

# Augmentation through guided bone regeneration in horizontal bone reconstruction

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**Abstract.** Objective: The objective of the study was to evaluate the success rate of guided bone regeneration (GRB) technique in the horizontal reconstruction of atrophied alveolar ridge using the Cytoplast™ Barrier Membrane in combination with anorganic bovine-derived bone mineral (ABBM) and autologous bone. Material and Method: This clinical study included fifteen patients, who presented partial mandibullary and maxillary edentations and were eligible for implanto-prosthetic rehabilitation. Two had co-morbidities - drug-controlled type II diabetes mellitus (DM) and six were smokers. All patients underwent GBR surgery, because all of them required horizontal crestal bone enlargement so that dental implants could be inserted. Treatment was made using the Cytoplast™ Barrier Membrane, a titanium-reinforced high-density polytetrafluoroethylene membrane (Ti-PTFE) and a mixture of 75% ABBM with 25% autologous bone. Maxillary reconstruction sites represented 40% and mandibular reconstruction sites represented 60%. Eight months after surgery the Ti-PTFE membrane was removed and the new dimension of the crest was determined, clinically and with cone beam computed tomography (CBCT) investigations. Results: The successful reconstructed areas, showed good incorporation and osteoconductive potential. The reconstruction site was successful for the diabetes patients. Referring to the smoke habit, the reconstruction site was successful for 66% of them. Conclusion: The use of the Cytoplast™ Barrier Membrane in combination with ABBM and autologous bone showed a success rate of 60%. The reconstruction site was stable after ridge augmentation and supported the functional loading of the implant.

**Key Words:** Ti-PTFE membrane; guided bone regeneration, autologous bone

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## Introduction

Given that implantology has increased in popularity in the young and elderly patients alike, the use of bone reconstructive procedures for implantology has become more frequent (Brägger et al 1996; Lang et al 1994; Baljoon et al 2003). It has been shown, that the long term lastingness rate of the implants is given by the integration rate of the implant in the sufficient and healthy bone (Sheikh et al 2015). Over the years, numerous researches (Brägger et al 1996; Lang et al 1994; Baljoon et al 2003) had highlighted failures of autografts and heterografts: graft resorption, graft fracture, donor bed morbidity, disease transmission risk and graft rejection. All the disadvantages of these methods required the search for another bone reconstruction technique. Nowadays, augmentation through guided bone regeneration (GBR) has become an important treatment option to obtain optimal bone support for osseointegrated dental implants. GBR is particularly useful when dehiscence or fenestrate are present after implantation (Brägger et al. 1996; Lang et al 1994; Baljoon et al 2003). In the case of alveolar ridges with large vestibular resorptions or sharp edges, implant placement and positioning is difficult, but with GBR is possible to correct the shape of the bony crest with the improvement of the bone supply both horizontally and vertically (Esposito et al 2009; Hämmerle et al

2003; Shanaman et al 1992; Baird 1993; Saadoun et al 1999; Dahlin et al 1988).

The results of lately clinical studies of ridge augmentation with GBR have demonstrated success of treatment with considerable implant survival rates and low complication rate (Dahlin et al 1989; Lee et al 2015; Di Stefano et al 2009; Rothamel et al 2009). The histological evaluations of the grafted sites, performed with GBR, showed that the combination of anorganic bovine-derived bone mineral (ABBM) and autogenous particulate bone can be an eligible material for localized ridge augmentation (Shanaman et al 1992; Baird et al 1993). Many studies previously reported excellent results on vertical augmentation using a non-resorbable titanium-reinforced expanded polytetrafluoroethylene membrane (Saadoun et al 1999; Simion et al 2006), but this membrane is no longer commercially available. Cytoplast™ Barrier Membranes (Ti-250 Titanium-Reinforced), is a non-resorbable - high-density PTFE membrane, who showed promising results, because it is impervious to bacteria and can withstand exposure (Ti-250 Titanium-Reinforced 2018). The marketing of the non-resorbable high density PTFE Ti-250 titanium reinforced PTFE membrane has funded this research. The aim of this study was to evaluate the success rate of GRB technique in the horizontal reconstruction of atrophied alveolar

ridges using the Cytoplast membrane in combination with ABBM and autologous bone.

## Material and method

In the present study were included 15 people who presented partial mandibullary and maxillary edentations, who were eligible for implanto-prosthetic rehabilitation. The distribution by gender and age was balanced, 9 female and 6 male patients aged 40-60 years. Of all the patients included in the study, only two had co-morbidities - drug-controlled type II diabetes mellitus (DM). The patients included in the study, 6 (3 females, 3 male) were smokers (20<cigarettes/day). All of the patients were referred to a private clinic in Cluj-Napoca, Romania for a period of 2 years. All patients underwent GBR surgery performed by the same operator and the prosthetic rehabilitation was performed by another practitioner. All of the patients selected for this treatment required horizontal crestal bone enlargement so that dental implants could be inserted. The patients included in the study were trained on the need to maintain a good oral hygiene.

Our patients were entirely informed about the treatment before any of the surgical procedure and they signed a written consent for the procedure and for the use of the data in the study. The study was approved by The Ethical Committee of the University of Medicine and Pharmacy Iuliu Hatieganu, Cluj-Napoca, Romania. Treatment consisted of horizontal ridge augmentation was made using Cytoplast™ Barrier Membranes: Ti-250 Titanium-Reinforced (Osteogenics Biomedical, Inc. Lubbock, TX USA) and a mixture of 75% ABBM (Bio-Oss, Geistlich Pharma AG, Wolhu-sen, Switzerland), with 25% autologous bone.

The surgical protocol used in this 15 case series followed the one described (Shanaman *et al* 1992; Urban *et al* 2011). The flap was designed in order to ensure primary free closure without tension after the bone grafting procedure, in spite of the increased size of the ridge. A full-thickness flap and a midcrestal incision of the keratinized gingiva was realized with a 15 c surgical scalpel. Two divergent vertical incisions were made. They were placed no less than one tooth distant from the surgical site. In areas with terminal edentations, the vertical incisions were made no less than 5 mm distant from the augmentation site. The eduction of the full-thickness flap was realized using periosteal elevators away the muco-gingival junction and at least 5 mm away the bone defect. The exposed alveolar ridge was measured using the periodontal probe. For the measurement of the vestibular-oral size of the crest the most vestibular point with the most lingual/palatine point was united. For spaces with one tooth missing, the measurement was performed midway between the two adjacent teeth of the edentulous space. In the case of edentulous spaces with two or three absent teeth, the determination of the vestibulo-lingual/palatal dimensions was made at: 5, 12 and 18 mm from the distal point of the tooth that limited mesial the edentation. The receiver bone bed was prepared using a small round bur. Multiple decorticalization holes were realized. A periosteal releasing incision that connected the two vertical divergent incisions was made to obtain better elasticity of the full-thickness flap.

Autologous bone harvesting was performed with the bone scrapper at the level of the neighboring areas. The autologous harvested bone was mixed in a vessel with ABBM, the mixing

ratio was 25% autologous bone and 75% ABBM. The mixture so prepared was applied to the bone defect. The bone graft containing the combination of autologous bone and ABBM was covered with the Ti-PTFE membrane. The membrane was settled through U-sutures. After the membrane was applied, the flap was released and moved to afford tension free closure. A suture in two layers was performed. Horizontal mattress sutures were placed first at a distance of 4 mm away from the incision line. After that, single interrupted sutures were placed in order to enclose the edges of the flap. The single interrupted sutures were eliminated after 10-14 days postoperative, and the mattress sutures after 2-3 weeks.

Patients were monitored postoperative and evaluated monthly looking for possible complications such as: membrane exposure, wound dehiscence, operator site infection and particulate graft elimination. Eight months after surgery the Ti-PTFE membrane was removed and the new dimension of the edentation crest was determined, following the same protocol as described above. The success of the technique was evaluated on the postoperative cone beam computed tomography (CBCT) and on the postoperator clinical measurement.

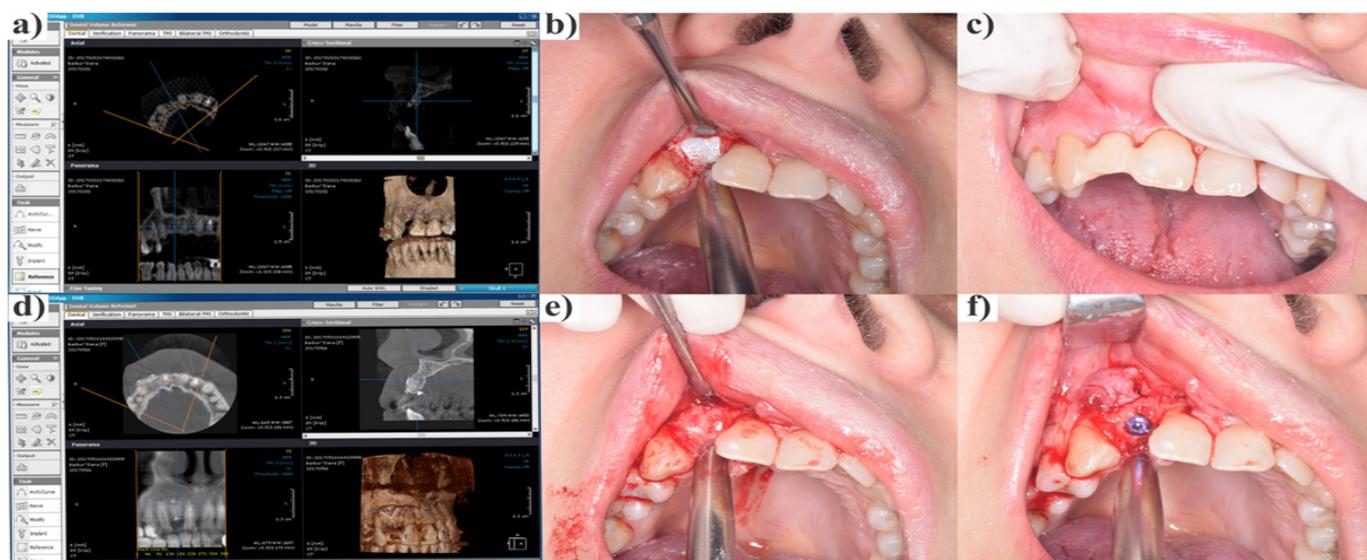
Data were statically analyzed using the Microsoft Excel Data Analysis (Descriptive statistics) and Social Science Statistical online calculator ([www.socscistatistics.com](http://www.socscistatistics.com)). The vestibulo-oral dimension in cases of one tooth missing was introduced as such, but for the multiple edentations (two, three teeth missing) the mean value was inserted into the database. The statistical analysis aimed to establishing correlations between the parameters evaluated respectively: age, gender, smoker or non-smoker, the presence/absence of comorbidities correlated with the success of the GBR technique. The correlation between age and growth of alveolar crest width was found using Pearson correlation coefficient and for correlation smokers/non-smokers T-test for two independent means was used.

## Case presentation

A 42 year-old female patient was referred by his treating dentist for replacement of his right second incisor by implant. A review of the patient's medical history, showed a healthy non-smoking individual, with no systemic contraindications for implant placement. The clinical examination revealed a healthy periodontium with no pathologic probing depth, good oral hygiene and no bleeding on probing. The preoperative CBCT showed a hight of de crestal bone of 12.48 mm and a width of 2.00 mm (Fig. 1a). Suggested treatment as approved by the patient consisted of ridge augmentation trough GBR and implant placement.

### Surgical procedure

The surgical protocol used followed the one described above. A full-thickness flap was designed to cover the bone graft and the Ti-PTFE membrane (Fig. 1b), a provisional bridge was designed to provide the patient's smile (Fig. 1c). Eight months after surgery the Ti-PTFE membrane was removed and the new dimension of the edentation crest was determined by CBCT investigations (Fig. 1d). The new bone offer was: 15.50 mm hight and 5.51 mm width Fig. 1e) and the implant was placed in accordance with the manufacturer's protocol (Fig. 1f).



Case report: a) preoperative CBCT; b) the Ti-PTFE membrane in place; c) the provisional bridge; d) postoperative CBCT; e) the new bone offer after 8 months and f) the implant in place.

Table 1. Patients distribution in terms of gender, health condition and smoking habit

Initial conditions	Age	Gender	Smokers	Diabetes
All Patients 100%	38-60	15 100%	6 40.00%	2 13.33%
Female 100%	38-60	9 60%	3 33.34%	
Male 100%	45-60	6 40%	3 50.00%	2 33.33%

Table 2. Location of the edentation and the width of the alveolar crest presurgery

Initial conditions	Mandible	Maxillary	Alveolar crest width-presurgery (mm) (SD)
All Patients 100%	9 60.00%	6 40.00%	2.16 (1.234)
Female 100%	5 55.55%	4 44.45%	2.33(1.031)
Male 100%	4 66.67%	2 33.33%	1.92 (1.562)

Table 3. Results 5 month after the GBR procedure for male and female

After treatment	Success SSR	Mean growth alveolar crest (mm) (SD)	Membrane exposure	Wound Dehiscence
All Patients 100%	12 80.00%	3.96 (0.940)	3 20%	3 20.00%
Female 100%	8 88.89%	3.81(0.961)	2 22%	1 11.11%
Male 100%	4 66.67%	4.00 (0.816)	1 17%	2 33.34%

Table 4. Results after the GBR procedure in terms of the reconstructed site position

Reconstructed site position	Success	Mean growth alveolar crest (mm) (SD)	Membrane exposure	Wound Dehiscence
Mandible 100%	6 66.67%	3.83 (1.125)	2 22.23%	3 33.34%
Maxillary 100%	6 100%	3.92 (0.664)	1 16.67%	

## Results

The patients before the treatment had the following distributions in terms of gender, health condition, smoking habit and location of the edentation and the width of the alveolar crest presurgery as presented in Table 1. and Table 2.

The method was successful for 80% of the cases, 13% of the unsuccessful (wound dehiscence 20%) cases being related to the smoking habit. In the same time, for 66% of smokers the reconstruction site was successful. Membrane exposure (ME), after more than 5 months after surgery was found in 20% of the cases, none of them being related to the wound dehiscence (WD), so that the success rate for all patients was 80%. Of

those 20% membrane exposures 2/3 were found for women. Wound dehiscence was found in 20% of total patients, 2/3 of this percentage was found for male. As for the mean alveolar crest width, the increasing for male was slightly higher than for women. Also, we observed the female successfully site reconstruction rate was higher than that for male (8 out of 9 for women, 4 out of 6 for men). After 5 month the results for female/male are presented in Table 3.

All wound dehiscence were found in mandible, so the success rate was maximum for maxillary only, as for membrane exposure of 20%, 2/3 was found on mandible. The increasing of the alveolar width was slightly higher than for maxillary reconstruction site. Results are presented in Table 4.

Table 5. Results after the GBR procedure in terms of smokers and non-smokers

	Success	Mean growth alveolar crest (mm) (SD)	Membrane exposure	Wound Dehiscence
Non-smokers	8 53.34%	4.19 (0.704)	3 20%	1 6.67%
Smokers	4 26.67%	3.25 (0.957)		2 13.34%

The reconstruction site was fully successful for the diabetic's patients. The main attention was given to the growth of the alveolar crest width mean (mm) calculated as the difference between the post-surgery and the pre-surgery alveolar crest width, and its correlation with different factors, mainly with the smoking habit. All cases were grouped according to gender, site position, smoking habit and are shown in the next synopsis tables (Table 5). All correlations and calculations were performed for successful cases only.

The Pearson correlation coefficient for age and growth of alveolar crest width was 0.251219 and the result was not statistically significant at  $p < 0.05$ . It cannot be said that there is a correlation between age and the size of the reconstructed site, the method for site reconstruction being suitable for all patients regardless their age. There was a difference in smokers and non-smokers mean of growth of the alveolar crest width, for smokers the reconstructed site being less. The group of smokers (all under 55 of age) was compared with non-smokers. T-test for two independent means gives a value of  $P = 0.04819$  and the result was significant at  $p < 0.05$ .

Studying separately the smoking effect on the growth of the alveolar crest width in female (2 smokers, 6 non-smokers) there was a significant correlation: mean smokers = 2.5 cm; mean non-smokers = 4.25 cm. In this case the P-Value was 0.004309 and the result was significant at  $p < 0.05$ . As for male the sample size was too small (2 smokers, 2 non-smokers) to perform any calculations, but this doesn't imply that there was no effect of smoking on male, recalling that 13% of the unsuccessful cases of 20% appeared in male smoking cases. Any test conducted on correlations regarding maxillary/mandible with gender, age or smoking was not statistically significant.

## Discussions

This research aimed to establish correlations between the evaluated parameters such as: gender, smoker or non-smoker habit, the presence/absence of comorbidities with the success of the GBR technique for horizontal bone reconstruction. The results of the study indicated that the biological principle of the technique is highly predictable for ridge augmentation. The results showed that the female success (46%) was better than the male success (20%). The forces that a man develops during dento-maxillary functions are much stronger and more aggressive, this can affect local healing. Regarding health conditions, 13% had drug-controlled type II DM, compared to other studies (Kornman et al 2000) in which was demonstrated that if the patient has a systemic disease, such as DM, there was an increased risk of a compromised healing capacity. The reconstruction site was fully successful for the diabetes patients. The result can be also linked to the small number of patients with DM included in this research.

Referring to smoke habits, 6 patients were smokers. The reconstruction site was successful for 66% of them. It is well known that smoking affects healing by reducing oxygen intake

in tissues, by making blood thicker and by limiting the activity of infection-fighting cells. Our results were in accordance with the study conducted by Yun et al 2011, which says, that one of the limits of the technique is if a patient is a heavy smoker. We obtained ridge measurements before and after the procedure. In this case series, there was a mean growth of alveolar crest of  $3.81 \pm 0.33$  for female and  $4.25 \pm 0.47$  for male. The differences may be attributed to differences in the severity of the initial defects treated. There was no correlation between age and growth of alveolar crest width. The surgical procedure can be suitable for all patients regardless their age. There were differences in smokers and non-smokers. The mean of growth of the alveolar crest was lower for smokers. There were no statistically significant correlations regarding maxillary/mandible with gender or smoking habit.

There were cases in which the horizontal resorption was associated with vertical resorption defined as a one-sided bone resorption of 2 mm or more of the interdental marginal bone apical to the alveolar crest. The resorption has a right-left symmetric distribution within the maxilla and mandible and more in the posterior than in the anterior area (Baljoon et al 2003). Various techniques have been used to augment the posterior mandibles and maxillaries (Esposito et al 2009; Hämmerle et al 2003). Vertical GBR is used for vertically/horizontally augmentation of posterior mandibles. This procedure has been prompted by the advent of prosthetic-driven surgery, in which implant positioning and angulation are determined by the final, optimal prosthetic rehabilitation (Shanaman 1992; Baird et al 1993; Saadoun et al 1999). The reconstructed areas treated with a combination of 75% ABBM and 25% autologous bone presented particles of ABBM with good incorporation, osteoconductive potential and no complications. This fact was in agreement with previous studies on ridge augmentation (Simion et al 2006; Urban et al 2011; Urban et al 2013). Simion et al 2007, showed GBR procedures, which used a mixture of autogenous and bovine deproteinized bone under an e-PTFE membrane to be successful for the treatment of vertical atrophies, both in two-step and single-stage surgeries and associated with implant placement. In the study of Di Stefano et al 2016, results were similar to the study performed by us. According with us they used an expanded polytetrafluoroethylene membrane. They have shown in radiographic analysis at the final follow-up time that both implants were osseointegrated and surrounded by a bone-like, structured tissue suggesting the bone block (Di Stefano et al 2016). This tissue was still remodeling at implant placement, had possibly undergone complete replacement with newly formed bone. Comparison of the presurgical CBCT scan with the 26-month follow-up scan showed no horizontal resorption within the augmented area bone. In addition, the newly formed bone appeared to have undergone reorganization, developing a cortical-like, more radio-opaque structure on its vestibular side bone (Di Stefano et al 2009; Di Stefano et al 2016). The extent of bone remodeling observed at 26 months was consistent with the histological and histomorphometrical findings at 8 months,

showing the bone graft was undergoing remodeling and substitution using the same material (though partially demineralized) (Di Stefano *et al* 2009). There are other studies of both bovine (Rothamel *et al* 2009; Simion *et al* 2006) and equine bone grafts reported contrasting results with regard to the potential resorption of both materials. These differences may be due to the type of membrane, non-resorbable membranes may protect the graft from resorption. The limit of the study was the evaluating only of parameters such as: gender, smoker habit and health condition with the success of the GBR technique for horizontal bone reconstruction.

## Conclusion

The use of a titanium-reinforced high-density polytetrafluoroethylene membrane and a mixture of 75% ABBM and 25% autologous bone showed a success rate of 60%. The reconstruction site was stable after ridge augmentation and supported the functional loading of the implant. Within the limitations of this case series, the preliminary results suggest that patients can be successfully rehabilitated by means of implant-supported prosthesis. Nevertheless, long-term clinical studies can confirm the success of the surgical protocol.

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