying bleeding was observed; thus, dropping the success rate for that group to 93% according to the criteria proposed by Buser et al.[17]

In a study on 114 HA-coated implants with a long (8–10 years) follow-up, Binahmed et al.[31] reported a survival rate in the maxilla of 70.59%. However, McGlumphy et al.[32] in a shorter follow-up study (5–7 years) on 429 HA-coated implants reported a much higher cumulative survival rate (96% at 5 years and 95% at 7 years of follow-up). The mean combined mesial/distal bone loss in this latter study was 1.2 mm in the mandible and 1.4 mm in the maxilla after 5 years of functional loading. Schwartz-Arad et al. [33] conducted a comparison study of HA-coated and commercially pure titanium implants with a 12-year follow-up. In this study, the reported total mean MBL was 1.07 ±2.16 mm. In addition, MBL was significantly lower with titanium implants (0.55 ±1.04 mm) compared to HA-coated implants (1.51 ±2.71 mm; $p < 0.001$). Furthermore, the total 12-year survival rate was 91.4%, and HA-coated implants had a significantly higher 12-year survival rate than titanium implants (93.2% compared to 89%; $p < 0.03$). Atia et al.[34] provided a comparison of the success rates according to Buser et al.[17] and Albrektsson et al.[16] for SLA implants placed in maxilla previously treated with PRP or augmented solely with an autogenous bone graft. These authors reported a cumulative success rate of 93.3% (97.5% for the bone graft group) according to criteria proposed by Buser et al.[17] at 15 years and 1 month of observation. However, the success rate according to the criteria proposed by Albrektsson et al.[16] was generally lower, and on the PRP side at the 5-, 10-, and 15-year observation points it was 96.7%, 94.4% and 43.7%, respectively, while on the control side it was 98.8%, 97.5% and 77%, respectively.

Conclusions

After 3 years of follow-up on the sinus lifting procedure solely using PRF with simultaneous implantation, the results obtained appear promising, especially regarding of soft tissue management. Thus, PRF can confidently be regarded as a credible alternative to previously used materials.

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