Vertical Bone Augmentation with Dental Implant Placement: Efficacy and Complications Associated with 2 Different Techniques. A Retrospective Cohort Study

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Purpose: *To compare retrospectively the efficacy of and complications associated with 2 different techniques for vertical bone augmentation at implant placement: autogenous particulated bone grafts covered either by nonresorbable titanium-reinforced e-PTFE barriers or by resorbable collagen barriers supported by osteosynthesis plates.* ***Materials and Methods:*** *Nineteen partially edentulous patients were consecutively treated: 11 patients had 18 implants treated for vertical bone augmentation with nonresorbable barriers, whereas 8 patients had 11 implants treated with resorbable barriers supported by osteosynthesis plates. Two independent assessors evaluated the amount of tissue regenerated and complications based on photographs and/or radiographs.* ***Results:*** *No implants failed. In the group treated with nonresorbable barriers, complete bone regeneration was obtained for 12 of 18 implants. More than 50% of the planned regeneration was obtained for the remaining 6 implants. One patient had a dehiscence with suppuration that required an additional surgical intervention to remove the barrier. For resorbable barriers, complete regeneration was obtained for 10 of 11 implants. Dehiscences occurred in 2 patients. In 1 case no treatment was necessary. The other patient was treated with applications of chlorhexidine gel; more than 50% of the desired bone regeneration was obtained.* ***Discussion and Conclusions:*** *No statistically significant differences for the amount of regenerated tissue and complications were observed between the 2 techniques; however, the power of the study was too low to detect a difference, if any. Randomized clinical trials with a sufficient number of patients are needed to determine which could be the most effective technique for vertical ridge augmentation.* Int J Oral Maxillofac Implants 2006;21:600–606

Key words: *bone augmentation, bone grafting, dental implants, guided bone regeneration*

It would be desirable to be able to regenerate bone vertically in a predictable way to allow for a favorable implant-crown ratio and better esthetics for implant placement. Several techniques have been proposed[1–6]; however, it has not been established whether any technique is more effective than the others.[7] In a retrospective investigation, it was demonstrated that it is possible to regenerate bone vertically using various techniques, although a few complications occurred.[8] More recently, a guided tissue regeneration technique for vertical ridge augmentation was compared with distraction osteogenesis in a randomized controlled clinical trial.[2] However, the trial was conducted with only a small sample, which makes it difficult to draw firm conclusions. The most predictable techniques for various clinical situations are not yet known. There is some weak evidence that placing resorbable barriers over bovine-derived material may allow healing with fewer complications than the use of a nonresorbable barrier.[9] The ideal augmentation procedure would be one with predictable results which could be accomplished simultaneously with implant placement.

The aim of this retrospective evaluation was to compare the efficacy of 2 different techniques of vertical bone augmentation simultaneous with implant placement: *(1)* bone grafting using a nonresorbable titanium-reinforced e-PTFE barrier to protect the graft and *(2)* bone grafting using a resorbable collagen barrier supported by osteosynthesis plates to protect the graft. The number and severity of complications that occurred in patients treated with the 2 techniques were noted.

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Table 1 Characteristics of Patients Treated with Nonresorbable Barriers Reinforced with Titanium

Patient	Operation period (mo/y)	Defect type*	Implant position†	Implant type‡	Healing period (mo)	Amount of regenerated tissue	Complications§
1N	6/2000	IVA	9(21)	Bk	9	≥ 50%	0
2N	1/2001	IIC	24(31)	Bk	8	≥ 50%	0
3N	2/2001	IIIC	19(36)	MkIV	6	Complete	0
		IIIC	18(37)	MkIV		Complete	
4N	5/2001	V	10(22)	MkIIIm	7	Complete	0
		V	11(23)	Bk		Complete	
		V	12(24)	MkIIIm		Complete	
5N	9/2001	IIC	25(41)	MkIV	5	Complete	0
		IIC	24(31)	MkIV		Complete	
6N	3/2002	V	24(31)	MkIII	6	≥ 50%	2
		V	23(32)	MkIII		≥ 50%	
7N	9/2002	V	21(34)	MkIII	6	Complete	0
		IIIC	19(36)	MkIII		≥ 50%	
8N	3/2003	IV	28(44)	3i	5	≥ 50%	0
9N	3/2003	IVB	20(35)	MkIII	4	Complete	0
10N	9/2003	V	25(41)	Micro	7	Complete	0
11N	9/2003	V	8(11)	MkIV	5	Complete	0
		V	6(13)	MkIV		Complete	

*See text for defect classification.
†Universal (FDI) tooth numbers given.
‡Bk = Brånemark standard MKII (Nobel Biocare, Göteborg, Sweden); MkIII = Brånemark MKIII TiUnite (Nobel Biocare); MkIIIm = Brånemark MKIII machined (Nobel Biocare); MkIV = Brånemark MKIV TiUnite (Nobel Biocare); 3i = 3i Osseotite (3i/Implant Innovations, Palm Beach Gardens, FL); micro = micro Astra (Astra Tech, Göteborg, Sweden).
§1= minor complication; 2 = major complication.

MATERIALS AND METHODS

The subjects in this study were 19 partially edentulous patients treated consecutively in an Italian private practice between January 2001 and March 2004 with autogenous particulate bone grafts, barriers, and simultaneous implant placement for vertical bone augmentation. The study focuses on the time between implant placement and abutment connection and reports the outcome of 29 implants placed in vertically augmented sites. The outcome of implants placed in nonaugmented bone or in horizontally augmented bony defects is not reported.

Any patient in which vertical bone augmentation was desirable for esthetic or prosthetic reasons for single or multiple implants was included. Patients were excluded if there were general contraindications to implant surgery or there had been irradiation in the head and neck area, or if they had poor oral hygiene and motivation, were pregnant or lactating, had uncontrolled diabetes, were substance abusers, or smoked more than 20 cigarettes per day.

Various implant systems were used. Patient and site characteristics are reported in Tables 1 and 2. The bony defects were described according to the following classification, which is a modified version of Cawood and Howell classification[10] (Fig 1). Subclasses were added for Classes III and IV for the posterior regions.

- Class II: Immediately postextraction; healed alveolus
- Class III: Well-rounded ridge, adequate in height and width
  - IIIA Height of the ridge ≥ 10 mm
  - IIIB Height of the ridge 7 to 9 mm
  - IIIC Height of the ridge 4 to 6 mm
- Class IV: Knife-edged ridge, adequate height but inadequate width (≤ 4 mm)
  - IVA Height of the ridge ≥ 10 mm
  - IVB Height of the ridge 7 to 9 mm
  - IVC Height of the ridge 4 to 6 mm
- Class V: Flat ridge, inadequate in height and width
- Class VI: Depressed ridge with varying degrees of basal bone loss. Bone loss may be extensive but follows no predictable pattern.

In the mandible, the bone height was calculated from the upper border of the inferior alveolar nerve canal.

Two different surgical techniques were used to obtain vertical regeneration. Group 1 (Table 1) consisted of 11 patients (7 men and 4 women; mean age at surgery, 60 years; range, 30 to 70 years; none smoked) who received 18 implants placed with vertical bone augmentation using autogenous bone grafts harvested intraorally and covered with titanium reinforced nonresorbable e-PTFE barriers (W. L. Gore & Associates, Flagstaff, AZ).

Table 2 Characteristics of Patients Treated with Resorbable Barriers and Osteosynthesis Plates

Patient	Operation period (mo/y)	Defect type*	Implant position†	Implant type‡	Healing period (mo)	Amount of regenerated tissue	Complications§
1R	3/2003	III	11(23)	MkIV	6	Complete	1
		III	12(24)	MkIV		Complete	
2R	5/2003	V	5(14)	MkIV	4	Complete	0
3R	5/2003	IIB	6(13)	MkIIIm	6	Complete	0
4R	10/2003	V	6(13)	MkIV	5	Complete	0
5R	12/2003	IVA	12(24)	MkIII	4	Complete	0
		IIIB	13(25)	MkIII		Complete	
6R	12/2003	III	25(41)	MkIV	4	Complete	0
		IVA	26(42)	MkIV		Complete	
7R	3/2004	III	11(23)	MkIII	4	≥ 50%	1
8R	3/2004	III	29(45)	MkIV	6	Complete	0

*See text for defect classification.
†Universal (FDI) tooth numbers given.
‡MkIII = Brånemark MkIII TiUnite (Nobel Biocare); MkIIIm = Brånemark MkIII machined (Nobel Biocare); MkIV = Brånemark MkIV TiUnite (Nobel Biocare).
§1= minor complication; 2 = major complication.

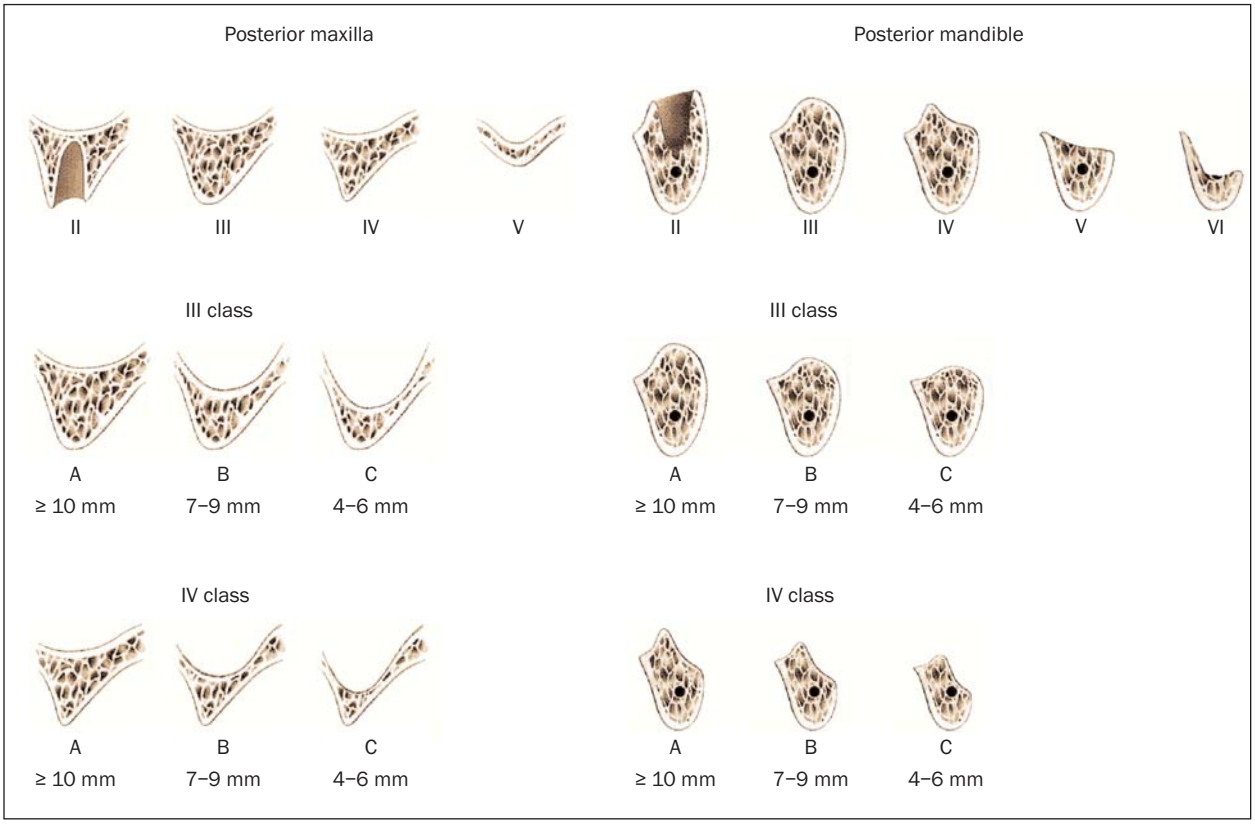

Fig 1 Classification of the bony defects modified from Cawood and Howell.[10]

Group 2 (Table 2) consisted of 8 patients (5 women and 3 men; mean age at surgery, 53 years; range, 37 to 68 years; 3 patients smoked) who received 11 implants with autogenous bone grafts and resorbable collagen barriers (Bio-Gide, Geistlich Pharma, Wolhusen, Switzerland) supported by osteosynthesis plates fixed with screws (Institut Straumann, Waldenburg, Switzerland, or Gebrüder Martin, Tuttlingen, Germany). In 2 patients a mixture of autogenous bone graft and Bio-Oss (Geistlich Pharma) was used. Patient 6R was treated with 80% autogenous bone graft and 20% Bio-Oss, and patient 7R was treated with 60% autogenous bone graft and 40% Bio-Oss.

All patients received prophylactic antibiotic therapy (1 g amoxicillin 1 hour prior to intervention and 1 g twice a day for 6 days postoperatively). Once implants were placed, only in Group 2, 1 or 2 osteosynthesis plates were shaped and fixed with titanium screws in the desired position to protect the area to be regenerated. The bone from the prepared implant site was collected with a bone trap, and particulated autogenous bone harvested from various intraoral locations was used as the grafting material. The bone marrow was perforated to increase bleeding. Particulated bone was used to fill the site to the desired height and shape until the implants were completely surrounded by graft material. The barriers were then folded over the grafts. Nonresorbable barriers were fixed with titanium screws (Institut Straumann or Gebrüder Martin). Two resorbable barriers were placed 1 on the top of the other in a few sites. Periosteal incisions were made to release the flaps as coronally as necessary. When considered useful, a periosteal flap was raised and reflected over the alveolar crest and inserted below the opposite flap.[11] Flaps were closed with horizontal mattress sutures until incisions were perfectly sealed.

Patients were instructed to use chlorhexidine gel twice a day and 0.12% chlorhexidine mouthwashes 3 times a day (Corsodyl; GlaxoSmithKline, Verona, Italy) for 2 weeks following surgery and to avoid brushing and trauma at the surgical site. Sutures were removed after 2 weeks. Patients were seen 1, 2, and 4 weeks after surgery.

After 4 to 9 months, a second surgery was performed. Nonresorbable barriers and osteosynthesis plates were removed, the implants were tested for stability (by tightening the abutments), and healing abutments were placed. The healing period required was determined by the surgeon in relation to the vertical amount of bone to be regenerated (the more bone to be regenerated, the longer the healing period).

The outcome measures considered were:

- Implant success. Any implant found to be mobile when manually assessed or any stable implant removed because of infection was considered a failure.
- The amount of tissue regenerated. This was assessed by comparing clinical photographs obtained at the time of implant placement with photographs obtained at abutment connection/barrier removal when available. When photographs were not available, the evaluation was based on comparison of intraoral or panoramic radiographs obtained immediately after surgery with radiographs obtained at abutment connection or definitive prosthesis delivery.

Two independent outcome assessors performed a joint assessment of each case. In the case of disagreement, which never occurred, a third independent assessor was to be consulted. The following system was used for grading the amount of tissue regenerated: A = complete regeneration; B = ≥50% regenerated; C = < 50% regenerated; D = no regeneration or additional loss of tissue.

- Operative and postoperative biologic complications. Complications were categorized as minor (dehiscence of soft tissues without treatment or treatment with chlorhexidine application) or major (dehiscence of soft tissues and/or abscesses treated with additional surgery and systemic antibiotics).

Independent sample chi-square tests were used to compare the relative numbers of patients who had bone regeneration ≥ 50% around at least 1 implant and the relative number of patients with at least 1 implant with complications. The significance level of .05 was used for all comparisons.

RESULTS

No patients dropped out of the study. No implants failed, and all planned prostheses were delivered. In the group treated with nonresorbable barriers (group 1), complete bone regeneration was obtained for 12 of 18 implants (Table 1; Figs 2a and 2b). For the remaining 6 implants in 5 patients, the amount of regenerated bone was quantified as B (more than 50% of the planned regeneration). One patient (6N) had a dehiscence over the nonresorbable barrier with suppuration. An additional surgical intervention was required to remove the infected barrier 2 months after its placement.

In group 2, the group treated with resorbable barriers, complete regeneration was obtained for 10 implants (Table 2). Complications in the form of soft tissue dehiscences occurred in 2 patients (1R and 7R). In 1 patient (1R) the dehiscence of the soft tissues did not require any treatment and did not compromise the outcome of the regenerative procedure (Figs 3a to 3d). In the other patient (7R) the dehiscence was treated only with applications of chlorhexidine gel and was associated with partial bone regeneration around the implant (≥ 50% of the amount desired).

There were no statistically significant differences between patients with respect to amount of regenerated tissue (chi-square test; $P = .13$) or complications between the 2 groups (chi-square test; $P = .35$).

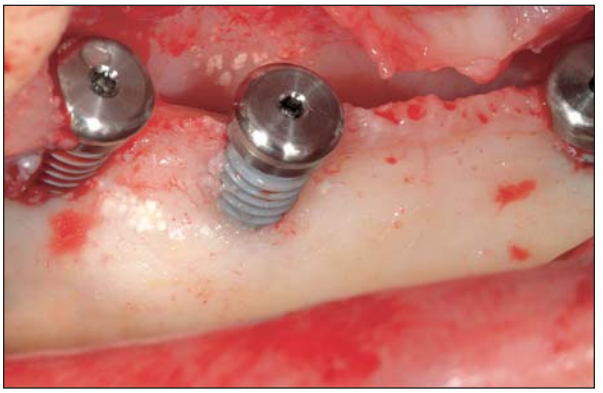

Fig 2a Patient 9N was treated with autogenous particulated bone grafts covered by a titanium-reinforced nonresorbable barrier. Three implants were placed in positions of the mandibular left premolars and first molar. The implant in the position of the second left premolar had a vertical defect of about 2 mm and was subjected to bone augmentation procedure together with an implant in the position of the first left premolar which had a buccal bone dehiscence.

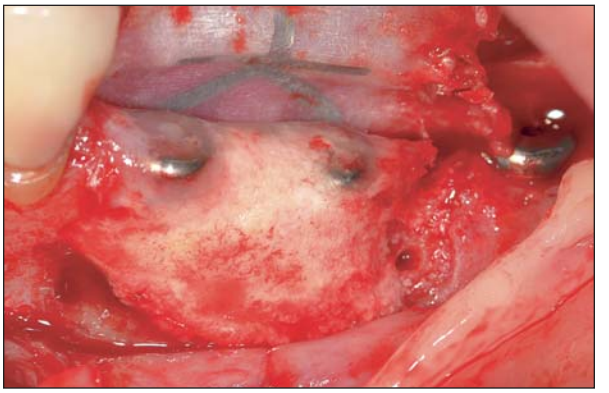

Fig 2b Patient 9N (Table 1) at abutment connection less than 4 months after the regenerative procedure. Note that the regenerated bone has almost completely submerged the cover screw of implant position of the mandibular left second premolar. No complications occurred during the healing period.

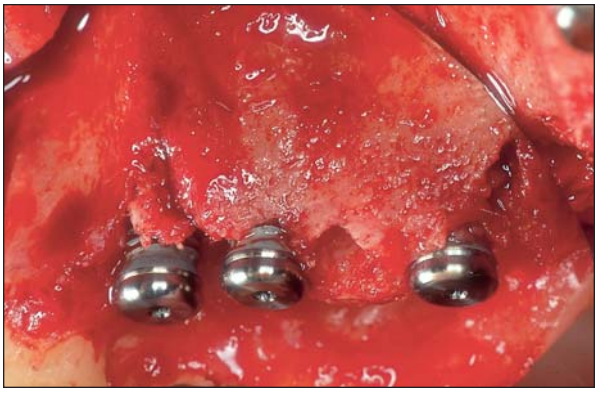

Fig 3a Patient 1R was treated with autogenous particulated bone covered by a resorbable barrier supported by an osteosynthesis plate. Three implants were placed in the maxillary left canine and premolar positions. The implants replacing the canine and the first premolar had a vertical defect and were subjected to bone augmentation.

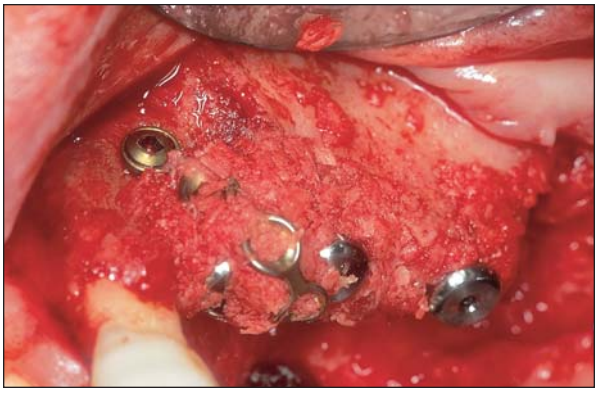

Fig 3b An osteosynthesis plate has been conveniently shaped, and the area has been filled with particulated autogenous bone.

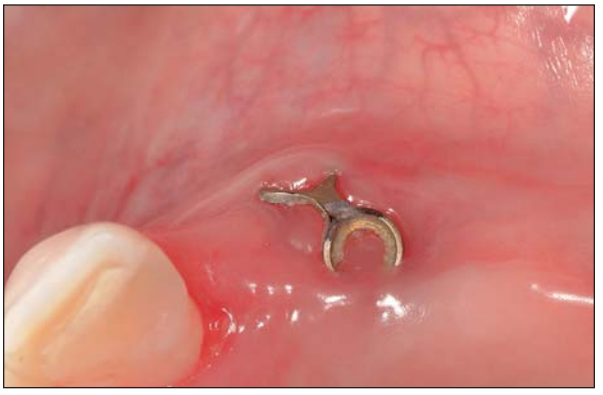

Fig 3c Photograph of the dehiscence obtained 6 months after the augmentation procedure prior to abutment connection. The osteosynthesis plate can be seen through the mucosa. No treatment was necessary.

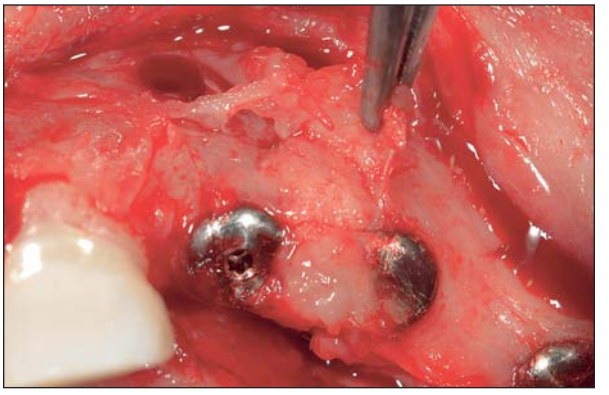

Fig 3d Patient 1R at abutment connection 6 months after the regenerative procedure. Note that after the removal of some soft tissue, implants replacing the maxillary left canine and first premolar are completely surrounded by regenerated bone.

DISCUSSION

Retrospective investigations have major limitations when used to investigate the efficacy of therapeutic interventions, since direct comparisons of different techniques may lead to biased and erroneous conclusions. In the present study the data were collected retrospectively, the operator allocated patients according to his preferences, patients were treated at different time periods, and the number of patients was too low to detect a significant difference, if any. Another issue was that the amount of bone regeneration was assessed on panoramic radiographs for 3 patients in the nonresorbable group (5N, 7N, and 8N), since clinical photographs were not available or not adequately readable. It is possible that the scoring on intraoral radiographs resulted in a more severe score than that obtained from photographs, since newly regenerated bone may not be completely mineralized. Therefore the present findings must be considered with extreme caution. On the other hand, all treated patients were accounted for, and assessment of the amount of tissue regenerated was performed in duplicate by 2 independent assessors.

The present investigation was designed to provide preliminary information on whether a novel technique for vertical bone regeneration, using autogenous particulated bone grafts protected by stable osteosynthesis plates and covered by resorbable barriers, could offer some advantage over using autogenous bone chips and titanium-reinforced nonresorbable barriers. The technique was originally developed based on the impression that more serious infections could develop when using nonresorbable barriers. Some scientific evidence supporting this view exists. A randomized clinical trial suggested that resorbable barriers over bovine-derived graft (Bio-Oss) may allow healing with fewer complications than a nonresorbable barrier.[9] In the present study, the only barrier exposure with purulent exudate requiring premature removal with an additional and unplanned operation occurred in the nonresorbable group. The sparse published literature on this topic also seemed to indicate that problems with nonresorbable barriers are not uncommon. For instance, a retrospective trial including 32 patients treated for vertical ridge augmentation with autogenous bone chips and titanium-reinforced barriers showed that a vertical augmentation procedure could be considered a failure in terms of regenerated tissues in 4 of 6 patients whose barriers became exposed.[1]

In another recent randomized clinical trial,[2] a group of 11 patients were treated for vertical ridge augmentation using autogenous bone chips and reinforced titanium barriers. In 3 patients barriers were exposed. In 2 of these patients the barriers had to be removed some weeks postoperatively, and the amount of regenerated bone was partially compromised. From the available scientific literature it can be estimated that about 1 of 6, 1 of 8, or 1 of 10 interventions[1,2,7] on patients treated using vertical ridge augmentation with autogenous bone chips and nonresorbable titanium-reinforced barriers was not completely successful; therefore, the predictability of such procedures may be questioned.

Despite the fact that the preliminary results for the few patients treated in the resorbable barrier group look promising, since only 2 minor complications occurred and the amount of bone regenerated was 100% in all but 1 case, where more than 50% of the desired amount of regeneration was achieved, the results of the present study failed to disclose any statistically significant difference between the 2 techniques. There could be 2 possibilities: either a significant difference does not exist, ie, the 2 techniques actually provide rather similar results; or a difference does exist, but the number of patients included in the present trial was insufficient to show it. To resolve this issue, a properly designed randomized clinical trial with sufficient power to detect meaningful differences was initiated.[7] Preliminary results of an interim analysis of the first 22 patients suggested that no significant differences in bone gain and complications were apparent, even though the trend seemed to favor the titanium-reinforced nonresorbable barriers. These contradictory results underline once more the importance of relying on the results of properly designed trials with large sample sizes. However, because of the difficulty of recruiting a large number of patients, some years will be needed before an evidence-based conclusion can be reached.

CONCLUSIONS

Complications may occur when using barriers for vertical ridge augmentation. Such complications may jeopardize the regeneration procedure. It would be useful to refine the techniques to minimize complications and to enhance predictability. No statistically significant differences with respect to the amount of regenerated tissue or the incidence of complications were observed between the 2 techniques investigated; however, the number of included patients was too low to detect a difference if any.

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