Clinical Outcome Following Guided Tissue Regeneration Using ePTFE Membranes: Attachment Gain and its Determinants

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Klinički rezultati dobiveni upotrebom ePTFE membrane u terapiji vođene regeneracije tkiva: Stvaranje pričvrstka i njegove karakteristike

Summary

The aim of the present study was (i) to evaluate the gain and maintenance of new clinical attachment following GTR therapy of deep intrabony defects and (ii) to analyse the significant factors associated with the clinical outcome.

Twenty-four defects in 19 patients were treated by GTR with ePTFE membranes. Clinical measurements were recorded at baseline and at 6 and 12 months post-surgically. GTR treatment resulted in a probing depth reduction (x = 3.8 ± 1.5 mm, p=.0001) and a gain clinical attachment (x = 2.6 ± 1.5 mm, p=.0001) after 6 months. The amount of probing attachment gain was explained in terms of a series of patient, defect morphology and surgical factors. Clinical attachment gain was significantly associated with the intrabony depth of defect, the defect configuration, and the level of oral hygiene.

Key words: *Guided tissue regeneration, polytetrafluorethylene mambranes*

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Introduction

The development of a novel periodontal treatment modality referred to as "Guides tissue regeneration" (GTR) has aimed at regenerating periodontal tissues at diseased root surfaces through the exclusion of undesired cells such as epithelium, gingival connective tissue or bone from the healing process. Instead, a physical barrier (e.g., a membrane composed of polytetrafluoroethylene, is placed temporarily between the detached root surface and the non-desired gingival tissues in such a way that progenitor cells from the periodontal ligament and osteoblasts can colonise the cavity, thus permitting the formation of new attachment on the denuded portion of the root (1,2). histologic examination of biopsies from animal experiments and numerous human studies (1,2,3,4) have documented that, indeed, new attachment may form follo-

wing GTR therapy. Furthermore, the membrane may divert functional stress from the coagulum-tooth interface which might otherwise disrupt the fragile adhesion of the maturing fibrin clog to the root surface during the early phase of healing (5,6).

Several clinical studies in humans have indicated that GTR treatment at root surfaces associated with various types of periodontal defects is highly effective, particularly in deep intraosseous vertical defects and grade II furcations (1, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17).

However, the critical factors associated with the healing response following GTR treatment have been subjected to subtle examination only in recent years. Defect characteristics and patient associated variables such as cigarette smoking and oral hygiene have been suggested to determine short-term GTR outcome (9,10,16,18,19).

The aim of the present study was (i) to evaluate the gain and maintenance of new clinical attachment following GTR therapy of deep intrabony defects and (ii) to analyse the significant factors associated with the healing outcome.

Materials and Methods

Study population

Twenty-four teeth with vertical defects characterized by probing attachment level loss of at least 7 mm (maximum: 14 mm) and radiographic evidence of an intrabony component which had insufficiently responded to conventional periodontal treatment, were included in the study. The tooth population included 7 incisors, 6 canines, 2 bicuspids, and 9 molars. Sixteen teeth were located in the maxilla and 8 in the mandible. The 19 healthy patients (mean age: 48 ± 6.7 years, range: 33.1 to 58.1 years) underwent a 3-week initial therapy phase, comprising scaling and root planing and oral hygiene instructions. Immediately before surgery, the baseline measurements of probing attachment level (PAL), probing pocket depth (PPD), and Plaque Index (20) were recorded using a calibrated North Carolina periodontal probe. Furthermore, 6 patients (with 9 treated sites) who smoke more than 10 cigarettes per day (see 19) were classified as smokers.

Surgical and postsurgical procedures

A mucoperiosteal full-thickness flap including two vertical releasing incisions was raised for proper access to the defect. After flap reflection, dento-gingival epithelium and granulation tissue was completely removed, and the root surfaces were meticulously scaled and root planed using curets and ultrasonic apparatus. Following debridement of the defects. the intraosseous depth of the defect (DD) was measured, representing the difference between the distance from the cemento-enamel junction to the bottom of the defect (CEJ-BD) and the distance from the CEJ to the alveolar crest (CEJ-AC).

Commercially available expanded polytetrafluorethylene (ePTFE) membranes (Gore periodontal material; Gore-tex® W.L. Gore&Ass. Inc., Flagstaff, Arizona, USA) were positioned coronal by to the bone crest. Membranes were secured in position with ePTFE sling sutures. Flaps were coronally positioned in order to cover the membranes to the best possible extent.

Postoperatively, the patients followed a chlorhexidine mouthwash regimen for two weeks following the removal of the membrane. An antibiotic cover was prescribed for two weeks following surgery. A second surgical procedure to remove the ePTFE barriers was performed 4 to 6 weeks following installation. As this time, membrane exposure (ME) was expressed in mm as the distance from the coronal margin of the membrane to the gingival margin.The patients were scheduled for a regular cheek-up, however, most of them kept their appointments erratically.

Follow-up measurements

Six months postsurgically, each site exposed to GTR therapy was examined anew. This examination included assessment of PPD, PAL, and plaque index at the surgically treated sites and was performed in a manner identical to that described for the baseline examination. At the one-year follow-up, identical measurements were obtained for 15 teeth.

Statistical analysis

The sites with the deepest baseline PPD of PAL associated with the defect treated by GTR were chosen for analysis. Data were expressed as means ± standard deviation. The significance of differences between baseline and follow-up measurements was tested using the non-parametric Wilcoxon matched-paris signed-ranks test.

Probing attachment gain δPAL_{0-6} (δPAL_{10-12}) and probing depth reduction δPPD_{0-6} (δPPD_{0-12}) represented the 6 months one year outcom variables respectively. They were compared in terms of patient variables (i.e., level of oral hygiene, smoking status) and defect/surgery characteristics (i.e., membrane exposure, depth of defect, membrane configuration) utilizing the non-parametric Mann-Whitney U test of Kruskal-Wallis One-way analysis of variance. In view of the restricted sample size, the (error was set at 0.05 despite multiple testing.

Results

The results of the clinical parameters are presented in Table 1.

Table 1. *Clinical parameters*
Tablica 1. *Klinički parametri*

Label	Mean	Std Dev	Minimum	Maximum	N
Probing attachment level					
PAL baseline	10.25	1.87	7	14	24
PAL 6 months	7.67	1.31	6	11	24
PAL 1 year	8.00	1.56	6	12	15
Change PAL baseline - 6 mths.	-2.58	1.53	-1	-6	24
Change PAL 6 mths. - 1 yr.	+.13	.64	-1	+1	15
Probing pocket depth					
PPD baseline	9.25	1.85	7	13	24
PPD 6 months	5.50	1.62	3	8	24
PPD 1 year	6.00	1.46	4	8	15
Change PPD baseline - 6 mths.	-3.75	1.51	-1	-7	24
Change PPD 6 mths. - 1 yr.	+.13	1.19	-2	+3	15
Oral hygiene level					
PI baseline	1.17	.49	.25	2.00	24
PI 6 months	1.19	.43	.50	2.00	24
PPD 1 year	1.07	.42	.50	1.75	15
Change PI baseline - 6 mths.	-.02	.41	-1.00	1.00	24
Change PI 6 mths. - 1 yr.	.07	.25	-.25	.75	15

Baseline characteristics

Fourteen sites showed 1+2-wall defects, 8 showed 2-3-wall defects, and 2 sites showed extremely wide angular defects with proximal furcation involvement. The depth of the intrabony component of the defect averaged 2.96 ± 1.63 mm (range: 1 to 8 mm).

At the time of the re-entry procedure, 8 patients had a minimal amount of membrane exposure (0 to 1 mm), 7 patients showed 2 to 3 mm of the material coronally to the gingival margin, and 4 patients showed a consistent exposure of the membrane (>3 mm).

Baseline measurements showed an average gingival recession amounting to 1.30 ± 2.03 mm (range: 0 to 7 mm). Compared with baseline, a significant average increase in gingival recession was observed between baseline and 6 months examination (2.00 ± 1.09 mm, range: 0 to 4 mm; $p<0.001$), while a non-significant mean decrease of recession of 0.13 ± 0.35 mm occurred from 6 months to 1 year postsurgically.

Mean baseline plaque index was 1.17 ± 0.49 (range: 0.25 to 2.0). No significant difference was observed between the plaque index obtained at baseline and the $^1/_2$ and 1 year evaluation (p=.581).

Primary treatment outcomes

A marked, significant gain of clinical attachment was obtained between the baseline and the 6-months observation (x = 2.58 ± 1.53 mm, range: 1 to 6 mm; $p<.0001$). 73.3% of the treated sites exhibited a gain in clinical attachment equal or greater than 2 mm; 21% exhibited a gain of more than 4

mm. Clinical attachment level remained stable between 6 months and one year. In fact, mean clinical attachment gain at one year was 2.93 ± 1.58 mm. No significant difference was detected between 6 months and one year PAL (p=.846). Both were significantly different from baseline PAL (.0001<p<.023).

A marked, significant reduction of probing pocket depth was obtained between the baseline and the 6-months observation (s = 3.75 ± 1.51 mm, range: 1 to 7 mm; p=.0001). Residual PPD at 6 months was 5.50 ± 1.62.

A non-significant mean increase in the probing pocket depth of 0.58 (1.01 mm (range: -1 to 2 mm) was seen from 6 months to one year follow-up (p=.56).

Factors affecting treatment outcome

6 months clinical attachment gain

The difference between sites showing slight and marked membrane exposure at 6 months post-surgically was statistically significant (p=.05). Unexpectedly, the mean attachment gain was greater with more exposed membranes (3.25 ± 1.77 versus 1.92 ± 0.90). See Figure 1.

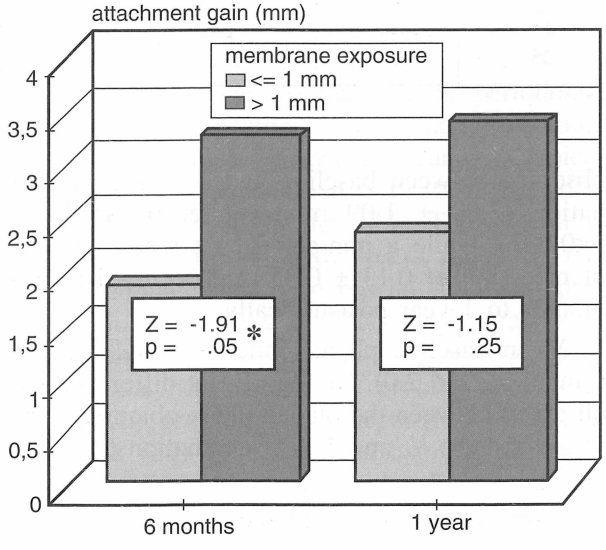


Figure 1. *Mean gain of clinical attachment after 6 months and one year depending on degree of membrane exposure*
(Z statistics and level of significance indicated)

Slika 1. *Povećanje kliničkog pričvrstka poslije 6 mjeseci i poslije jedne godine prema stupnju otkrivenosti membrane*

There was a tendency for smokers to gain less attachment (2.0 ± 1.32) compared to non-smokers (2.93 ± 1.58), however, this difference was not significant (p=.12). See Figure 2.

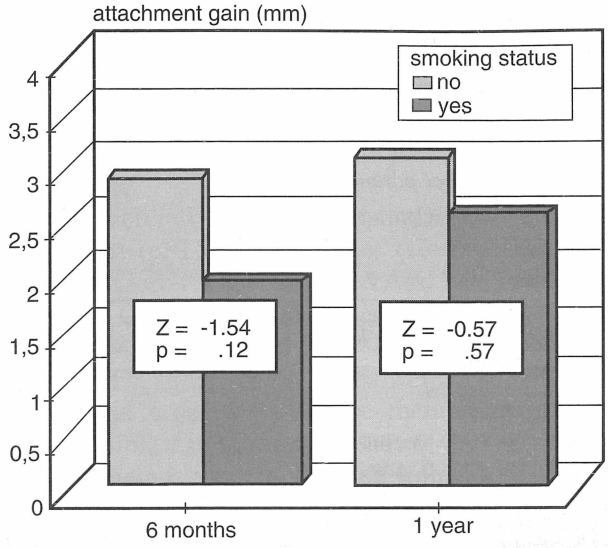


Figure 2. *Mean gain of clinical attachment after 6 months and one your depending on smoking status*
(Z statistics and level of significance indicated)

Slika 2. *Povećanje kliničkog pričvrstka poslije 6 mjeseci i poslije jedne godine prema ovisnosti o pušenju*

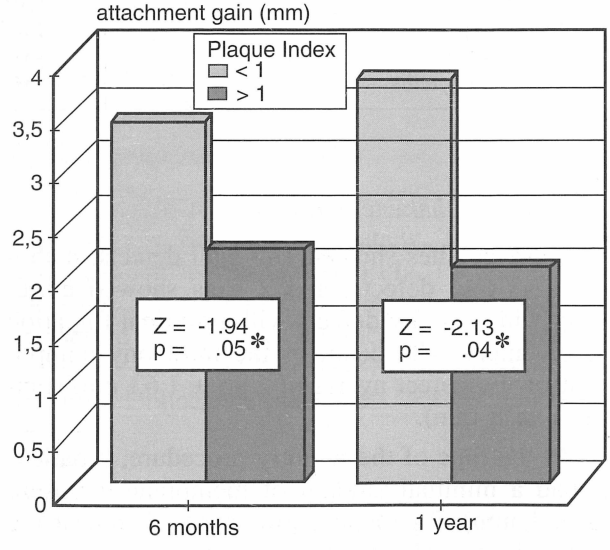


Figure 3. *Mean gain of clinical attachment after 6 months and one year depending on level of oral hygiene (Plaque Index)*
(Z statistics and level of significance indicated)

Slika 3. *Povećanje kliničkog pričvrstka poslije 6 mjeseci i poslije jedne godine prema stupnju oralne higijene (Plak indeks)*

The amount of probing attachment gained at 6 months after surgery was significantly greater with better oral hygiene (PI<1) compared to modest of poor oral hygiene (3.43 ± 1.27 versus 2.24 ± 1.52, p=.0.5). See Figure 3.

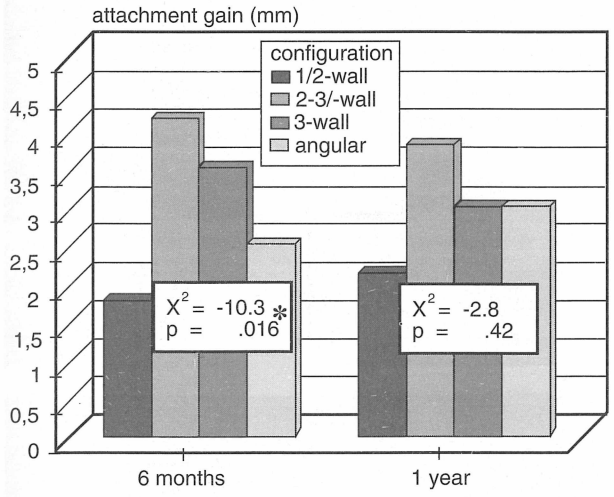


Figure 4. *Mean gain of clinical attachment after 6 months and year depending depending on the configuration of the defect*
(Z statistics and level of significance indicated)

Slika 4. *Povećanje kliničkog pričvrstka poslije 6 mjeseci i poslije jedne godine prema obliku defekta*

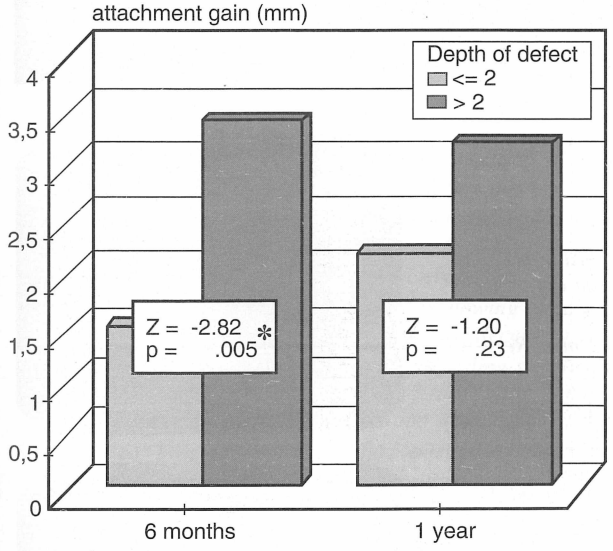


Figure 5. *Mean gain of clinical attachment after 6 months and one year depending on the intrabony depth of the defect*
(Z statistics and level of significance indicated)

Slika 5. *Povećanje kliničkog pričvrstka poslije 6 mjeseci i poslije jedne godine prema dubini koštanog defekta*

Attachment gain significantly varied depending on the type of defect involved p=.016). 2-3/- and 3 wall defects showed a markedly higher amount of gained attachment (3.5 - 4.17) compared to 1-/2-wall and angular defects (1.79 - 2.5). See Figure 4.

The intrabony depth of the defect proved to be significantly correlated to treatment outcome (p=.005). Defects exceeding 2 mm in depth presented a greater amount of attachment gain after 6 months (3.39 ± 1.56 versus 1.64 ± 0.81). See Figure 5.

1 year clinical attachment gain

At the one year examination, the difference in gained attachment between sites showing slight and marked membrane exposure was no longer statistically significant (p=.25). However, the mean attachment gain still somewhat greater with more exposed membranes (3.33 ± 1.73 versus 2.33 ± 1.21) See Figure 1.

Smokers and non-smokers did non show any significant differences in the one-year attachment gain (2.6 ± 1.67 versus 3.1 ± 1.6, p=0.57), however, the clinical outcome was better in non-smokers. See Figure 2.

The amount of probing attachment gained at one year after surgery was significantly greater with better oral hygiene (PI<1) compared to modest or poor oral hygiene (3.83 ± 1.60 versus 2.0 ± 0.93, p=.034). See Figure 3.

At the one-year follow-up, no differences in attachment gain were found depending on the type of defect involved (p=.42). However, the clinical outcome observed in 2-/3-wall defects were still markedly better than those in 1-/2-wall defects (3.8 ± 1.64 versus 2.17 ± 1.33). See Figure 4.

The intrabony depth of the defect was not significantly associated with amount of the attachment gain recorded at one-year post surgery (p= .23). However, there was a tendency for deeper defects to present a more favourable results (3.3. ± 1.70 versus 2.2 ± 1.10.). See Figure 5.

Discussion

The goal of the present study was to evaluate the amount, and possible determinants, of attachment gain utilizing ePTFE membranes in the treatment of deep intrabony defects. in agreement with

previous observations, our findings show that periodontal treatment, based on the principle of guided tissue regeneration, may result in varying amounts of gain of clinical attachment (7, 8, 12, 15, 17, 18). Our clinical results are within the range of those reported by Kocher (21). Fath (22), Gouldin (23) Becker (24) for intrabony defects. They indicate that GTR is a highly efficient treatment

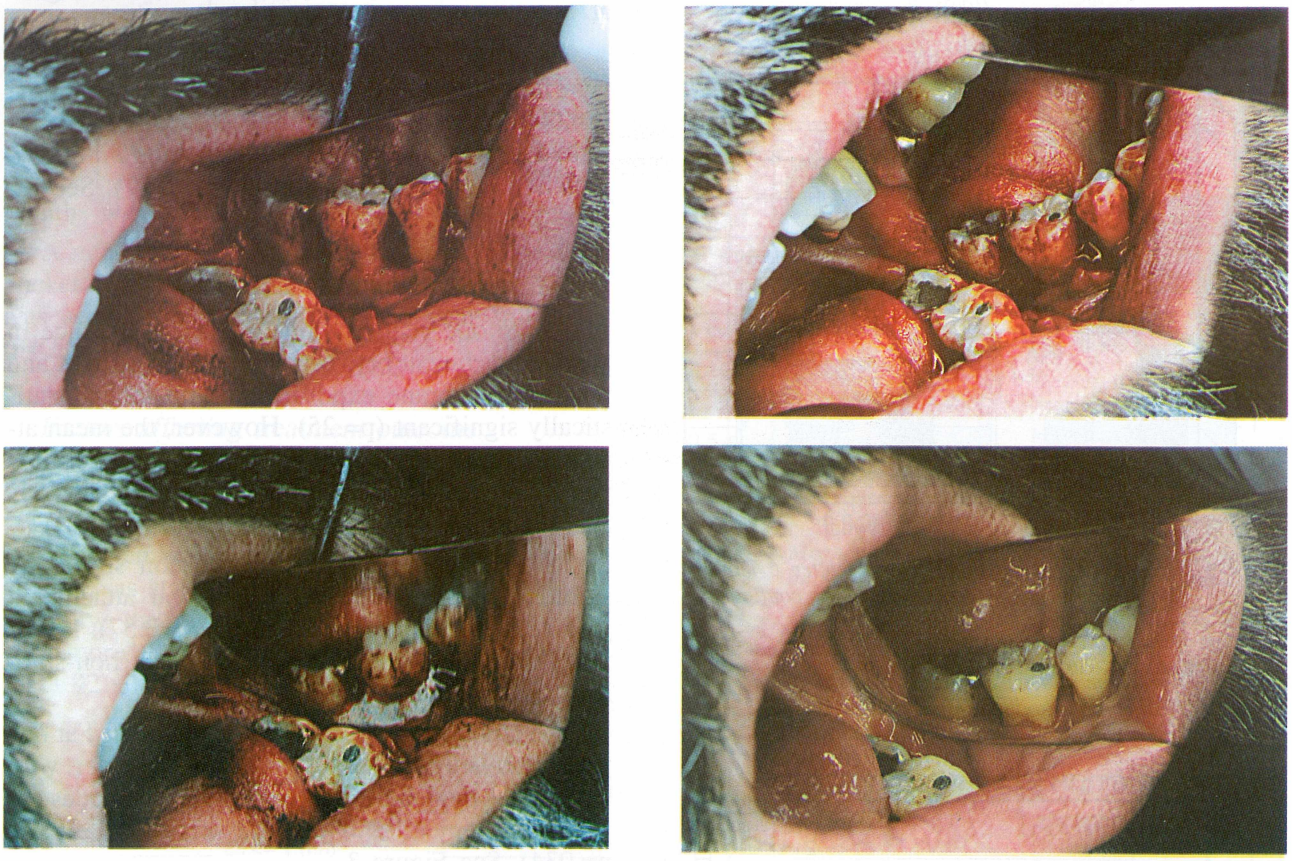


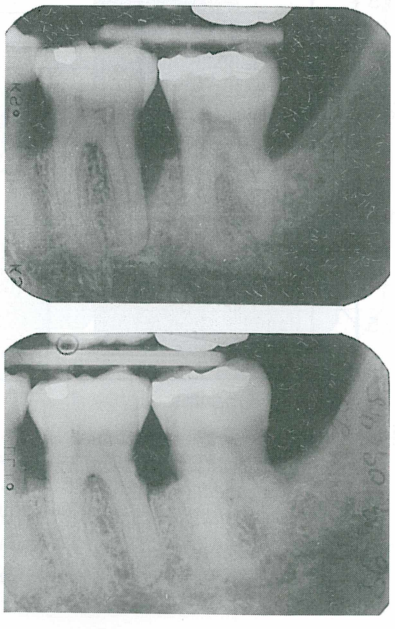
Figure 6. *a) 1-/2-wall osseous defect with marked disto-buccal bone loss. Presurgical state presenting a 11 mm deep pocket and attachment loss 12 mm at the lower left first molar*

b) ePTFE membrane adapted over the defect

c) Defect completely filled by regenerated tissue after membrane removal 5 weeks post operatively. Note the migration of new tissue coronally from the alveolar margin

d) State 1 year postsurgically showing attachment gain of 2 mm. Recession increased by 1 mm

e) Radiologically proven formation of new bone one year postoperatively. Compare both radiograms



Slika 6. *a) Dvozidni koštani defekt s izraženim gubitkom distobukalne kosti. Nalaz prije zahvata pokazuje džep dubine 11 mm i gubitak pričvrstka od 12 mm na prvom donjem lijevom kutnjaku*

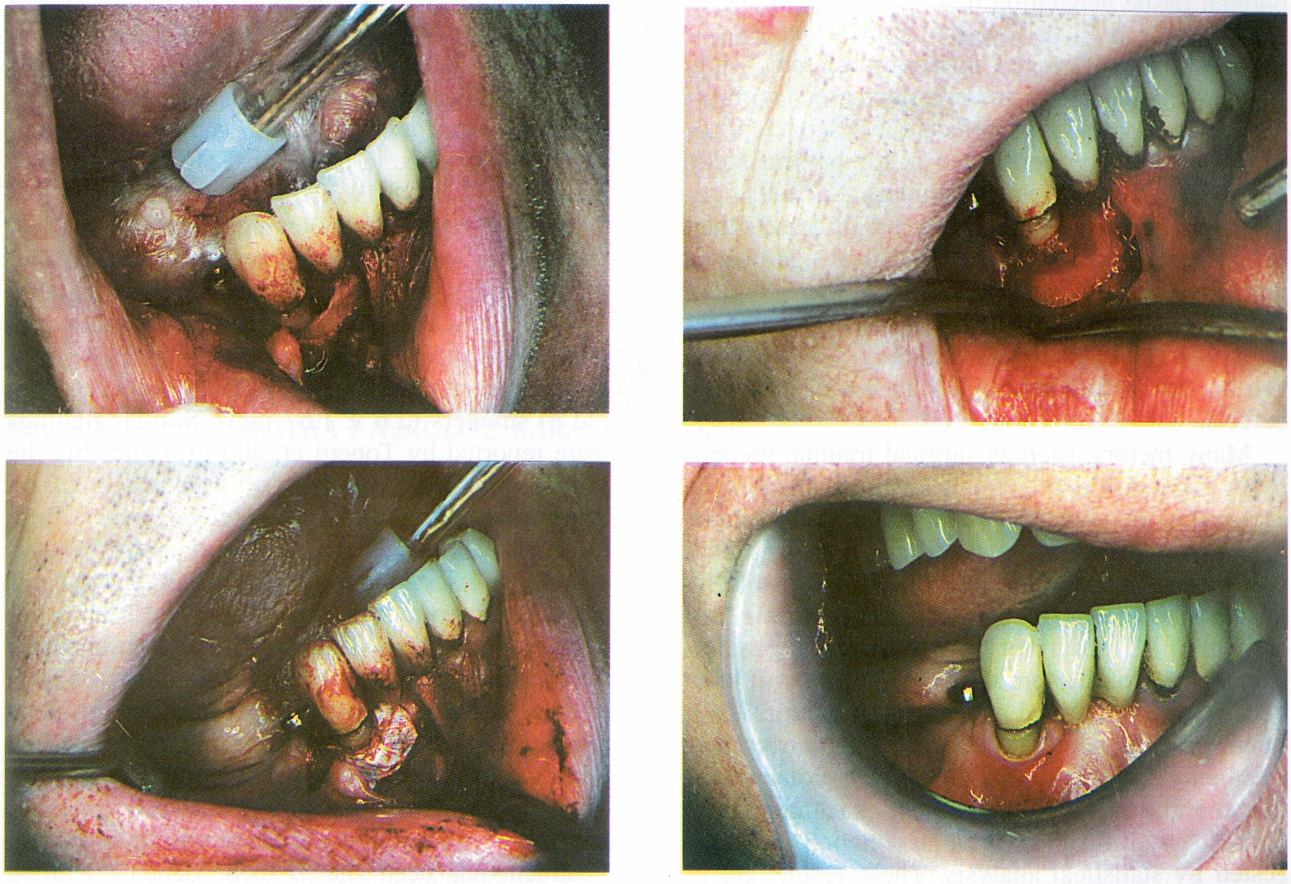
b) ePTFE membrana postavljena na koštani defekt

c) Defekt u potpunosti ispunjen s novim tkivom nakon odstranjenja membrane 5 tjedana postoperativno

d)Jednu godinu poslije zahvata povećanje pričvrstka za 2 mm. Recesija je povećana za 1 mm.

e) Rendgenološki je dokazano stvaranje nove kosti godinu dana poslije operacije. Usporedi oba rendgenograma

modality for intrabony defects even in patients showing suboptimal oral hygiene and various defect morphotypes. The variety of conditions and outcome encountered in clinical practice is illustrated by the two cases presented in Figure 6 and Figure 7.



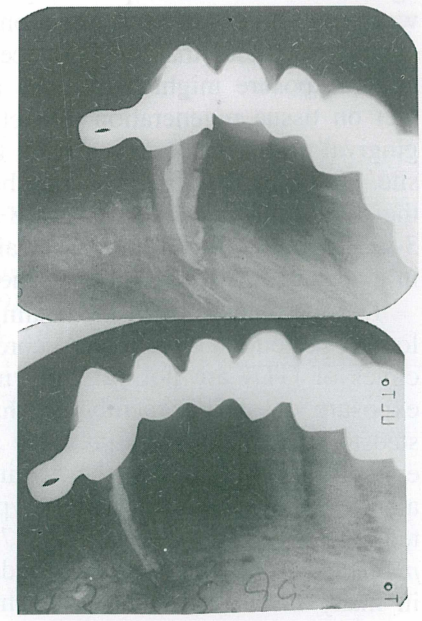


Figure 7. *a) Three osseous defect after flap elevation and removal of granulation tissue. Preoperative state presenting a 8 mm deep pocket and attachment loss of 9 mm at lower right canine*

b) PTFE membrane adapted over the defect following trimming

c) Defect completely filled by regenerated tissue after PTFE membrane removal 6 weeks post operatively

d) State one year postsurgically showing attachment gain of 5 mm. Note the healthy contour of the gingiva. Recession increased by 2 mm

e) Compare both radiograms regarding significant formation of new bone. Note the disappearance of root filling compound from the bone defect. Endo-Periocommunication proven in upper part of the picture

Slika 7. *a) Trozidni koštani defekt poslije odmicanja režnja i odstranjenja granulacijskog tkiva. Nalaz pokazuje 8 mm duboki džep i gubitak pričvrstka od 9 mm uz donji desni očnjak*

b) PTFE membrana postavljena preko defekta nakon čišćenja

c) Defekt u potpunosti ispunjen s novim tkivom nakon što je u 6 postoperativnom tjednu odstranjena PTFE membrana

d) Nalaz godinu dana poslije zahvata pokazuje pomicanje pričvrstka od 5 mm. Zdrav izgled gingive. Recesija povećana za 2 mm

e) usporedba oba rendgenograma potvrđuje značajno stvaranje nove kosti. Masa za pnjenje ne postoji više u koštanom defektu. Komunikaciju korijenskog kanala i parodontnog prostora dokazuje gornji rendgenogram.

Several factors such as the location and configuration of the defect have been suggested to influence clinical outcome of GTR treatment. Current clinical indications for the use of guided periodontal tissue generation include degree II furcation defects and 2- or 3-walled vertical interproximal and circumferential intrabony defects, while the predictability of success is decreased with other types of periodontal defects (25). Statistic analysis of association performed in the present study indicated that the amount of clinical attachment gain was greater in 2+3-wall- and 3-wall defects than in 1+2-wall defects, however, statistical significance was obtained only for the 6 months examination. Thus, our findings are in agreement with those reported by Becker and co-workers (7,8) who observed the best responses to GTR in 3-wall intrabony defects.

Many factors, such as surgical trauma, preoperative recession depth, tooth location, and plaque accumulation, give way to a variable amount of membrane exposure. At the time of the retrieval procedure, 11 patients showed exposure of the membrane exceeding 1 mm coronally to the gingival margin. Exposure of the membrane is generally supposed to interfere with the exclusion of epithelial cells and clinical attachment gain (26,27,28). In contrast, we found no negative relationship between exposure of the membrane at the time of retrieval and the amount of clinical attachment gain. Rather, a significant positive association was suggested by statistical analysis. These results are in agreement with those reported by Machtei and coworkers (29) in degree II furcation treatment. The authors concluded that gingival recession and membrane exposure might even have a beneficial effect on tissue regeneration via retracting cells of gingival origin further away from the regenerative site. However, our findings may be biased due to the occasional coincidence of the presence of 2-/3-wall defects which favour clinical attachment gain and marked exposure of the membrane.

Despite many efforts, the healing dynamics following periodontal treatment according to the principles of GTR are not yet fully understood. The exposure of ePTFE membranes has been suggested to be related to the presence and quantity of epithelium found within the healing defect beneath the membrane (30).This viewpoint is supported by histological observations (27,31; Bokan, *unpublished data*) who found attached epithelial cells in many instances. The relationship between the presence of epithelium and clinical response to treatment remains unclear.

Taking account of the literature and our own findings, we consider defect morphology and the depth of defect to be the more influential factors compared to the exposure of the membrane.

Besides defect morphology and surgical parameters, patient characteristics such as oral hygiene and smoking status have been shown to be paramount importance in terms of GTR treatment outcome (10,12,16,18,19,32). Smokers present a less favourable response following both non-surgical and surgical periodontal therapy (33,34,35). Although smoking status was not significantly associated with clinical attachment gain, non smokers presented better clinical results in terms of one-year clinical attachment gain (3.10 (1.60 mm) compared to smokers (2.6 ± 1.67 mm). Similar findings were reported by Tonetti et. al. (19) indicating the significant negative impact of smoking status on the clinical outcome following GTR procedure (18,19).

It is well documented that the level of oral hygiene is an important determinant of the healing response following both conventional and regenerative periodontal surgery (10,36). Rosling (36) observed that surgical treatment of intrabony pockets resulted in significant improvement in plaque-free dentitions, while progressive deterioration was noticed in plaque-infected individuals. In particular, the stability of periodontal support following GTR treatment has been shown to be dependent upon effective plaque-control (10,12,16,32). This relationship is supported by our findings. Statistical analysis revealed that the level of oral hygiene is, in fact, a decisive factor of treatment outcome following treatment with ePTFE membranes. Praticularly at the one-year follow -up, the amount of clinical attachment gained was markedly associated with the level of oral hygiene. The lower the mean PI score observed between baseline and one-year follow-up, the better was the maintenance of the clinical outcomes following GTR treatment.

Conclusion

The application of non-resorbable membranes according to the principles of guided tissue regeneration has become a routine procedure in everyday practice with predictable clinical improvements. The present study indicates that on average, satisfactory clinical outcome following GTR treat-

ment can be obtained even under suboptimal circumstances. The interplay of the factors mentioned leads, however, to considerable interindivuduval veriability of clinical outcome. Excellent results can be expected only in the presence of numerous favourable influences. On the other hand, various circumstances, i.e., combinations of influential factors, may result in a similar amount of clinical attachment gain. The two cases documented in Figure 6 and 7 underline this conclusion. In general, the gain of clinical attachment is clearly associated with the level of oral hygiene and - at least on the first months following surgery - with the intrabony depth and the configuration of the defect. Conflicting results in terms of the role of membrane exposure indicate that the dynamics of the healing process following GTR treatment have yet to be clarified.

KLINIČKI REZULTATI DOBIVENI UPOTREBOM ePTEF MEMBRANE U TERAPIJI VOĐENE REGENERACIJE TKIVA: STVARANJE PRIČVRSTKA I NJEGOVE KARAKTERISTIKE

Sažetak

Cilj ovog ispitivanja bio je utvrditi postojanje pričvrstka dobivenog GTR terapijom dubokih koštanih defekata i analizirati utjecaje različitih čimbenika na kliničke rezultate. 24 defekta kod 19 pacijenata tretirana su GTR terapijom pomoću ePTFE membrane. Klinička su mjerenja provedena na početku, 6, te 12 mjeseci nakon zahvata. GTR tretmanom se nakon 6 mjeseci postiže smanjenje dubine defekta ($x=3.8 \pm 1.5$ mm, $p=.0001$) i stvaranje pričvrstka ($x=2.6 \pm 1.5$ mm, $p=.001$). Uspjeh stvaranja pričvrstka promatran je ovisno o pacijentu, morfologiji defekta i kirurškim čimbenicima. Stvaranje pričvrstka značajno je povezano s dubinom koštanog defekta, konfiguracijom defekta i stupnjem oralne higijene.

Ključne riječi: *Vođena regeneracija tkiva, PTFE membrane*

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