Open Med. 2017; 12: 24-32 **DE GRUYTER**

Case Report **Open Access**

Antonio Cortese, Giuseppe Pantaleo*, Massimo Amato, Candace M. Howard, Lorenzo Pedicini, Pier Paolo Claudio*

Platelet-rich fibrin (PRF) in implants dentistry in combination with new bone regenerative flapless technique: evolution of the technique and final results

DOI 10.1515/med-2017-0005
received December 19, 2016; accepted January 15, 2017

Abstract: Most common techniques for alveolar bone augmentation are guided bone regeneration (GBR) and autologous bone grafting. GBR studies demonstrated long-term reabsorption using heterologous bone graft. A general consensus has been achieved in implant surgery for a minimal amount of 2 mm of healthy bone around the implant.

A current height loss of about 3-4 mm will result in proper deeper implant insertion when alveolar bone expansion is not planned because of the dome shape of the alveolar crest. To manage this situation a split crest technique has been proposed for alveolar bone expansion and the implants' insertion in one stage surgery. Platelet-rich fibrin (PRF) is a healing biomaterial with a great potential for bone and soft tissue regeneration without inflammatory reactions, and may be used alone or in combination with bone grafts, promoting hemostasis, bone growth, and maturation. Aim: The aim of this study was to demonstrate the clinical effectiveness of PRF combined with a new split crest flapless modified technique in 5 patients vs. 5 control patients. Materials and methods: Ten patients with horizontal alveolar crests deficiency were treated in this study, divided into 2 groups: Group 1 (test) of 5 patients treated by the flapless split crest new procedure; Group 2 (control) of 5 patients treated by traditional technique with deeper insertion of smaller implants without split crest. The follow-up was performed with x-ray orthopantomography and intraoral radiographs at T0 (before surgery), T1 (operation time), T2 (3 months) and T3 (6 months) post-operation. Results: All cases were successful; there were no problems at surgery and post-operative times. All implants succeeded osteointegration and all patients underwent uneventful prosthetic rehabilitation. Mean height bone loss was 1 mm, measured as bone-implant most coronal contact (Δ-BIC), and occurred at immediate T2 post-operative time (3 months). No alveolar bone height loss was detected at implant insertion time, which was instead identified in the control group because of deeper implant insertion.

Conclusion: This modified split crest technique combined with PRF appears to be reliable, safe, and to improve the clinical outcome of patients with horizontal alveolar crests deficiency compared to traditional implanting techniques by avoiding alveolar height-loss related to deeper insertion of smaller implants.

Keywords: PRF; Split crest; Elderly patients; Bone regeneration

***Corresponding author: Pier Paolo Claudio,** Department of BioMolecular Sciences, and Department Radiation Oncology,University of Mississippi, Jackson Cancer Center, 2500 N. State St, Jackson, MS 39216, USA, E-mail: pclaudio@olemiss.edu
Giuseppe Pantaleo, Department of Neurosciences, Reproductive and Odontostomatological Sciences, University Federico II of Naples, Naples, Italy, E-mail: ancortese@unisa.it
Antonio Cortese, Department of Medicine and Surgery, Unit of Maxillofacial Surgery, University of Salerno, Salerno, Italy
Massimo Amato, Department of Medicine and Surgery, University of Salerno, Salerno, Italy
Candace M. Howard, Department of Radiology, University of Mississippi Medical Center, Jackson, MS, USA
Lorenzo Pedicini, Second University of Naples, Naples, Italy

1 Introduction

Alveolar atrophy, which occurs following dental avulsion, has been ordinarily documented. The most significant bone loss observed is in the horizontal dimension with documented post-extractive alveolar reductions ranging between 3.8-6.1 mm over 3-12 months [1,2].

In these patients alveolar bone augmentation surgery is needed to obtain proper implant positioning and frontal teeth aesthetic of the smile [3,4].

The most common techniques for alveolar bone regeneration are guided bone regeneration (GBR) and autologous bone grafting [5,6].

GBR studies demonstrated long-term reabsorption using heterologous bone graft [7,8].

Problems may arise in autologous bone grafting and also from different conditions after mucosal dehiscence and graft infections with immediate or long-term reabsorption and unpredictable final bone volume [9].

The general consensus has been achieved in implant surgery for a minimal bone amount need of 2 mm of healthy bone tissue around the implant to achieve a good dental emergence and a correct prosthetic rehabilitation both for aesthetic and function [10-12].

Particularly, to preserve a healthy implant, a 1.5-2 mm thickness and a minimal alveolar width of about 7-8 mm is needed on the buccal cortical wall in relation to a 3.3-4.1 mm implant insertion [13-14].

Often, because of the dome shape of the alveolar crest, a height-loss of about 3-4 mm will be observed following deep implant insertion to avoid thread exposure, when alveolar bone expansion hasn't been properly planned. To manage this situation, the split crest technique was proposed in the first original study by Osborn in 1985 for alveolar bone expansion and implant insertion in one stage surgery without the need for an autologous bone graft [15-16].

Further modifications were proposed adopting partial thickness mucosal flaps' incision to preserve the periosteum adhesion to the alveolar bone [17].

In this way vascular supply and nourishment of the underlying bone was preserved, thereby avoiding bone resorption.

Moreover, bone substitute addition at the mid-crest osteotomy site was also proposed [18].

Since then, the split technique has undergone further evolution to solve several aesthetic and functional issues such as:

1. Buccal cortical wall reabsorption, managed by partial thickness flap or limited periosteal elevation [15].
2. Lack of primary implant stability at the insertion time, managed by double level implant site preparation by current implant kit bur [16,19].
3. Primary closure difficulties after bone expansion, managed by releasing incisions of the buccal periosteum [20].

To overcome some of the problems related to the technique and to achieve better aesthetic and functional results, we proposed an evolution of the procedure with the use of autologous protein rich fibrin at the osteotomy site.

PRF consists of an autologous leukocyte-platelet-rich fibrin matrix composed of a tetra molecular structure, with cytokines, platelets, and stem cells within, which acts as a biodegradable scaffold, and favors the development of micro-vascularization and is able to guide epithelial cell migration to its surface [21-22].

Some studies have demonstrated that PRF is a healing biomaterial with a great potential for bone and soft tissue regeneration, without inflammatory reactions, which may be used alone or in combination with bone grafts, promoting hemostasis, bone growth, and maturation [22-24].

Several studies have evaluated the effectiveness of PRF in intra bony and mandibular grade II defects and have found a positive clinical and radiographic outcome [25]. The routine use of such an inexpensive, autologous growth factor delivery system certainly offers an attractive option for the treatment of horizontal defects [22,26].

The aim of this study was to demonstrate the clinical effectiveness of PRF combined with a new split crest flapless modified technique also in elderly patients. In this study, patients in the study arm have been subjected to the new split crest flapless modified-technique with the use of PRF, and were compared with patients treated with traditional implanting techniques.

2 Materials and methods

This study was performed following the principles of the Declaration of Helsinki regarding research on humans; the signature of a written informed consent form from all patients was requested and obtained. Ten patients with horizontal alveolar crests deficiency were treated in this study, and were divided into 2 groups: group-1 (test group) consisting of 5 patients treated following the new flapless split crest procedure to optimize regenerative conditions by bone augmentation and implant insertion in a single stage procedure; and group-2 (control group) consisting of

5 patients treated by traditional implant surgery without split crest.

Orthopantomography and CT DentaScan/CT Cone beam were performed for every patient before treatment. In test group-1 autologous PRF was used to fill the split crest gap as regenerative material.

In control group-2, 5 patients showing similar alveolar crests horizontal deficiency were treated by a traditional technique with deeper insertion of smaller implants without any split crest. Follow-up was performed with x-ray, orthopantomography and intraoral radiographs at T0 before surgery, T1 (operation time), T2 (3 months) and T3 (6 months) from the operation time.

The patient's past medical and social history were non-contributory, and all patients had good oral hygiene. All the patients had no contraindication to implant placement.

The operations were not performed in patients with systemic or psychological disorders that contraindicate oral surgery.

2.1 Surgical procedure

For every patient of group-1, after administration of a local anesthetic, the crestal mucosa incision was performed shifting it toward the palatal/lingual side to avoid positioning of the mucosa incision on the same site of the osteotomy line; flap elevation was performed by full thickness technique up to the buccal border of the alveolar crest. We did not perform any periosteum elevation on the buccal side to preserve vascular supply.

Linear osteotomies were performed by a scalpel blade #15 or by Beaver blade #64 on the upper jaw up to 1 mm from adjacent teeth or 4 mm exceeding expansion site limits in edentulous cases. Either bone chisel or piezo-surgery was used on the mandible in case of harder alveolar bone. No buccal bone release cuts were performed to preserving buccal bone fragment vascular supply. Expansion was possible by final oblique crest bone cuts at 1 mm from adjacent teeth without any buccal cuts (Figure 1) by splitting the buccal cortical wall from alveolar cortical wall.

To obtain implant primary stability, a double level implant site preparation was performed: split crest was limited at the alveolar bone level by chisels; at the basal bone level site, preparation was performed by implant kit burs up to 2.8mm diameter, followed by round osteotomes or round burs up to 3.5 mm to avoid cortical wall damages. Due to the shape of the alveolar bones, thin at the top and expanded at the basal level, bone expansion was not usually needed at basal level, where implant site preparation by set kit burs followed by round osteotomes or ball burs, resulted in precise implant site preparation at basal level with good primary stability. Round osteotomes or ball burs were selected to avoid the risks of buccal wall fracture for bone fragment entrapment when drilling by larger (3.5) implant kit drills (Figure 2).

To obtain expanded bone stability and promoting regeneration, osteotomy gaps were filled by autologous PRF and bone substitute, therefore combining regenerative technique with split crest (Figure 3).

To prepare the PRF, 20-40 ml of peripheral blood at the time of surgery were collected. Blood samples were collected into an 8.5 ml tubes without any anticoagulant, and immediately centrifuged at 2,700 rpm for 12 minutes to prevent coagulation cascades: this protocol was used in 2 of 5 cases, obtaining a normal gelling biomaterial to be used as regenerative and stimulating material. In the other three cases centrifugation time setting was 15-20 minutes at 3,000 rpm for more consistent substance to be used as a membrane in the split crest gap.

Centrifugation time changed in relation to consistency needed for the PRF: the longer the centrifugation time, the more the consistency of the PRF sample.

After centrifugation a PRF was obtained from the middle of the tube: red corpuscles centrifuged at bottom and acellular plasma at the top were discarded.

PRF was put directly inside the osteotomy gap mixed with coral bone substitute for larger defects, therefore combining both split crest technique and GBR (Figure 3).

To obtain primary closure of the wound, releasing incision was performed at the crestal mucosa level to gain sufficient lengthening for primary closure (Figure 4) [27].

In this way no periosteal elevation was performed on the buccal area preserving cortical plate nourishment. Also attached gingiva full coverage was obtained at the osteotomy sites by keratinized mucosa elongation for proper bone nourishment and stability.

Attention must be paid during the healing time to avoid any compression on the implant site by provisional prosthesis. Prosthesis must be trimmed to avoid compression on vertical and particularly on the horizontal dimension after alveolar arch expansion by splitting.

An orthopantomography and CT DentaScan/CT Cone beam were performed for every patient before surgery to have a preliminary radiological investigation and to get a general overview of the jawbones and relevant anatomic landmarks in a bi-dimensional plane (Figure 5). Also intraoral and face photographs were taken pre-operatively for aesthetic and functional evaluation of the patients status. For all the patients a beta-lactam antibiotic (Amoxicillin) was given orally, 2gr. one-hour

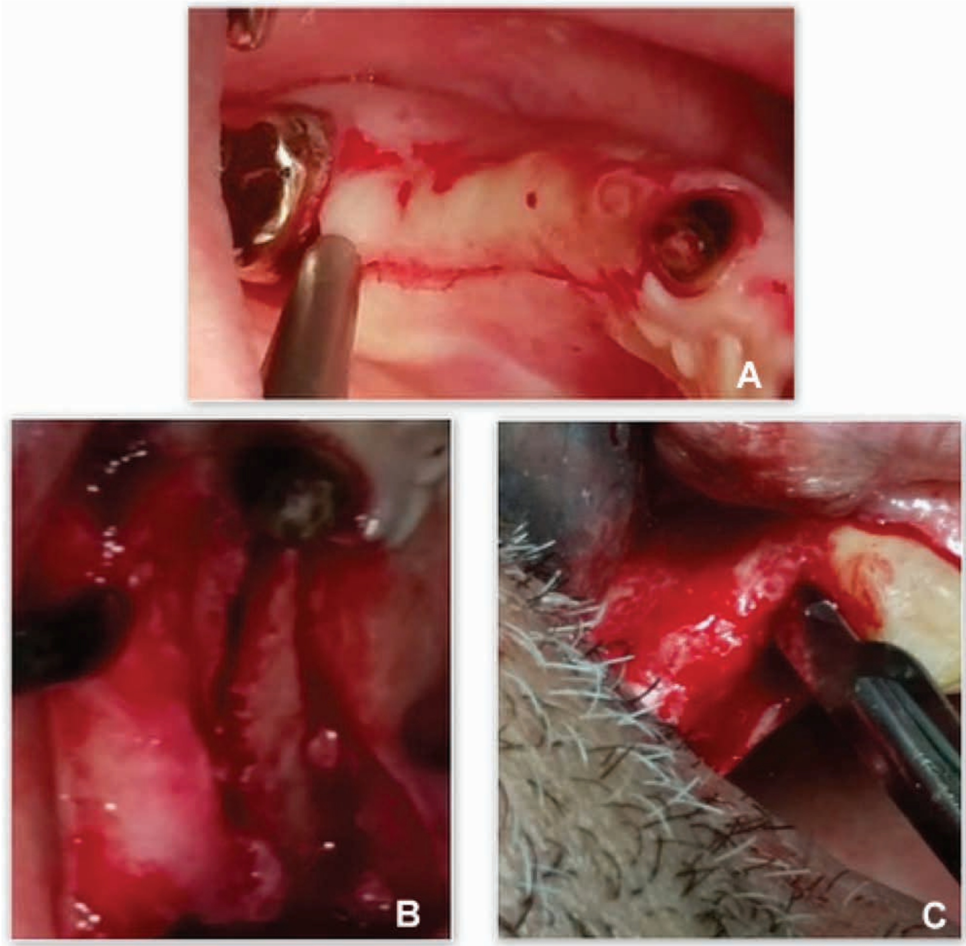

Figure 1: Clinical view of the initial surgical steps performed in one patient treated with the new flapless split crest procedure combined with PRF.

A: View of the crestal mucosa incision shifted toward the palatal/lingual side to avoid positioning of the mucosa incision at the same site of the osteotomy line;

B: View of full thickness flap elevation up to the buccal border of the alveolar crest. No periosteum elevation was performed on the buccal side to preserve vascular supply;

C: View of linear osteotomies performed on upper jaw up to 1 mm from adjacent teeth.

before surgery. Post-operative therapy required good oral hygiene, rinsing with mouthwash containing 0.2% chlorhexidine solution twice a day and an evening application of the same product in gel form, as well as the administration of a non-steroidal anti-inflammatory drug (Ketoprofen 80mg) for three consecutive days.

Follow-up was performed by conventional radiological imaging (orthopanoramic and intra-oral x-rays) at T1 (immediately after surgery), T2 (3-months after surgery) and T3 (6-months after surgery).

3 Results

All cases were successful; there were no problems at surgery time, as well as at post-operative and osteointegration periods. All implants achieved good osteointegration. These results were obtained by accurately managing the immediate and late postoperative period in all of the treated patients. All patients underwent uneventful implant surgery. All implants were placed according to the manufacturer's instructions and achieved primary stability. No intra-operative surgical complications were recorded.

Particular attention was paid to oral hygiene, and to inappropriate early prosthodontic loading by provisional prosthesis at immediate and late postoperative time.

The main characteristics and results related to the 10 patients belonging to the study are presented in Tables 1 and 2 concerning the 5 cases of group-1 (test cases) and in Table 3 for the 5 cases of group-2 (control cases).

Bone heights before surgery were calculated by measuring the distances between alveolar crest and implant bone limits (sinus and nasal floors and the connecting lines) for the upper jaw and between the inferior border of the mandible and alveolar crest for the lower jaw.

At postoperative time, after implant insertion, bone height was measured from bone limits and the lower border of the mandible up to the most coronal level of bone to implant contact (BIC).

Comparing results shown in Table 1 and Table 3 for height decrease at T0, T1, T2 and T3 between the new split crest and the traditional technique, it is evident that the new split crest technique group experienced less bone height loss.

In group-1, as shown in Table 1, the mean final height bone loss was 1.2 mm mainly occurring at postoperative time T2 (3 months after surgery) measured by Δ-BIC at T2 and T3 in relation to T0.

In the control group, patients with similar alveolar crest thinness were implanted without any split crest bone expansion, but only by deeper insertion of smaller

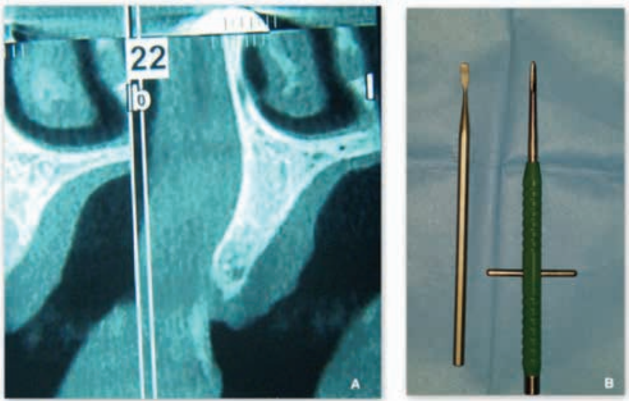

Figure 2: Double level implant site preparation.

A: To obtain implant primary stability, a double level implant site preparation is performed: split crest is limited at the alveolar bone level by chisels;

B: at the basal bone level site preparation is performed by implant kit burs up to 2.8mm diameter, followed by round osteotomes or round burs up to 3.5mm to avoid cortical wall damage.

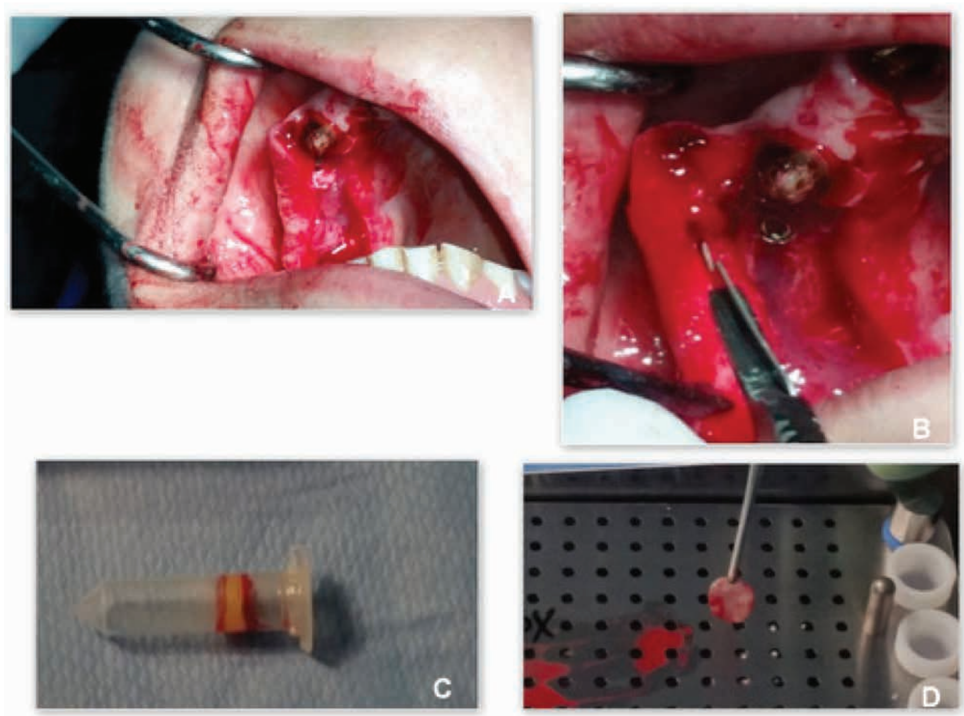

Figure 3: Clinical view of surgical steps performed in one patient treated with the new flapless split crest procedure combined with PRF.

A: To obtain expanded bone stability osteotomy gaps were filled by autologous PRF and bone substitute to combine regenerative technique with split crest;

B: To obtain primary closure of the wound, releasing incision was performed at the crestal mucosa level to gain sufficient lengthening for primary closure; C: Blood samples were collected into an 8.5 ml tubes without any anticoagulant, and immediately centrifuged; D: After centrifugation PRF was obtained from the middle of the tube.

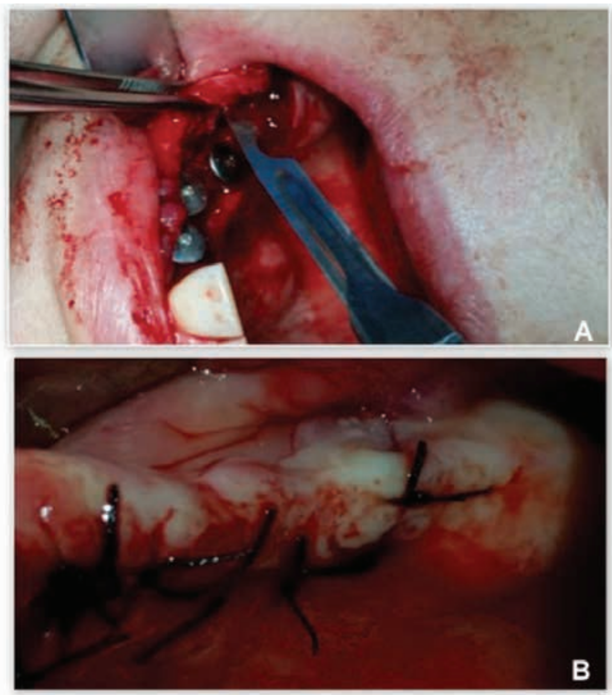

Figure 4: Clinical view of the final surgical steps performed in one patient treated with the new flapless split crest procedure combined with PRF.

A: Implant insertion and flap release incision; B: Primary closure of the flap

implants (Table 3). Final height bone loss was of 2.8 mm at T3, showing a bone loss of 2.2 mm at T1 (immediately after surgery) and of additional 0.6 mm at T3 (6 months after surgery) in relation to T0.

In test group operated by the modified split crest technique, the mean alveolar crest expansion was 3.35 mm. As shown in Table 2, the expansion measurements achieved by the new modified split crest technique are demonstrated by the initial (before surgery) and final (after surgery) alveolar crest measurements.

4 Discussion

Several advantages are achieved by the single stage split crest procedure for alveolar crest augmentation and implant insertion among which are: reduction of the morbidities and time needed for dental rehabilitation compared with other common regenerative procedures (guided bone regeneration and autologous bone graft) [15,19]; increment of bone height availability for implant insertion allowing fixture positioning at the marginal crest level by expansion.19 On the other hand we observed that traditional implant insertion in control group-2 patients with similar alveolar crest thinness who were implanted without any split crest, but only by deeper insertion of

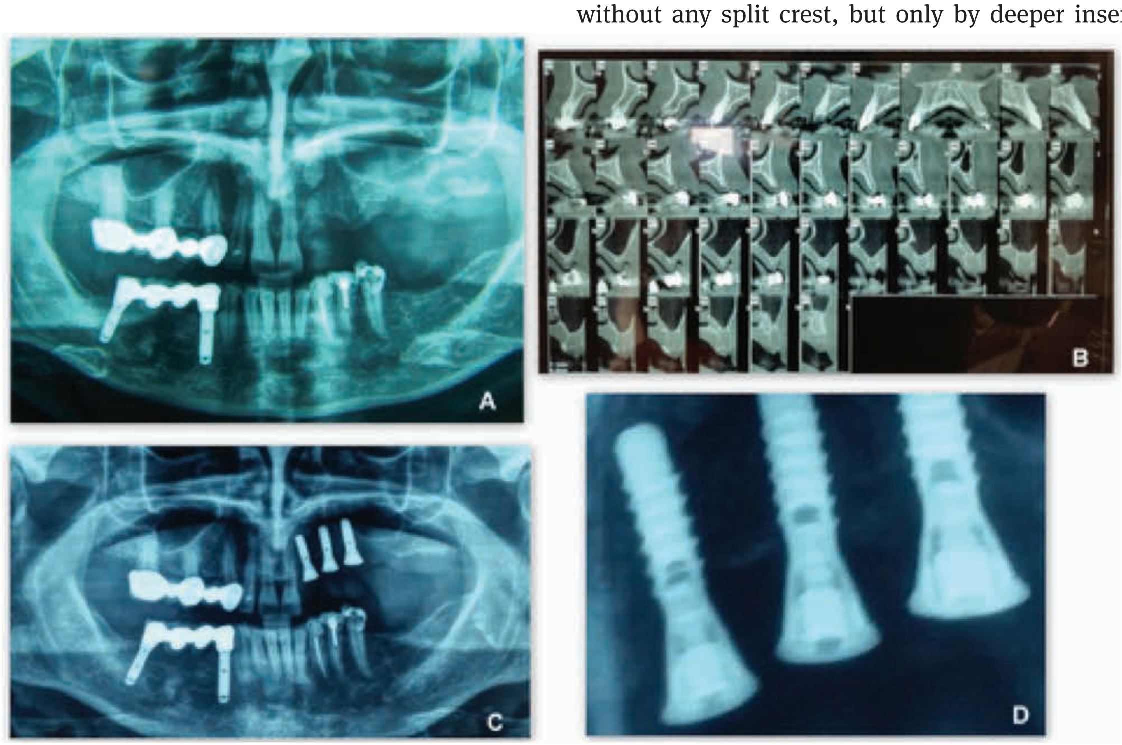

Figure 5: Radiographic views of a patient treated with the new flapless split crest procedure combined with PRF.

A: Pre-operative X-Ray Orthopantomography; B: Pre-operative CT-Dentascan; C: Post-operative X-Ray Orthopantomography;

D: 6 months post operative detail X-Ray image of the bone level at T3.

Table 1: Demographic and clinical data from group-1 patients.

Table illustrates for five patients treated with split crest flapless technique, their implants distribution, type of PRF used, bone height loss measured from lower border of the mandible and from nasal and sinus floors to alveolar bridge (pre-op) and to highest bone-implant contact (post-op) at T0 (pre-operative time), T1 (immediate post-operative time), T2 (3 months after surgery), and T3 (6 months after surgery).

	Age	Implants placed	Implant length, mm	Torque, N.cm	PRF type	Bone height loss (T0, T1, T2, T3) mm
Patient 1	53	1	11	35	More consistent	T0:0; T1:0; T2:0; T3:1
Patient 2	59	4	≥ 8; ≤ 13	40	Normal gel	T0:0; T1:0; T2:0; T3:1
Patient 3	60	2	11	35	More consistent	T0:0; T1:0; T2:1; T3:2
Patient 4	57	1	8.5	35	More consistent	T0:0; T1:0; T2:0; T3:1
Patient 5	55	2	≥ 8; ≤ 11	40	Normal gel	T0:0; T1:0; T2:0; T3:1

Table 2: Demographic and clinical data from group-1 patients.
Table illustrates for five patients treated with split crest flapless technique the initial and final alveolar crest width. The mean expansion by split crest technique in 10 cases was 3.35 mm.

	Age	Sex	Initial bone width	Final bone width	Number of implants	Timing of implant placement	Complications
Patient 1	53	F	3.5 mm	7.5 mm	3	Immediate	NO
Patient 2	59	F	4 mm	7 mm	4	Immediate	NO
Patient 3	60	F	3 mm	7 mm	2	Immediate	NO
Patient 4	57	F	4 mm	7 mm	1	Immediate	NO
Patient 5	55	F	3.5 mm	6.5 mm	2	Immediate	NO

Table 3: Demographic and clinical data from group-2 patients.
Table illustrates bone height loss for five control patients with similar alveolar crest thinness that were implanted by direct deeper insertion of smaller implants.

	Age	Implants placed	Implant length, mm	Torque, N.cm	Bone height loss (T0,T1,T2,T3), mm
Patient 1	57	2	11	40	T0:0; T1:2; T2:3; T3:3
Patient 2	60	1	8	35	T0:0; T1:3; T2:4; T3:4
Patient 3	52	4	≥ 11; ≤ 13	35	T0:0; T1:2; T2:2; T3:2
Patient 4	55	2	11	40	T0:0; T1:2; T2:2; T3:3
Patient 5	57	2	≥ 8; ≤ 11	35	T0:0; T1:2; T2:2; T3:2

Figure 6: Final result and clinical oral view of a patient treated with the new flapless split crest procedure combined with PRF. Final aesthetic result obtained without any additional graft.

smaller implants, showed greater bone resorption at T1 because of bone height loss at implant insertion.

The main problem in alveolar expansion is the stability of the buccal cortical plates over time [28]. To prevent this risk, our modified surgical technique utilizes several procedures aimed at preserving nourishment of the buccal cortical plates by: 1) shifting the flap incisions on the palatal/lingual side without any buccal muco-periosteal elevation; 2) gentle osteotomy techniques for the alveolar crest that avoid medial and distal bone buccal cuts [19,29]; 3) autologous PRF positioning at osteotomy gap after expansion, for contemporary GBR by bone substitute addition for wider expansions; 4) preservation of periosteal attachment on buccal wall and osteotomy gap coverage by attached gingiva with primary closure by elongation of keratinized mucosa flap. All of these procedures seem to be effective for the quality of the final results [30].

In accordance with previously published data showing good results from the combination of split crest technique with GBR [27,31], we presented improved results achieved by the association of new developed split crest with the use of autologous PRF.

5 Conclusion

Although limitation of this study are the restricted number of cases and the shortness of the postoperative control time, this modified split crest technique appears to be reliable, safe and able to improve clinical results obtained, compared to traditional techniques by avoiding alveolar height loss related to deeper insertion of smaller implants.

Alternative procedures like GBR and autologous bone grafting both shows some disadvantages for membrane exposure risks with related bone resorption or implant and donor site morbidity risks with immediate- and long-term bone graft resorption.

Additional studies are needed to verify long-term survival of the buccal cortical walls by this modified split crest technique. Further evolutions may be possible in relation to the development of these significant new techniques in the Maxillofacial Surgery arena [32-35].

Conflict of interest: The authors declare that they do not have any conflict of interest related to this study.

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