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Surgical guided tissue regeneration treatment of advanced periodontal defects: a 5-year follow-up study

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Abstract

Objectives: To study the 5-year outcome of combined use of guided tissue regeneration (GTR) barriers and bovine bone in advanced periodontal defects.

Material and Methods: In each of 24 patients, one defect was surgically exposed, debrided, filled with bovine bone, and covered with a bioresorbable barrier. Re-examinations were made after 1, 3, and 5 years.

Results: Average full-mouth plaque scores (FMPS) were 14.5% at baseline and 10.7%, 9.8%, and 18.9% after 1, 3, and 5 years, respectively. Mean probing pocket depth (PPD) was 10.0 mm at baseline. Mean PPD reduction was 5.2 mm after 1 year, 5.6 mm after 3 years, and 5.3 mm after 5 years. Mean gingival recession was 1.0 mm after 1 year, 1.6 mm after 3 years, and 1.3 mm after 5 years. Mean gain in clinical attachment level (CAL) was 4.2 mm at the 1-year, 4.1 mm at the 3-year, and 4.3 mm at the 5-year examination. Smoking significantly influenced CAL change at all re-examinations. FMPS were significantly correlated with radiographic defect depth at the 5-year examination and CAL with smoking and FMPS at the 3-year examination.

Conclusion: Advanced periodontal defects can be successfully treated with the combined use of GTR barriers and bovine bone to substantially reduce PPD and achieve a stable, long-term gain of CAL.

Key words: bone substitute; filler material; guided tissue regeneration; periodontal healing

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Guided tissue regeneration (GTR) is a periodontal surgical technique that was introduced more than 20 years ago (Nyman et al. 1982a, b, Gottlow et al. 1984, 1986). Stable gains in the clinical attachment level (CAL) after GTR have been observed in long-term (4–8 years follow-up) GTR data (Gottlow et al. 1992, Cortellini et al. 1996b, 1999, Kim et al. 2002, Eickholz et al. 2004, 2007, Sculean et al. 2004a, 2006, Mengel et al. 2006).

Conflict of interests and source of funding statement

The authors declare that they have no conflict of interests.

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To avoid a second surgical procedure, bioresorbable barriers of different materials were developed (Chung et al. 1990, Gager & Schultz 1991, Caffesse et al. 1994, Lundgren et al. 1994, Becker et al., 1996, Cortellini et al. 1996a, Camelo et al. 1998). Barrier collapse, which would lead to suboptimal space for the regenerating periodontal tissue, is a risk in advanced periodontal defects (Tonetti et al. 1996). In such situations, filler materials such as bovine bone mineral (Bio-Oss®) can be used to maintain space beneath the barrier (Camelo et al. 1998).

In a previous paper, we reported short-term results on the use of bovine bone mineral (Bio-Oss®) with a bioresorbable barrier (Guidor®) in six patients who had undergone surgery for anatomically complicated periodontal defects (Lundgren & Slotte 1999). Several studies have since been published on the combined use of GTR barriers and Bio-Oss® (Camelo et al. 1998, Camargo et al. 2000, Paolantonio 2002, Stavropoulos et al. 2003, 2004, Sculean et al. 2004b, Vouros et al. 2004, Stavropoulos & Karring 2005). In contrast, few studies have presented long-term data on this technique

(Stavropoulos & Karring 2005, Sculean et al. 2007).

The aim of this study was to investigate long-term stability after surgical treatment of advanced periodontal bone defects with a bioresorbable barrier (Guidor® or Bio-Gide®) to cover defects filled with Bio-Oss®.

Material and Methods

Patients

Twenty-four consecutive patients, 43–74 years of age, referred to the Department of Periodontology at the Institute for Postgraduate Dental Education, Jönköping, Sweden, for the treatment of advanced periodontal disease were selected for the study.

One patient had well-controlled long-term diabetes type I and two patients type II. The others were considered generally healthy. Eight patients were smokers (self-reported smoking ⩽10 cigarettes/day; heavy smokers were excluded from the study). After initial cause-related periodontal treatment, the patients were enrolled in the study. They were thoroughly informed about the treatment and the follow-up procedure and gave their written consent to participate.

The study was approved by the ethical research committee at Linköping University, Sweden and was conducted in accordance with the Helsinki Declaration of 1975 as revised in 1983, 1989, and 1996.

One deep intrabony defect in each patient was selected for the study. No systemic antibiotic treatment had been prescribed within 6 months before treatment. Table 1 lists patient and defect characteristics.

Bone mineral

The barrier support material was natural bovine bone mineral (Bio-Oss®, Geistlich AG, Wolhusen, Switzerland) comprising cancellous granulae 0.25–1 mm in diameter.

Bioresorbable barriers

The defects were covered with Guidor® (Guidor AB, Novum, Huddinge, Sweden) or Bio-Gide® (Geistlich AG, Wolhusen, Switzerland). In the first treated patients Guidor® was used. After this the product was no longer available on the market, which is why Bio-Gide® was used in the following patients.

Pre-surgical protocol

During the 3–6 months before surgery, the patients repeatedly attended sessions on proper oral hygiene technique. Diseased root surfaces were scaled and planed 3–6 months before surgery and then evaluated for indications for periodontal surgery.

Table 1. Baseline and peroperative characteristics

Patient characteristics		Defect characteristics	
Number of patients	24	Number of sites	24
Female/male	13/11		
Age (years)		Defect type	
Mean (SD)	57 (9)	One-walled	11
Range	43–74	Two-walled	9
		Three-walled	4
Number reexamined		Clinical assessments (mm)	Mean (SD)
Year 1	24	PPD	10.0 (1.8)
Year 3	18	CAL	11.9 (2.0)
Year 5	24	Defect depth*	7.9 (2.0)
		Defect width*	2.9 (0.8)
Systemic disease	3	Radiographic assessments (mm)	
Smokers (1–10 cigarettes/day)	8	CEJ-BD	12.3 (2.7)
		RDD	7.4 (2.5)
		RDW	2.8 (1.1)
Mean full-mouth plaque score (%) (SD)	14.5 (18.9)	Barrier material	Number
		Guidor®	14
Mean full-mouth bleeding score (%) (SD)	14.4 (15.9)	Bio-Gide®	10

*As judged during surgery.

PPD, probing pocket depth; CAL, clinical attachment level; CEJ, cemento-enamel junction; BD, bottom of defect; RDD, radiographic defect depth along the root surface; RDW, radiographic defect width.

Surgical procedure

After local anaesthesia, buccal and lingual full-thickness flaps that extended one tooth mesial and distal to the defect tooth were raised. The periodontal defect was meticulously debrided, but with no intention to perforate the cortical bone walls. Following placement of Bio-Oss®, a barrier that extended about 2 mm beyond the defect margins was placed over the defect and tightly adapted to the teeth. The flaps were relocated and sutured. When indicated, periosteal incisions were made to establish tension-free suturing. All patients were given post-operative antibiotics (phenoximethyl-penicillin 4 g daily for 7 days) and advised to rinse twice daily for 6 weeks with a chlorhexidine digluconate solution (Hexident 0.1%, IPEX, Solna, Sweden). Peroral analgesics were given immediately after surgery and then prescribed when indicated.

Postoperative care and re-examinations

The patients were instructed not to brush the surgical areas until 6 weeks after surgery, when mechanical plaque control was reinstituted. The patients were recalled for professional tooth cleaning once every second week for the first 3 months and once a month for the next 3 months. Subgingival instrumentation was avoided the first year after surgery. After 1 year, the patients were recalled to the Department of Periodontology individually and reinstructed on proper oral hygiene. Sites were rescaled when indicated.

Clinical assessments

Immediately before surgery, presurgical baseline recordings were assessed. These recordings were repeated 1 year, 3 years, and 5 years after treatment. Full-mouth plaque and bleeding (%) were assessed (Lang & Tonetti 1996). At surgical sites, local plaque scores (Löe 1967), probing pocket depth (PPD), bleeding on probing (BOP), recession of gingival margin (REC), and CAL were recorded.

During surgery, depth and width of the intrabony defect were measured and defect type (one-, two-, or three-walled defects) was characterized. All measurements were made with a mm-graded Hu-Friedy probe (PCP-UNC 15, Hu-Friedy, Chicago, IL, USA).

Radiographic assessments

Radiographs were taken with parallel standardized technique at baseline, immediately after surgery, and 1, 3, and 5 years after surgery. Radiographic defect depth (RDD) along the root surface, radiographic defect width (RDW) of the intrabony defects at the marginal bone crest, and the position of the bottom of the defect (BD) in relation to reference landmarks on the tooth [determined as the distance from the cemento-enamel junction to BD (CEJ-BD)] were measured according to Heden & Wennström (2006) using a millimetre-graded transparent ruler and a magnifying lens (× 2.5). The presence of Bio-Oss® was evaluated in the 5-year radiographs as follows: 0 = undetectable, 1 = detectable traces, 2 = clearly detectable.

Calibration

All re-examination measurements were made by one author (B. A.); baseline and surgical measurements were made by two authors (B. A. or C. S.). Intra-and inter-examiner reproducibility were assessed by duplicate PPD measurements. Intraexaminer intraclass correlation coefficients (ICC) were 0.94 [95% confidence interval (CI): 0.90–0.96] for BA and 0.94 (CI: 0.91–0.97) for CS. Inter-examiner ICC was 0.91 (CI: 0.86–0.94).

Statistical analyses

Means (SD) or medians (minimum–maximum) were calculated for each parameter. Changes over time were expressed as means (SD). Linear and logistic univariate regression models were used to analyse which factors influenced the outcome variables (PPD, CAL, BOP) at all re-examinations. In addition, stepwise multiple regression analyses on changes in CAL were made using full-mouth plaque scores (FMPS) and smoking as independent variables. All analyses were carried out with the statistical software SPSS (v14.0, SPSS Inc., Chicago, IL, USA).

Results

In all, six patients missed their examination appointment during the study, all in year 3 (Table 1). The reasons for the missed appointments were as follows: moved from the area (three patients), unwilling to attend examination (two patients), and could not be reached (one patient). Five of the treated teeth were incisors, 13 were canines, four were pre-molars, and two were molars.

Median (minimum–maximum) FMPS were relatively stable throughout the period; 10.0% (0–59%) at baseline and 11.0% (0–40%) at the 1-year, 6.5% (0–50%) at the 3-year, and 16.0% (0–50%) at the 5-year examinations. Median (minimum–maximum) full-mouth bleeding scores were 9.0% (0–54%) at baseline and 6.5% (0–75%) at the 1-year, 5.9% (5.6%) at the 3-year, and 7.5% (0–50%) at the 5-year examinations. In the surgical areas, median (minimum–maximum) plaque scores were 0 (0–2) at baseline and 0 (0–1) at the 1-year, 0 (0–1) at the 3-year, and 0 (0–2) at the 5-year examinations.

Table 2 lists the clinical and radiographic measurements made in the surgical areas. Twenty-three of the 24 surgical sites (96%) had BOP at baseline. Seven of the 24 sites (28%) bled on probing after 1 year, seven of 18 sites (39%) after 3 years, and 15 of 24 sites (62%) after 5 years.

In the 5-year radiographs, Bio-Oss® was undetectable in seven patients and detectable in 17 patients (as traces in 10 patients, clearly in seven patients).

Table 3 shows the CAL changes between baseline, year 1, and year 5 according to barrier type, patient, and site characteristics at 1 and 5 years.

The barrier became exposed in five patients within the first 2 weeks of healing (Guidor® in one patient, Bio-Gide® in four patients). The difference in number of exposed barriers between the two systems was significant ($p = 0.018$, ANOVA). After 4 weeks, three of these four Bio-Gides® were no longer exposed while exposure of the Guidor® was the same or more pronounced and an additional Guidor® barrier had become exposed.

Linear or logistic regression analyses of the 1-, 3-, and 5-year values for PPD, BOP, REC, CAL, and RDD were used for these factors: defect anatomy (one-, two-, or three-walled defects), barrier type, barrier exposure during initial healing, full-mouth and local plaque scores, smoking, and general health (diabetes). Smoking significantly influenced CAL at all examinations ($p =$ 0.033, 0.025, and 0.009 at the 1-, the 3-, and the 5-year examinations, respectively). The regression coefficients were − 1.94 (CI: − 3.71– − 0.17) at the 1-year, − 2.09 (CI: − 3.90– − 0.29) at the 3-year, and − 2.20 (CI: − 3.77– − 0.63) at the 5-year examinations. FMPS significantly influenced RDD along the root surface at the 5-year examination; the regression coefficient was 0.10 (CI: 0.02–0.18; $p = 0.012$). No other factors were found to significantly influence the outcome variables. Stepwise multivariate analysis of change in CAL at the 3-year examination was significant for the independent variables smoking ($p = 0.001$) and full-mouth plaque (baseline and year 3 values, $p = 0.000$ and 0.002, respectively). The regression coefficients were − 2.21 for smoking (CI: − 3.34– − 1.04), 0.23 for FMPS at baseline (CI: 0.13–0.32), and − 0.15 for the 3-year FMPS (CI: − 0.24—0.07). For clinical illustrations see Figs 1 & 2.

Table 2. Clinical and radiographic measurements at baseline and changes observed 1, 3 and 5 years after treatment compared with baseline

	PPD (mm)	BOP	REC (mm)	CAL (mm)	CEJ-BD (mm)	RDD (mm)	RDW (mm)
Baseline	10.0 (1.8)	1.0 (0.2)	2.0 (1.8)	11.9 (2.0)	12.1 (2.6)	7.4 (2.5)	2.8 (1.1)
Change year 1	− 5.2 (2.2)	− 0.7 (0.6)	1.0 (1.5)	− 4.2 (2.1)	− 6.0 (3.8)	− 6.5 (2.8)	− 2.1 (1.1)
Change year 3	− 5.6 (2.1)	− 0.6 (0.5)	1.6 (1.5)	− 4.1 (1.8)	− 4.8 (3.2)	− 5.9 (3.4)	− 1.7 (1.1)
Change year 5	− 5.3 (2.3)	− 0.3 (0.5)	1.3 (1.4)	− 4.3 (2.0)	− 4.8 (2.8)	− 6.3 (2.7)	− 1.6 (1.3)

Means and (SDs).

PPD, probing pocket depth; BOP, bleeding on probing; REC, recession of gingival margin; CAL, clinical attachment level; CEJ, cemento-enamel junction; BD, bottom of defect; RDD, radiographic defect depth along the root surface; RDW, radiographic defect width.

Table 3. Stability of attachment level according to defect/patient characteristics and barrier type

Patient	Tooth	Defect type (no. of walls)	Barrier type	CAL change (mm)		General health	Smoking habit	Barrier exposure during healing (mm) 2 weeks/4weeks	FMPS (%)		PlI (0–3)	
				BL–year 1	year 1–year 5				BL	year 5	BL	year 5
1	23	1	G	2	3	–	+	0/0	10	8	0	1
2	46	2	G	5	0	–	–	0/0	10	50	0	2
3	25	3	G	5	−3	–	–	1/1	12	30	0	2
4	13	1	G	5	−3	–	+	0/0	11	5	0	0
5	42	1	G	4	0	–	–	0/0	0	16	0	0
6	21	1	G	5	0	–	+	0/0	59	7	0	1
7	23	3	G	5	0	–	–	0/0	0	13	0	1
8	13	2	G	4	3	–	–	0/0	10	28	0	1
9	13	1	G	1	−1	–	+	0/0	50	9	2	0
10	14	1	G	4	−2	–	+	0/1	1	5	0	0
11	26	2	G	6	−2	Diabetes type 1	–	0/0	3	30	0	0
12	13	1	G	10	−2	–	–	0/0	50	50	1	0
13	21	1	G	6	−1	Diabetes type 2	–	0/0	10	17	0	1
14	43	3	G	6	−1	–	–	0/0	1	0	0	1
15	24	2	BG	6	2	–	–	0/0	8	6	0	0
16	11	2	BG	2	2	Diabetes type 2	+	1/0	10	18	0	0
17	33	2	BG	4	−1	–	–	1/0	11	19	0	0
18	34	2	BG	2	1	–	–	0/0	56	16	1	0
19	43	1	BG	5	0	–	–	0/0	0	14	0	1
20	23	2	BG	1	−1	–	+	0/0	3	6	0	0
21	13	2	BG	3	0	–	+	0/0	3	45	0	0
22	23	3	BG	0	0	–	–	0/0	25	20	0	0
23	11	1	BG	4	−1	–	–	1/1	5	24	0	1
24	23	1	BG	4	1	–	–	1/0	0	0	0	0

CAL, clinical attachment level; FMPS, full-mouth plaque score; PI, plaque index at defect site; BL, baseline; G, Guidor®; BG, Bio-Gide®; +, yes, −, no.

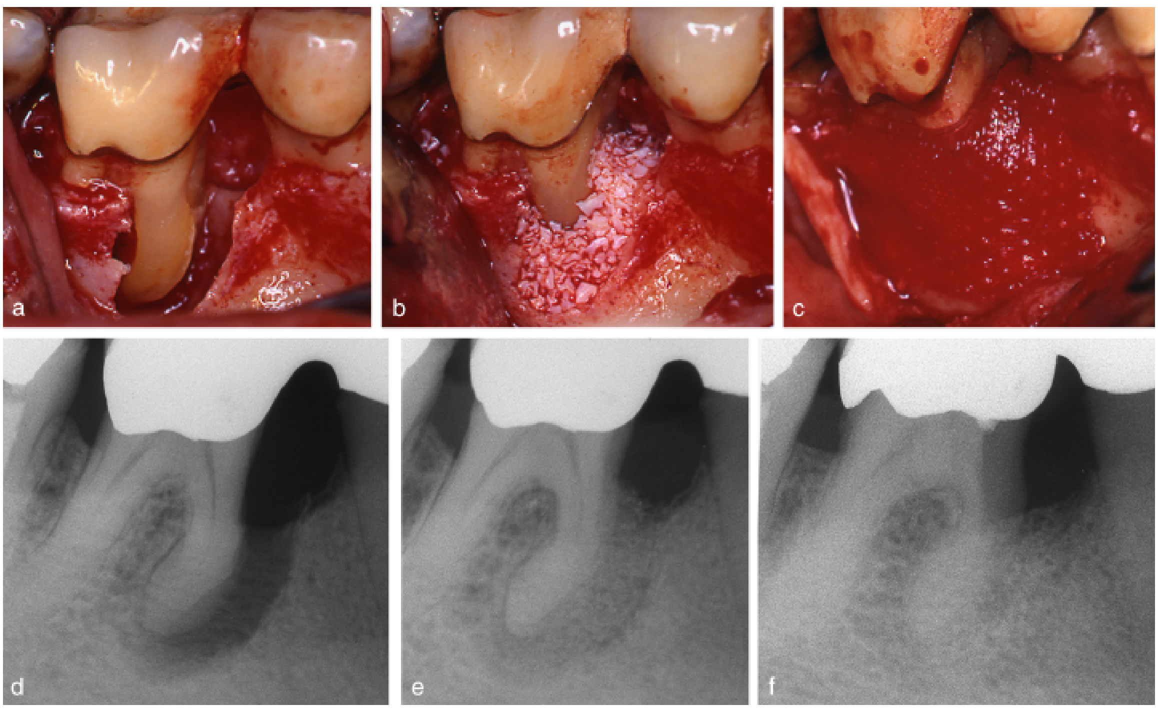

Fig. 1. Extensive periodontal defect along the mesial root: tooth shown to be vital in pre-operative testing (a); defect filled with bovine bone mineral (b) and covered with a bioresorbable barrier (c); radiographic appearance before surgery (d), immediately after surgery (e), and 5 years after surgery (f).

Discussion

The average 5-year gain in CAL of 4.3 mm observed in this study is similar to or even better than results of other long-term investigations on GTR treatment (Gottlow et al. 1992, Cortellini et al. 1996b, 1999, Kim et al. 2002, Eickholz et al. 2004, 2007, Sculean et al. 2004a, 2006, Mengel et al. 2006) and also of studies on GTR and bovine bone mineral (Camelo et al. 1998, Camargo et al. 2000, Paolantonio 2002, Sculean et al.

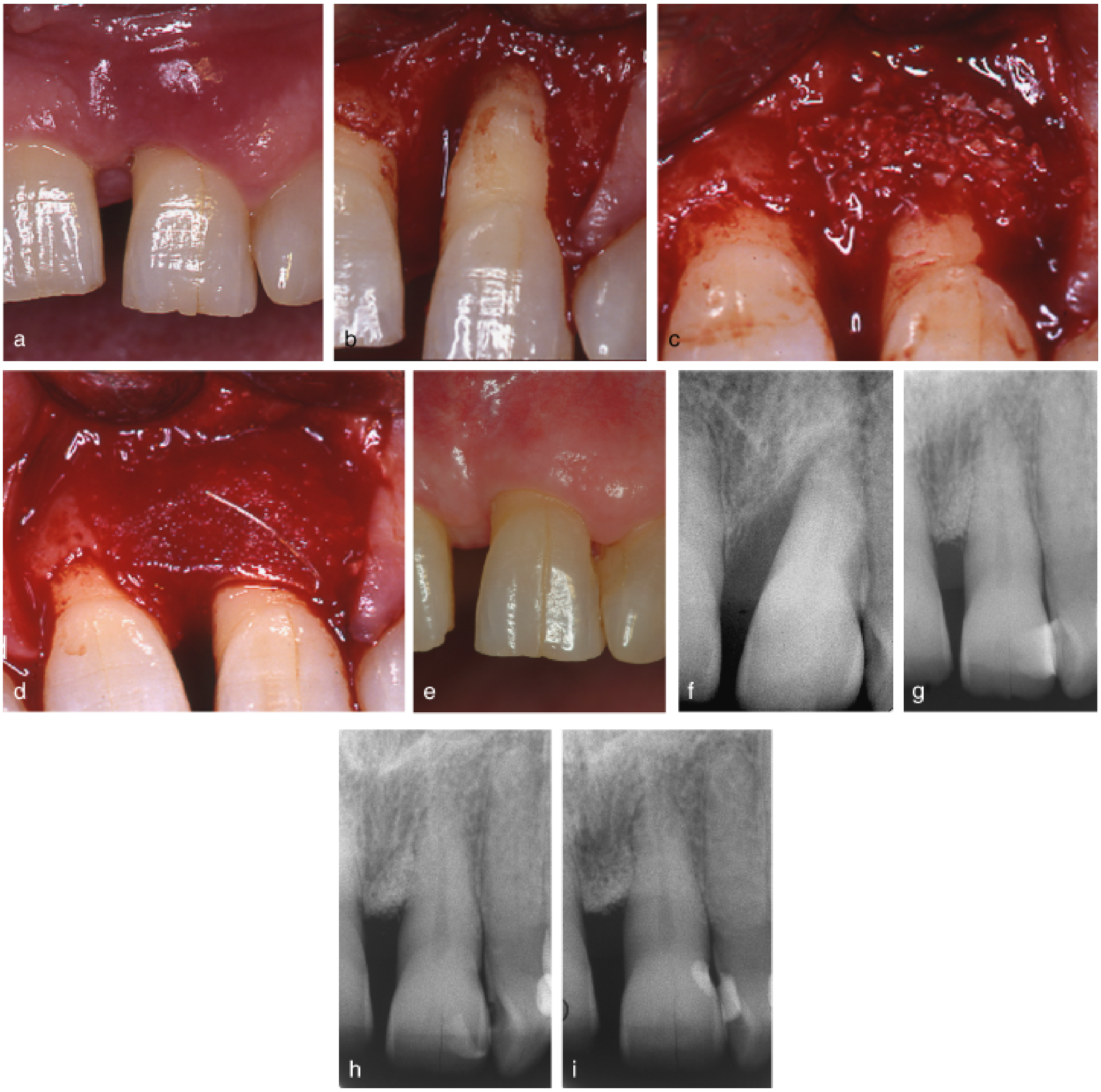

Fig. 2. Vertical defect running to the apex of tooth #21 in a diabetic patient (a, b), application of bovine bone mineral and a bioresorbable barrier (c, d); healthy periodontal tissue 5 years after surgery (e); radiographic appearance pre-operatively (f) and 1 year (g), 3 years (h), and 5 years (i) after surgery.

2003, 2004b, 2007, Stavropoulos et al. 2003, Stavropoulos & Karring 2005).

Tonetti et al. (1996, 2004) found that defect type does not necessarily influence GTR treatment outcome. On the other hand, e.g. Falk et al. (1997) and Cortellini et al. (1993) found that the total depth, width, and angle of the intrabony component significantly affected CAL outcome. In this study, the topography of the periodontal defect had no effect on healing despite an average defect depth of 7.9 mm and width of 2.9 mm. It can be speculated that the filler material stabilized the clot and thereby prevented wound contraction (Wikesjö & Nilveus 1990). In our opinion, treatment outcome would probably have been less favourable if bioresorbable barriers had been used without a filler material to maintain space and prevent barrier collapse. In addition, our clinical experience is that filling the defect with bovine bone material clearly aided barrier placement and prevented barrier collapse into the defect.

Authors of animal guided bone regeneration studies have discussed whether perforation or removal of the contiguous cortical bone during surgery promotes bone augmentation by enhancing bleeding and clot formation in the defect area and by facilitating vascular ingrowth (Kostopoulos & Karring 1994, Kostopoulos et al. 1994, Gordh et al. 1997, Rompen et al. 1999, Lundgren et al. 2000, Slotte & Lundgren 2002, Slotte et al. 2005). In this study, substantial gain in CAL was achieved without surgical perforation, which corroborates the findings of the Karring research group (Kostopoulos & Karring 1994, Kostopoulos et al. 1994, Stavropoulos & Karring 2005). It has been suggested that resorption of cortical bone during healing (Schmid et al. 1997, Slotte & Lundgren 2002) or natural, pre-existing communications through the bone walls (Slotte et al. 2005) may make surgical perforation unnecessary. Moreover, surgical perforation may also negatively influence or retard bone healing (Lundgren et al. 2000). Whether this influences healing of periodontal defects remains to be experimentally investigated.

Significantly more Bio-Gide® than Guidor® barriers became exposed during the initial 2 weeks. But the exposure of Bio-Gide® was mostly minimal, and after 4 weeks only one Bio-Gide® barrier was still exposed. Bio-Gide® is a bilayered material while Guidor® is a double-layered material, thicker than Bio-Gide® (Lundgren et al. 1994). Interestingly, barrier exposure during healing was not found to affect CAL.

As measured on radiographs, mean CEJ–BD had improved by 6.0 mm at the 1-year examination. But at the 3- and the 5-year examinations, this improvement in bone level had dropped to 4.8 mm compared with baseline data. Radiographic improvement was roughly 2 mm greater than CAL measurements at the 1-year examination and non-significantly greater at the 3- and 5-year examinations. The differences in CEJ–BD distance between the 1-year examination and the 3- and 5-year examinations might be explained as a tighter packing of the implanted bovine bone mineral through tissue remodelling. Besides, the radiographic measurements in this study indicate that the implanted bovine bone mineral masked the true marginal bone level compared with the criterion standard (CAL) at the 1-year examination. Hence, based on the discrepancy between the 1-year values of RDD and CAL in this study, radiographic measurements should be interpreted with caution when filler materials are used in periodontal surgery (Linares et al. 2006). Also, the radiographic examination in the present study did not include customized film holders, which may have caused lack of agreement in projection geometry.

After 5 years, the implanted bovine bone mineral was still detectable on radiographs. Because the resorption rate of this material is very slow, bone fill of the defect probably consists of a combination of bovine bone particles and regenerating vital human bone (Berglundh & Lindhe 1997, Sculean et al. 2004c). In addition, human biopsy studies have shown that this technique promotes the formation of new cementum and inserting periodontal ligaments (Camelo et al. 1998, Mellonig 2000, Sculean et al. 2004b). One matter of debate is whether remnants of filler material negatively affect healing outcome or cause recurrent infection (Stavropoulos & Karring 2005). In this study, the implanted material seemed to be incorporated in bone tissue with no clinical signs of adverse material reaction.

Diabetes did not influence CAL gain in this study. But the disease was well controlled in the three patients with diabetes. This finding is in accordance with results in a study by Westfelt et al. (1996) who also found that well-controlled diabetes has no influence on healing in periodontal treatment.

Daily smoking of $\leqslant 10$ cigarettes negatively influenced CAL gain at all examinations. This finding corroborates findings in other studies (Cortellini et al. 1995, Rosen et al. 1996, Trombelli & Scabbia 1997, Trombelli et al. 1997, Stavropoulos et al. 2004, Cortellini & Tonetti 2004) and emphasizes the detrimental effects of smoking on periodontal healing. In addition, stepwise multivariate analysis demonstrated that FMPS levels at baseline and at re-examination in smokers strongly influence CAL after 3 years. The high standard of plaque control that was observed at the surgical sites in most patients is probably why this variable had a non-significant influence on healing. But FMPS did influence gain in the radiographic marginal bone level (CEJ–BD), which agrees with the results of several studies (Rosling et al. 1976, Tonetti et al. 1993, Cortellini et al. 1994, Falk et al. 1997).

This study showed that advanced periodontal defects can be restored using bioresorbable membranes (Bio-Gide® or Guidor®) and bone filler material (Bio-Oss®) with stable long-term result. However, the study design included no control group with a different treatment modality. The authors' stress that the surgical technique presented in this and other similar studies is demanding from a dexterity point of view and requires that the surgeon has considerable perio-surgical experience (Falk et al. 1997, Sanz et al. 2004, Cortellini & Tonetti 2005).

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Clinical Relevance

Scientific rationale for the study: Comparatively little long-term data are available regarding surgical treatment of vertical periodontal defects by the combined use of GTR and bone substitutes. This study presents 5-year results of treatment of advanced periodontal defects using barrier membranes supported by bovine bone mineral.
Principal findings: Treatment resulted in a considerable reduction of probing depth and RDD as well as gain in the CAL. The improvements were shown to be maintained throughout the study period.
Practical implications: Data indicate that surgical treatment of advanced periodontal defects with complicated topography using a combination of GTR and bone filler material can be successfully treated and also maintained over a long period of time.