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Long-term stability of periodontal conditions achieved following guided tissue regeneration with bioresorbable membranes: case series results after 6–7 years

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Abstract

Objectives: To evaluate the results of guided tissue regeneration (GTR) treatment of intrabony defects with bioresorbable membranes after 6–7 years, and to disclose factors that may influence the long-term outcome of the treatment.

Methods: Twenty-five defects in 19 patients were treated by means of polylactic acid/citric acid ester copolymer bioresorbable membranes. At baseline and after 1 and 6–7 years, the following parameters were recorded: (1) probing pocket depth (PPD), (2) gingival recession (REC), (3) probing attachment level (PAL) = PPD+REC, (4) presence/absence of plaque (PI), (5) presence/absence of bleeding on probing (BOP). Smoking habits and frequency of dental-control visits were also recorded. Significance of differences between categorical variables was evaluated with McNemar's test, and between numerical variables with the *t*-test for paired observations. Generalized linear models were constructed to evaluate the influence of various factors on PAL gain and PPD changes from 1 to 6–7 years. Association of smoking, frequency of dental controls, oral hygiene, and BOP with sites losing $\geqslant 2$ mm in PAL was evaluated with Fisher's exact test.

Results: At baseline, a mean PPD of 8.7 ± 1.1 mm and a mean PAL of 9.8 ± 1.5 mm was recorded. Statistically significant clinical improvements were observed at 1 and 6–7 years after GTR treatment. An average residual PPD of 3.8 ± 1.1 mm and a mean PAL gain of 3.8 ± 1.4 mm were observed after 1 year. After 6–7 years the corresponding values were 4.7 ± 1.3 and 3.6 ± 1.4 mm, respectively. There were no statistically significant differences between the 1- and the 6–7-year values. At the 6–7-year control, only 16% of the sites had lost $\geqslant 2$ mm (maximum 3 mm), of the PAL gain obtained 1 year after GTR treatment. None of the sites had lost all of the attachment gained 1 year after treatment. Smoking, frequency of dental controls, oral hygiene, and BOP did not seem to influence the change of PPD and PAL gain, or the stability of PAL gain (i.e. losing PAL or not) from 1 to 6–7 years from treatment.

Conclusion: Clinical improvements achieved by GTR treatment of intrabony defects by means of bioresorbable membranes can be maintained on a long-term basis.

Key words: bioresorbable membranes; clinical; guided tissue regeneration; long term; smoking

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Guided tissue regeneration (GTR) is a biological treatment concept by which a desired wound healing result can be achieved when it is ensured, for example, by means of a physical barrier (e.g. membrane), that cells with the capacity to regenerate the particular type of lost/diseased tissue are allowed to populate the defect/wound during healing

(Karring et al. 1993). Several case series and controlled clinical trials have demonstrated considerable clinical improvements (i.e. shallow pockets, gains in probing attachment level (PAL), and bone fill) following treatment of a variety of periodontal defects according to the GTR principle. In addition, several reports have provided histological evidence in humans that GTR treatment in fact results in true regeneration of the attachment apparatus on previously periodontitis affected roots (for a review see Karring et al. 2003).

It has been shown that GTR treatment of periodontal lesions results in significantly greater clinical improvements than only surgical debridement (Cortellini & Tonetti 2000, Needleman et al. 2002, Stavropoulos 2002), and that non-bioresorbable and bioresorbable membrane materials are equally effective (for a review see Stavropoulos 2002). Recently, it was demonstrated that periodontal tissues regenerated by means of non-bioresorbable membranes are not more susceptible to periodontitis than either the pristine periodontium (Ling et al. 1994, Kostopoulos & Karring 2004) or the periodontal tissues at sites treated with root planing (Cortellini et al. 1996). There is, however, relatively few reports on the long-term results following GTR treatment and most of these reports concern treatment with non-bioresorbable membranes (Gottlow et al. 1992, Becker & Becker 1993, Cortellini et al. 1994, 1996, 1999, Weigel et al. 1995, De Sanctis & Zucchelli 2000). Only a few studies are reporting on the long-term effect of treatment with bioresorbable membranes (Christgau et al. 1997, Sculean et al. 2001, Kim et al. 2002).

The aim of the present study was to report on the results of GTR treatment of intrabony defects with bioresorbable membranes after 6–7 years, and to disclose factors that may influence the long-term outcome of the treatment.

Material and Methods

Twenty-one patients (10 males and 11 females, mean age: 41 years) with at least one interproximal intrabony defect treated with GTR at the Department of Periodontology and Oral Gerontology, Royal Dental College, University of Aarhus, Denmark, and examined after 1 and 6–7 years were included in the study. Sixteen patients had one defect, four had two, and one had four treated defects (total: 28 defects). At the time of surgery, approximately 3 months after initial periodontal treatment, which consisted of oral hygiene instruction and scaling and root planing, the defects presented the following characteristics: (a) probing pocket depth (PPD) $\geqslant 7$ mm and radiographic evidence of an intrabony component $\geqslant 4$ mm, and did not include a furcation involvement, (b) the site had not been treated surgically within the last year before treatment, and (c) systemic antibiotics had not been used within the last 6 months prior to treatment.

The following surgical procedure was used. Following local anesthesia, intrasulcular incisions were made on the buccal and oral aspects of the jaw at the defect site and extended to the adjacent teeth mesially and distally. Care was taken to preserve as much as possible of the interdental tissues at the defect site. Full thickness mucoperiosteal flaps were then raised at both the buccal and oral aspect of the teeth. The defect was debrided and the roots were scaled and planed and rinsed with sterile saline. At this time it was assessed whether the defect was $\geqslant 4$ mm deep. A polylactic acid/citric acid ester copolymer bioresorbable barrier membrane (Guidor®, Guidor AB, Huddinge, Sweden) was then trimmed and adapted to fully cover the defect. The membrane was extending at least 3 mm beyond the margins of the defect, and was stabilized by means of a bioresorbable ligature, incorporated in the membrane, around the neck of the adjacent teeth (Figs 1a–d). The membrane was covered by coronal displacement of the mucoperiosteal flaps. In order to avoid tension on the flaps, horizontal split-thickness and/or vertical releasing incisions were made as needed. The flaps at the defect site were secured in position by means of vertical mattress and single interdental 4.0 teflon sutures (Gore-Tex® suture material, W.L. Gore & Associates, Flagstaff, AZ, USA). The sutures were removed 2–3 weeks later.

The patients received a combination of amoxicillin 750 mg (Imacillin®,

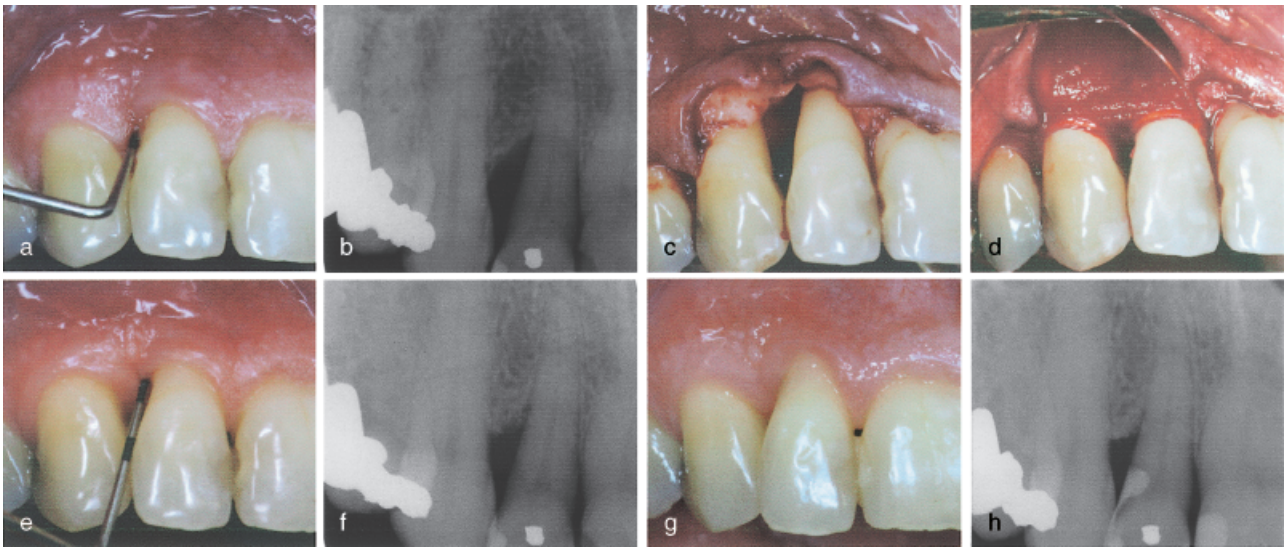

Fig. 1. Clinical photograph (a) and radiograph (b) at baseline, of a two-wall defect. After debridement (c), the defect is covered with an absorbable membrane (d). Clinical photographs and radiographs of the treated site after 1 year (e, f), and after 6 years (g, h).

Astra Danmark A/S, Albertslund, Denmark) and metronidazol 250 mg (Elyzol®, Dumex, A/S Copenhagen, Denmark) systemically for a period of 5 days, starting 1 h before surgery. They were instructed to rinse with a 0.2% solution of chlorhexidine digluconate twice a day and to avoid brushing the operated area for 6 weeks post-operatively. Subsequently careful mechanical oral hygiene measures including interproximal tooth cleaning were re-instituted. The patients were recalled for control and professional prophylaxis, consisting of supragingival polishing with a rubber cup once a week for the first 6 weeks. Once per month, for the following 5 months, the patients were examined and calculus, if present, was removed and the teeth were polished. Deep subgingival instrumentation was avoided at the GTR-treated sites for the first year after surgery. One year after surgery, a control examination was made and the patients were transferred to their own private dentist, where each of them followed an individualized maintenance program. All patients were recalled for another control of the membrane-treated sites 6–7 years after treatment.

At the day of surgery (baseline), after 1 and after 6–7 years, the following clinical parameters were recorded at each GTR-treated site (both from the buccal and the palatal/lingual aspect) to the closest millimeter by means of a manual periodontal probe with a round tip of 0.5 and 1 mm marked increments (Hu-Friedy LL 20: Hu-Friedy Mfg. Co. Inc., Chicago, IL, USA): (a) PPD, (b) gingival recession (REC) – in case that the cemento-enamel junction was difficult to distinguish or absent, the margin of a restoration or crown was used as the coronal reference point, (c) PAL: PPD+REC. In addition, presence or absence of plaque (PI) and presence or absence of bleeding on probing (BOP) were assessed. Information about the patients smoking habits was collected at the 1 and the 6–7-year control visits. Patients declaring that they smoked regularly (at least five cigarettes on a daily basis) at both the 1- and the 6–7-year control were classified as smokers. The frequency of dental visits at their own dentist since the 1-year control and the kind of treatment administered during these visits was also recorded according to information given by the patients. Furthermore, non-standardized radiographs were taken at the 1- and the 6–7-year controls. The surgeries and the recordings at baseline and after 1 year were performed by dentists undergoing specialty training in periodontology. A single investigator made the recordings at the 6–7-year control examination (A.S.).

Significance of differences for PI and BOP between baseline, the 1- and the 6–7-year data were evaluated with McNemar's test. Significance of differences between baseline, the 1- and the 6–7-year clinical data were evaluated by means of Student's *t*-test for paired observations. Patients declaring that they smoked regularly at both the 1- and the 6–7-year control were classified as smokers. Patients receiving a dental control and/or professional prophylaxis at least every 4 months after the 1-year control, were classified as being frequently controlled. Presence of plaque at the site in both the 1- and the 6–7-year control was acknowledged as evidence of poor oral hygiene. Sites that bled after probing in both the 1- and the 6–7-year control were classified as showing frequent BOP. Generalized linear models were constructed to evaluate the influence of smoking habits (smoking/no smoking), frequency of dental controls (frequent/infrequent), oral hygiene (good/bad), and BOP (frequent/infrequent) on the change of the primary outcome variables (i.e. PAL gain, PPD) from 1 to 6–7 years after GTR, including in the analysis only one randomly chosen defect per patient. The threshold to characterize sites loosing attachment between the 1- and the 6–7-year control was set to PAL loss $\geqslant 2$ mm, in order to compensate for interexaminer variation (Breen et al. 1999). Association of smoking, frequency of dental controls, oral hygiene, and BOP with sites that showed PAL loss was evaluated with Fisher's exact test. The level of significance was set at 0.05. All calculations were performed with the SPSS for Windows, version 10.0.5, software package (SPSS Inc., Chicago, IL, USA).

Results

All surgically treated sites healed without significant problems (Figs 1e–h). The site (buccal or oral) of the interproximal defect with the deepest PPD value at baseline was chosen as the site of analysis. In case baseline PPD values did not differ, the site (buccal or oral) with the deepest PPD after 1 year was chosen as the site of analysis. At the 6–7 years examination, two patients had lost their treated tooth and one patient had lost one of his two treated teeth. All three cases had PAL gains of 3–4 mm and PPDs not exceeding 5 mm at the 1-year control. It was not possible to disclose whether these teeth were lost because of periodontal breakdown since the patients were not aware of/remembered the exact reason for extraction. Thus, 25 sites were available for evaluation in the remaining 19 patients. According to the patients, regular maintenance care (i.e. tooth cleaning) was the only periodontal treatment administered in relation to these teeth. Out of the 25 defects, eight were in smokers (none of the patients who smoke at the 1-year control altered smoking habits during the study, and no patient started smoking regularly during the follow-up period), 14 were in patients who received control frequently, nine in patients performing poor oral hygiene, and eight defects bled on probing at both the 1- and the 6–7-year control.

The clinical parameters at baseline, 1 and 6–7 years after treatment are shown in Table 1 and Fig. 2. A statistically significant decrease in the number of sites with BOP compared with baseline was observed after 1 year (McNemars's, $p < 0.01$) and after 6–7 years (McNemars's, $p = 0.04$), although oral hygiene did not change significantly (PI: McNemars's, $p = 0.4$ and 0.5, respectively). A statistically significant PPD reduction and PAL gain compared with the baseline values was observed (paired *t*-test, $p < 0.001$, for both parameters) after 1 year, and these clinical improvements were preserved for up to 6–7 years. However, a statistically significant increase in PPD (paired *t*-test, $p < 0.001$) occurred from 1 to 6–7 years. REC was statistically significantly smaller at the 6–7-year control compared with 1 year after treatment (paired *t*-test, $p = 0.008$), and did not differ from baseline (paired *t*-test, $p = 0.2$). Smoking, frequency of dental controls, oral hygiene, and BOP did not seem to influence the change of the primary outcome variables (i.e. PPD, PAL gain) from 1 to 6–7 years after treatment (Table 2). The radiographs showed that in most of the cases almost total resolution of the bone defect with bone regeneration had occurred after treatment, but evidence of crestal resorption was also observed. No obvious differences could be distinguished between the 1- and the 6–7-year radiographs.

Table 1. Clinical parameters at baseline and 1 and 6–7 years after treatment, and PAL gain classes at the 6–7-year control (25 defects)

	Baseline	1 year	6–7 years	*P*		
PI	32%	64%	44%	0.02*,†	0.5*,‡	0.2*,§
BOP	92%	40%	64%	0.01*,†	0.04*,‡	0.1*,§
	mean ± SD	mean ± SD	mean ± SD			
PPD	8.7 ± 1.1	3.8 ± 1.1	4.7 ± 1.3	<0.01¶,†	<0.001¶,‡	<0.001¶,§
PPD reduction		4.9 ± 0.9	4.0 ± 1.2			
REC	1.1 ± 1.3	2.2 ± 1.4	1.5 ± 1.9	<0.01¶,†	0.2¶,‡	0.008¶,§
REC increase		1.1 ± 1.1	0.4 ± 1.4			
PAL	9.8 ± 1.5	6.0 ± 1.5	6.2 ± 1.9	<0.01¶,†	<0.01¶,‡	0.4¶,§
PAL gain		3.8 ± 1.4	3.6 ± 1.4			

PAL loss	0⩽PAL gain<2	2⩽PAL gain<4	4⩽PAL gain<6	6⩽PAL gain
0	0	16 (64%)	4 (16%)	5 (20%)

*Analyzed with the McNemar's test.
†1 year compared with baseline.
‡6–7 years compared with baseline.
§6–7 years compared with 1 year.
¶Analyzed with Student's *t*-test for paired observations.
PAL, probing attachment level; PI, plaque; BOP, bleeding on probing; PPD, probing pocket depth; REC, gingival recession.

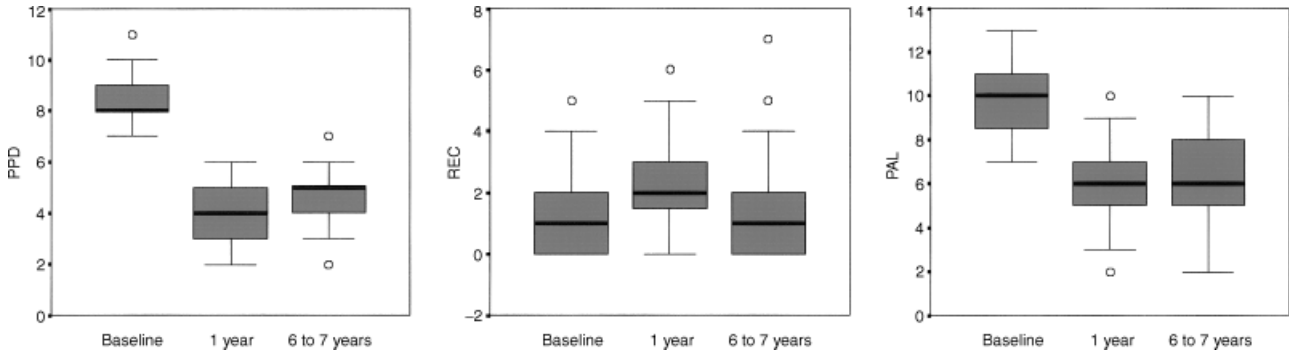

Fig. 2. Boxplots based on the median, quartiles, and extreme values for probing pocket depth (PPD), gingival recession (REC), and probing attachment level (PAL) gain at baseline, 1 and 6–7 years after guided tissue regeneration treatment. The box represents the interquartile range, which contains 50% of the values. The lines extending from the box indicate the highest and lowest values, excluding outliers. The black line across the box indicates the median. o, outlier; *, extreme.

At the 6–7-year control, four sites had lost ⩾2 mm (maximum 3 mm) of the PAL gain obtained 1 year after GTR treatment. None of the sites had lost all of the attachment gained 1 year after treatment. Some sites actually gained more in attachment (maximum 3 mm) during the observation period. Smoking, frequency of dental controls, oral hygiene, and BOP did not seem to influence the stability of PAL gain (i.e. losing PAL or not) from 1 to 6–7 years after treatment (Table 3).

Discussion

The results of the present study showed that PAL gains obtained 1 year after GTR treatment of intrabony defects with bioresorbable membranes were maintained for 6–7 years, in the majority of the cases. This finding is in agreement with those of previous reports on the long-term effect of GTR treatment with bioresorbable membranes (Christgau et al. 1997, Sculean et al. 2001, Kim et al. 2002). Christgau et al. (1997) reported that from 4.3 mm PAL gain obtained on average 1 year after GTR treatment of intrabony defects with polyglactin-910 bioresorbable membranes, only 0.3 mm were lost over a period of 1.5 year. Similarly, Sculean et al. (2001) reported that only 0.3 mm of the average PAL gain (3.2 mm) obtained 1 year after GTR treatment with PLA/PGA bioresorbable membranes were lost over an additional 3-year follow-up period. Kim et al. (2002), on the other hand, failed to detect any difference in PAL gain (3.0 mm) from 1 to 5 years after GTR surgery. These results are similar to those reported following GTR treatment with non-bioresorbable membranes, where the majority of defects/patients remained relatively stable over various long-term observation periods (Gottlow et al. 1992, Cortellini et al. 1994, 1996, 1999, Weigel et al. 1995). Cortellini et al. (1999), for instance, showed that the PAL gains obtained 1 year after GTR were preserved at least 8 years after treatment. Nevertheless, in the studies of Cortellini et al. (1994, 1996) and Weigel et al. (1995), an average loss of 1.2–2.8 mm of the PAL gain obtained 1 year after GTR treatment was recorded 4–5 years after surgery. This PAL loss was associated with lack of compliance with a supportive periodontal program, poor oral hygiene, and smoking. In contrast to the above-mentioned observations, smoking, frequency of dental controls, oral hygiene,

Table 2. Results of the generalized linear models with significance levels (p), estimates of differences (Est.) and lower and upper limits of 95% confidence interval for the effect of smoking, frequent controls, good oral hygiene, and absence of prolonged inflammation on PPD and PAL gain differences between the 1- and 6–7-year control

	p	Est.	95% confidence interval	
			lower	upper
PAL gain				
smoking	0.26	− 0.93	− 2.63	0.77
controls	0.33	0.75	− 0.83	2.33
oral hygiene	0.29	− 0.84	− 2.48	0.81
inflammation	0.16	− 1.18	− 2.88	0.52
PPD				
smoking	0.98	− 0.01	− 1.13	1.10
controls	0.51	0.32	− 0.71	1.36
oral hygiene	0.09	0.91	− 0.17	1.98
inflammation	0.29	0.57	− 0.55	1.69

PAL, probing attachment level; PPD, probing pocket depth.

Table 3. Classification of sites with PAL loss $\geqslant 2$ mm between the 1- and the 6–7-year control, according to smoking habits, frequent dental controls, OH, and frequent BOP

	PAL loss $\geqslant 2$ mm		p*
	no	yes	
Smoking			
yes	8		0.27
no	13	4	
Controls			
yes	12	2	1.00
no	9	2	
Oral hygiene			
good	13	3	1.00
bad	8	1	
BOP			
no	13	4	0.27
yes	8		
Total	21	4	

*Analyzed with Fisher's exact test.
PAL, probing attachment level; OH, oral hygiene; BOP, bleeding on probing.

and BOP did not seem to play a role for the stability of PAL gain in the present study. This discrepancy is probably because of the fact that, on average, there was only a minimal (0.2 mm) PAL gain difference between 1 and 6–7 years and because of the very small number of sites (only 16%) in the present study that lost part of the PAL gain attained 1 year after GTR treatment. In the present study, a threshold of PAL loss $\geqslant 2$ mm was used to characterize sites that lost attachment between the 1- and the 6–7-year control visit. It is acknowledged that if a lower threshold value (i.e. $\geqslant 1$ mm) were used, a larger number of sites would probably have been identified as having lost PAL between the two control examinations. However, this would probably also have increased the number of false-positive cases, because of measurement error and/or interexaminer variation during probing.

The improvements in clinical parameters (PAL gain = 3.8 mm, residual PPD = 3.8 mm) 1 year after GTR treatment in the present group of patients are similar to the calculated weighted means presented recently (Stavropoulos 2002) in a review of 39 studies (published between 1990 and 2000) reporting about the results of treatment of 1019 intrabony defects by means of various types of bioresorbable membranes (PAL gain = 3.6 mm, residual PPD = 3.6 mm). PPD measurements are not useful for assessing the efficacy of regenerative periodontal surgery since reductions in PPD may occur not only as a result of regeneration but also because of increased periodontal health or REC (Reddy & Jeffcoat 1999). However, PPD evaluation after regenerative treatment is as critical as PAL gain since deep residual PPD has been identified as a risk indicator for the progression of periodontitis (Armitage 1996). In most of the aforementioned studies on GTR treatment (Cortellini et al. 1994, 1999, Weigel et al. 1995, Christgau et al. 1997, Sculean et al. 2001, Kim et al. 2002) and in the present study, an average increase of 0.5–0.9 mm in PPD was observed from the early to the late post-surgical control. This increase in PPD, however, was not always attributable to attachment loss but was partly because of a reduction in REC (i.e. gingival regrowth).

It has been suggested that for the evaluation of different periodontal treatment modalities, true end points (e.g. tooth loss, quality of life) should be used (Hujoel et al. 2000). It can be argued that a decrease in tooth mortality as a result of GTR treatment is the desirable therapeutic effect. However, tooth loss following periodontal treatment is not solely associated to the treatment method, but may rather be related to post-operative maintenance and/or general dental care. In the present study, only three (or 11%) out of the 28 originally treated defects were lost at some time point during the 1- and the 6–7-year control, and it was not possible to disclose whether these teeth were indeed lost because of periodontal breakdown since all three cases showed good clinical results at the 1-year control and the patients were not aware of/remembered the exact reason for extraction. On the basis of the results of the present study and those of others (Christgau et al. 1997a, Sculean et al. 2001, Kim et al. 2002), it seems reasonable to anticipate that the majority of teeth treated with bioresorbable membranes according to the GTR principle can be preserved for a long period of time. In fact, these results considered along with the finding that periodontal tissues regenerated by means of GTR are not more susceptible to periodontitis than the pristine periodontium (Ling et al. 1994, Kostopoulos & Karring 2004) or periodontal tissues at sites treated with root planing (Cortellini et al. 1996), support the view that the results of GTR treatment are just as stable on a long term basis as the results of conventional periodontal treatment.

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