Horizontal Bone Augmentation in the Anterior Esthetic Area of the Maxilla Using a Flap Design Adapted from Mucogingival Surgery in Association with PLA Membrane and β-TCP

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Systematic reviews showed possible esthetic complications with the use of traditional flap designs after guided bone regeneration (GBR) procedures in the esthetic zone and the aim of this case series was to analyze hard and soft tissue changes over 18 months after these procedures. Healthy subjects requiring tooth extraction and single-implant placement in the anterior maxilla were enrolled in the study. Three months after tooth extraction and ridge preservation, a prosthetic-driven implant was placed. The horizontal bone deficiency was treated with a resorbable bone graft substitute (beta tricalcium phosphate [β-TCP]) and a bioresorbable polylactic acid (PLA) membrane. Primary closure was obtained by a novel coronally advanced flap adapted from mucogingival techniques. Final metal-free implant restorations were delivered 4 months after placement. Clinical measurements, pictures, and radiographs were acquired after delivery of the final restoration (T1) and at the 18-month follow-up (T2). Digital impressions were taken at the time of tooth extraction (T-1) and implant insertion (baseline; T0) and at T2. Marginal bone level changes were assessed by radiographic analysis, while soft tissue changes were evaluated with ExoCad software. Student t test for paired data was used to detect differences between the different time points. Twelve subjects (7 men and 5 women; mean age: 63.7 ± 14 years) completed the study and received 15 implants. All implants healed uneventfully and were clinically osseointegrated and stable, showing no sign of infection. No GBR complications were noted. Statistically significant ridge-width changes were observed after extraction (T-1 vs T0 = –1.72 ± 0.30 mm; P = .00001) and after horizontal GBR (T0 vs T2 = 1.41 ± 0.64 mm; P = .00001). Radiographic bone levels after implant placement remained stable T0 to T2 (0.09 ± 0.08 mm). Periodontal parameters never exceeded physiologic levels. It can be concluded that GBR using a bioresorbable PLA membrane and resorbable β-TCP bone graft in conjunction with a coronally advanced flap is a predictable procedure for horizontal bone augmentation with simultaneous implant placement in the esthetic area.


Guided bone regeneration (GBR) is a surgical technique that is often required during or prior to dental implant placement.1 GBR aims to recreate adequate bone volume to provide dental implants with ideal prosthetic location and long-term stability.2-5 Modern implantology concepts pose great attention on esthetics and implant-prosthetic design.

In order to be successful, GBR procedures depend on four key factors outlined by Wang and Boyapati6: primary wound closure, angiogenesis, stability of the blood clot, and space maintenance. For primary wound closure, flap design and releasing techniques play a crucial role in achieving a tensionless complete closure for graft coverage. Wound dehiscence with membrane exposure was reported to result in inferior quality and quantity of bone regeneration, with fewer successful dental implant performances.7-10 Aiming to optimize primary closure and flap release, numerous flap approaches have been described in the literature.11 Some designs allow limited flap advancement and can be utilized in small grafting procedures.12-14 Buser et al.15,16 proposed the lateral incision technique for localized staged horizontal ridge augmentation. Some other flaps allow for a moderate advancement, defined to be around 5 to 6 mm.17-20

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Surgical procedures in the esthetic area employ flap designs that aim to preserve the gingival integrity of adjacent restorations and teeth; the goal is to avoid gingival recessions, scarring, and potential loss of the interdental papilla, as these can have adverse esthetic impacts and may affect the teeth adjacent to those involved in GBR of the anterior zone. Some gingival flaps used for GBR can be employed to improve unsatisfactory or symptomatic gingival deformities affecting neighboring teeth and/or restorations. A GBR procedure was performed to regenerate horizontal bone deficiencies in the anterior esthetic area by way of (1) a flap design adapted from mucogingival surgery used in association with (2) a resorbable membrane and bone graft substitute (beta tricalcium phosphate [β-TCP]). The purpose of this case series was to investigate, over 1 year, the hard and soft tissue changes following this GBR procedure.

### Materials and Methods

Twelve consecutive patients presenting hopeless maxillary anterior teeth (from canine to canine) with absence of buccal plate (socket Class II, according to Elian et al), were recruited from April 2015 to January 2016 from a private dental clinic in Rome. Inclusion/exclusion criteria are summarized in Table 1. All subjects belonged to American Society of Anesthesiologists Class I and signed a detailed informed consent form explaining the study steps and requirements. These subjects were followed up during a period of 18 months after final implant prosthetic rehabilitation.

The present study was performed following the principles outlined in the Declaration of Helsinki on experimentation involving human subjects.

### Tooth Extraction and Ridge Preservation

Preoperatively, each patient underwent a full periodontal examination and had a series of radiographs taken. One week prior to dental extraction, subjects were treated with a full-mouth professional prophylaxis. Antibiotic therapy (amoxicillin and clavulanic acid) began 1 day prior to extraction (1 g) and continued for 4 days postoperation (1 g, tid) (Fig 1).
Teeth were extracted with a minimally invasive approach followed by ridge preservation in type II sockets according to a specific protocol.26 β-TCP grafting material (GUIDOR calc-i-oss CLASSIC, Sunstar) was used (Fig 2). Right after ridge preservation (T-1), a digital impression of the area was taken by means of a scanner (F3600, Car estream). This digital file would be superimposed to the one at final crown delivery (T1) and the one at 18 months postoperation (T2) for GBR analysis.

**Horizontal Bone Augmentation**

Virtual implant planning was performed at 3 months after ridge preservation, using cone beam computed tomography analysis to compare the ideal prosthetic implant location and the available bone volume (Fig 3). One week prior to surgical implant placement, a full-mouth professional prophylaxis was performed and a digital impression of the oral cavity was taken (baseline; T0).

The proposed surgical technique represents a combination of GBR and mucogingival surgical techniques. The buccal flap was designed similarly to the coronally advanced flap used for the treatment of multiple recession defects in soft tissue plastic surgery:27 an envelope flap was performed at the buccal aspects, and the design included a midcrestal incision and creation of surgical papillae (part of the flap to be adapted on the de-epithelialized papilla at time of suturing) bilaterally two or three teeth away from the site to be regenerated. The flap was elevated as split-thickness up to the cementoenamel junction level, then elevated as full-thickness thereafter. The interdental papillae were de-epithelialized in order to act as connective tissue beds for the surgical papillae.

The lateral extension of the flap allowed for a tensionless coronal advancement and graft coverage, without the need of vertical releasing incisions.

A prosthetically driven crestal implant (3.8 mm in diameter, 13 mm in length; CSR Implants, Sweden & Martina) placement was performed (Fig 4). The peri-implant bone deficiency was treated with resorbable β-TCP graft material mixed with patient autogenous bone (50/50) harvested locally and covered with a bioresorbable polylactic acid (PLA) membrane (GUIDOR bioresorbable matrix barrier, Sunstar). The membrane was fixated in place via metal tacks positioned buccally 2 to 3 mm away from the bony defect. An additional amount of graft was then applied, and finally the membrane was secured on the palatal wall by means of resorbable sutures (Vicryl 6.0, Ethicon, Johnson & Johnson) (Figs 5 and 6).

To obtain primary closure, the flaps were coronally advanced by double periosteal and submucosal incisions and sutured on the anatomic papilla (left in place after de-epithelialization of interproximal papillae) without vertical releasing incisions. Synthetic, nonresorbable monofilament 6.0 sutures were used (Polynil, Sweden & Martina) (Fig 7).

**Postoperative Treatment**

Patients were instructed to avoid brushing in the surgical area for at least 15 days postsurgery, and sutures were removed after 14 days.
**Follow-up Evaluation**

Second-stage implant exposure was performed by minimal crestal incisions over the implant location 3 months after implant placement. The abutments were connected to the implants, and provisional restorations were seated and secured by temporary cement according to the manufacturer’s instructions. Keratinized mucosa was left attached circumferentially to the implants.

Clinical evaluation criteria at the time of second-stage implant exposure included potential crestal bone resorption (due to an early, unintentional implant exposure) and patients’ reports of pain and/or discomfort.

The final metal-free restorations were connected 2 months after implant exposure (T1).

**Follow-ups**

Patients were recalled every 6 months until 18 months after prosthetic loading (Fig 8).

**Primary Measurements**

Clinical measurements, images, and radiographs were taken at the time of final restoration delivery (T1) and after 18 months (T2); digital impressions were taken at the time of tooth extraction (T-1), before implant placement (T0), and at 18 months postloading (T2).
and hard tissue volume) from tooth extraction and ridge preservation to right before implant insertion and flap elevation (T-1 to T0) and from just before implant placement to final restoration after 18 months (T0 to T2). This was achieved by comparing digital models, following a previously published protocol. Briefly, using an intraoral scanner, patient maxillae were scanned. Stereolithography (STL) files were then imported into a dedicated software (ExoCad, Exocad). Digital models taken at different time points were superimposed to identify tissues' volumetric changes. Measurements were taken at different heights (–1 mm and –3 mm, using the soft tissue margin of neighboring teeth as a reference). Mean values were used for each patient.

The second outcome assessed was the change in marginal bone level (MBL). Radiographs taken at the time of definitive restoration (T1) were compared to those after 18 months of follow-up. A dedicated software was used according to an existing published protocol.

Periodontal parameters as well as biologic (pain, swelling, suppuration, etc) and/or mechanical complications (fracture of the framework and/or the veneering material, screw loosening, etc) occurring during the follow-up period were recorded.

Statistical Analysis

Descriptive statistics, including mean values and standard deviations, were used to describe changes in MBL and ridge width over time. Data were normally distributed. Student t test for paired data was used to compare MBL at different time points. The same statistical test was performed to evaluate any significant difference of ridge width changes at T-1 vs T0 and T0 vs T2. Statistical significance was set at P < .05.

Results

At the end of the study, 12 consecutive patients (7 men and 5 women with a mean age of 63.7 ± 14 years) received 15 dental implants. No dropouts were experienced during the study.

During the healing phase, no membrane exposures were noticed. All implants were clinically osseointegrated with no signs of pathology or infection. Periodontal parameters never exceeded physiologic levels during the 18 months. Absences of biologic and biomechanical complications were noticed. Alveolar ridge width showed a statistically significant (P < .0001) reduction after tooth extraction (T-1 vs T0 = –1.7 ± 0.3 mm). On the other hand, comparing the baseline with the last follow-up, significant ridge width increase was observed (T0 vs T2 = 1.3 ± 0.6 mm; P < .00001; Table 2). Radiographic analysis showed stable MBL from baseline to the final follow-up (T0 to T2 = 0.09 ± 0.08 mm).

Discussion

In the present prospective study, the combination of a flap design adapted from mucogingival surgery and traditional GBR techniques, using a resorbable PLA membrane with resorbable β-TCP, compensated for the bone resorption that usually follows tooth extraction.

In fact, superimposition of digital impressions showed a significant horizontal buccal tissue reduction (1.7 mm) after the ridge preservation procedure following tooth extraction. Eighteen months after GBR, soft tissue width showed a significant gain of 1.4 mm compared to the pre–implant placement time point (T0).

At the first observation point, the difference between ridge preservation (T-1) and pre–implant
placement (T0) volumes seems to be comparable with previously published studies.30,31

Although some authors suggest including soft tissue augmentation during GBR procedures to improve implant-esthetic outcomes,32 the technique used in the present study did not entail any kind of connective tissue augmentation.

Additionally, the reported outcomes may be related to the surgical sequence adopted. In fact, two interventions were performed: (1) postextraction site preservation and (2) horizontal ridge augmentation with simultaneous implant placement using a combination of a novel surgical approach and established protocols.

If the use of graft material at the time of tooth extraction allowed for minimization of physiologic bone resorption, correct timing of the implant insertion and bone regeneration approach allowed a complete restoration of tissue volume. It has to be noted that the site selection included anterior teeth with absence or major resorption of the buccal plate, as described by Elian et al25 for type II sockets.

Considering the adopted preservation technique used flapless bone grafting without membrane to treat Class II sockets, it can be concluded that the results reported in the present study align with averages reported in the literature.30,33,34

One study’s interesting observation was that the risk of wound dehiscence and membrane exposure was lower with delayed implant placement, regardless of the type of membrane used.35

Cosyn et al36,37 demonstrated that esthetic complications following delayed implant placement and GBR mainly related to insufficient volume of mesial and distal papillae after healing. In fact, mean Papilla Esthetic Scores following GBR were significantly lower than scores following immediate implant placement. Surgery with bone augmentation was found to be a significant predictor of insufficient volume of mesial papillae. The authors hypothesized that multiple surgeries increase the risk for incomplete wound closure, leading to soft tissue grooves or depressions. They indicated that, regardless of the underlying mechanisms responsible for interproximal recession, procedures that include elevation of interdental papillae should be limited to favor their preservation. Gomez-Roman21 concluded that a minimum interdental papilla width of 1 mm, remaining firmly attached to the adjacent tooth and bone, assures adequate blood supply to the papillary tip and prevents necrosis as well as detrimental esthetic outcomes.

In a more dated study on guided tissue regeneration with nonresorbable membranes, Murphy38 reported that the use of crestal incisions, maintenance of the full thickness of papillae, and the exposure of interproximal bone on the inner surface of the healing flap decrease the incidence of flap recession in esthetically sensitive areas. The technique described in this study proposed a novel flap design concept that prevented soft tissue recession around teeth involved in GBR procedures, without the need of connective tissue augmentation.

The selection of materials in the present study was based on their specific properties. The hardening and union of β-TCP particles greatly improved the stabilization of the graft and coagulum mixed with autogenous bone. The synthetic resorbable membranes used in the present study allow additional graft stabilization, eliminate the need for membrane removal at second stage, and show improved soft tissue responses compared to a nonresorbable membrane.

Conclusions

Within the limitations of this trial, it can be concluded that the use of a resorbable PLA membrane and resorbable bone graft substitute (β-TCP) in conjunction with a coronally advanced flap is a predictable procedure to restore atrophic ridge with simultaneous implant placement in the esthetic zone.

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