J Clin Periodontol 2007; 34: 334–341 doi: 10.1111/j.1600-051X.2007.01051.x

Journal of Clinical Periodontology

Long-term effects of supportive therapy in periodontal patients treated with fibre retention osseous resective surgery. I: recurrence of pockets, bleeding on probing and tooth loss

Gianfranco Carnevale[1], Francesco Cairo[2] and Maurizio S. Tonetti[3]

[1]Private practice in Periodontology, Rome, Italy; [2]Department of Periodontology, University of Florence, Florence, Italy; [3]European Research Group on Periodontology, Department of Clinical Research, Medical Faculty, University of Berne, Switzerland

Carnevale G, Cairo F, Tonetti MS. Long-term effects of supportive therapy in periodontal patients treated with fibre retention osseous resective surgery. I: recurrence of pockets, bleeding on probing and tooth loss. J Clin Periodontol 2007; 34: 334–341. doi: 10.1111/j.1600-051X.2007.01051.x.

Abstract

Background: Periodontal surgery is indicated in the treatment of persistent pockets following cause-related therapy. The aim of this study was to evaluate the long-term effect of supportive therapy in periodontal patients treated with fibre retention osseous resective surgery.

Methods: Three-hundred and four consecutive patients were identified and retrospectively examined while presenting for a supportive periodontal care (SPC) appointment (T2). All had received non-surgical periodontal treatment and osseous resective surgery as needed, to obtain no sites with probing depth (PD) >3 mm before being enrolled in the SPC programme. The mean SPC duration for the patients was 7.8 ± 3.2 years while the mean interval of SPC was 3.4 ± 0.8 months.

Results: During SPC, a total of 67 teeth had been removed (0.9%). At T2, mean full-mouth plaque scores (FMPS) was $13 \pm 11.3\%$ and full-mouth bleeding scores (FMBS) was $2 \pm 3\%$. In 98.5% of the sites, PD was minimal ($\leqslant 3$ mm). The majority of pockets at T2 showed PDs of 4–5 mm (83.4% of pockets). At the same time, the total number of pockets $\geqslant 6$ mm was 68 and limited to 41 patients (13.8% of sample). Initial periodontal diagnosis of severe periodontitis, smoking habits, FMBS, number of teeth at completion of active periodontal therapy (T1), number of surgically treated teeth, number of teeth with furcation involvement and number of multi-rooted teeth were associated with the number of pockets at T2. A total of 598 sites (2.1%) displayed bleeding on probing (BOP) at T2. The odds ratio of sites 4 mm or deeper to be BOP positive was 32.9 compared with sites of <3 mm depth. Gender, FMBS, FMPS, furcation involvements and overall number of pockets were associated with the number of bleeding pockets at T2.

Conclusion: Shallow PDs achieved by treatment of the persistent pockets by fibre retention osseous resective surgery can be maintained over time. These patients displayed minimal gingival inflammation and tooth loss during SPC.

Key words: bleeding on probing; fibre retention; long-term effects; osseous resective therapy; periodontal therapy; pocket prevalence

Accepted for publication 13 December 2006

© 2007 The Authors. Journal compilation © 2007 Blackwell Munksgaard

Conflict of interest and source of funding statement

The authors declare that they have no conflict of interest.
The study was self-funded by the authors and their institutions.

The primary goal of periodontal therapy is to arrest the inflammatory disease process and to manage the possible risk factors associated with periodontal disease. Several clinical studies showed that cause-related therapy is effective when adequate plaque control is maintained (Westfelt et al. 1985). Periodontal surgery is generally indicated to treat deep pockets that responded less favourably to non-surgical treatment. Different surgical modalities have been proposed. Regenerative procedures are generally indicated for the treatment of deep intrabony defects (>3 mm; Tonetti et al. 1998a). Open-flap debridement or apically positioned flaps with or without bone recontouring are generally performed for the treatment of moderate to advanced periodontal lesions.

In the past years, several longitudinal studies have compared ''conservative'' *versus* ''resective'' approaches reporting no difference (Knowles et al. 1979, Becker et al. 2001) or higher pocket reduction for resective treatment (Townsend Olsen et al. 1985, Kaldahl et al. 1996a, b). Conflicting results were generally attributed to surgical techniques that were not clearly defined, to different endpoints of surgical treatment (attachment gain or pocket reduction) or to statistical analysis based on mean data that might hide residual pockets. Long-term studies also highlighted the importance of supportive periodontal care (SPC) following active therapy to maintain the clinical results irrespective of the specific surgical procedure performed (Rosling et al. 1976). On the contrary, in the absence of a regular SPC programme all surgical techniques were equally ineffective in preventing recurrence of periodontal destruction (Nyman et al. 1977).

During SPC, clinicians monitor the presence of pockets [sites with probing depths (PDs) >3 mm] and the presence of inflammation [bleeding on probing (BOP)]. These parameters are collected as proxy parameters of periodontitis progression and eventually precursors of tooth loss (Lang & Tonetti 1996).

The aim of this retrospective study was to evaluate the long-term effect of periodontal therapy in term of prevalence of pockets, BOP, BOP positive pockets and tooth loss in periodontal patients treated by fibre retention osseous resective surgery (FibReORS) and maintained for several years.

Materials and Methods

This was a retrospective study on the effect of periodontal therapy following the completion of active periodontal therapy (APT) and after the last SPC visit. The population consisted of consecutive patients recruited during routine SPC visits in a private periodontal office. All patients had received APT delivered by a single clinician (G. C.) and had a minimum set of periodontal parameters recorded at least three times: at the original consultation (T0), at the first SPC visit following the completion of APT (T1) and at the latest clinical session of SPC (T2).

Experimental population

The population consisted of patients referred for the treatment of periodontal disease in a private office of periodontology. All patients had:

(1) APT performed with non-surgical treatment and at least one periodontal surgical procedure.
(2) Completed APT and at least 3 years participation in the SPC programme.
(3) Less than 20% full-mouth plaque scores (FMPS), no periodontal site with BOP or PD >3 mm at the first SPC visit following the completion of APT (T1).
(4) No contributory medical history recorded at time T0, T1 and T2, and in particular no medical diagnosis of diabetes mellitus, or use of immune-depressant, anti-epileptic and calcium antagonistic drugs.
(5) Availability of complete clinical records including periodontal probing and diagnostic quality radiographs.

The final sample included 304 patients, 193 females and 111 males, between 25 and 85 years of age (52 ± 10.3 years) who satisfied all the above criteria. All patients indicated their acceptance to participate in the study by signing an informed consent.

Clinical evaluation

PD was measured at four sites per tooth (buccal, lingual, deepest mesial and distal) using an UNC-15 periodontal probe and recorded in a periodontal chart. Dental plaque and BOP were also dichotomously evaluated at four sites per tooth. FMPS and full-mouth bleeding scores (FMBS) were then calculated. Furcation involvements were recorded by using a Nabers 2 probe. All measurements were performed at T0, T1 and T2. A set of full mouth dental radiographs was present for each patient to evaluate residual bone support at the time T0 and T1.

On the basis of clinical chartings and dental radiographs, patients were retrospectively classified as suffering at T0 from gingivitis, mild, moderate or severe periodontitis, according to the American Dental Association (ADA) case type classification.

Treatment

Following the initial examination (T0), all patients received cause-related therapy, including oral hygiene motivation and instruction, coronal and subgingival scaling, as needed. At the revaluation after cause-related therapy, surgical procedures were planned, where needed, in order to achieve pocket elimination in each site with PD $\geqslant 4$ mm. Periodontal surgery consisted only of apically positioned flaps with FibReORS (Carnevale 2007). All surgical procedures were performed by the same operator (G. C.), with more than 10 years of experience in periodontology. APT included operative, endodontic and prosthetic treatment as necessary. Following the completion of APT, patients were placed in an SPC programme with a dental hygienist and at the first SPC visit clinical data were recollected (T1).

SPC programme

Each SPC session consisted of a 60 min. appointment and included an initial diagnostic phase (medical history, dental diagnosis, periodontal parameters) and a re-motivation of the patient. A full-mouth professional prophylaxis and a cautious subgingival debridement in all sites were also accomplished. During SPC any additional periodontal, prosthetic, endodontic and operative treatment or tooth extraction performed was recorded in the clinical chart.

© 2007 The Authors. Journal compilation © 2007 Blackwell Munksgaard

Data collection

Based on the clinical records and interview, the following variables were collected at the latest SPC visit (T2) and considered for statistical analysis.

- Gender
- Age
- Initial periodontal diagnosis (ADA case type)
- Smoking habits (self reported as current, former or never smoker)
- Surgical/non-surgical treatment
- Prosthetic abutment
- Duration of SPC (time in years of participation in recall programme)
- Interval of SPC (average interval in months defined as duration of SPC divided by number of appointments)
- Tooth loss
- Furcation involvements
- Number of pockets 4–5, 6–7 and $\geqslant 8$ mm deep
- Number of bleeding pockets 4–5, 6–7 and $\geqslant 8$ mm deep
- FMPS
- FMBS

Data management and statistical analysis

After proofing for entry errors, the database was locked and loaded in SAS format (Statistical Application Software; SAS Institute; Cary, NC). All calculations were performed using SAS version 8.1. Descriptive statistics included calculation of averages and standard deviations. Significance of difference between groups was tested with unpaired parametric (normally distributed continuous variables) or non-parametric (non-normally distributed data or frequencies) tests. Comparisons within the same group were performed with paired tests. For all analysis, significance was set at 0.05. Multivariate analysis (general linear models procedure) was also performed to evaluate the possible influence of clinical variables on the number of pockets and pockets with BOP at the last SPC visit.

Results

The sample included 304 periodontal patients, 193 females (63%); the mean age was 52 ± 10.3 years; 37% of patients were smokers and 27% former smokers.

Initial periodontal diagnosis was retrospectively classified for each patient at T0 according to the ADA case type classification. One percent of the patients had gingivitis (ADA case type 1); 13% had mild periodontitis (ADA case type 2); 45% had moderate periodontitis (ADA case type 3); 41% had severe periodontitis (ADA case type 4; Fig. 1). In the 87% of the patients, periodontal lesions were generalized with at least two involved sextants. For each patient, several appointments for causal-related therapy (oral hygiene motivation and instruction, coronal and subgingival scaling under local anaesthesia as needed) were scheduled to minimize the plaque accumulation and presence of BOP. One to 2 months following the last appointment, a periodontal revaluation was performed. In each site where PD was $\geqslant 4$ mm, an apically positioned flap with FibReORS was performed. Surgical procedures were performed at 3510 teeth (49% of the sample). At the first SPC visit (T1), clinical data were recollected.

The SPC programme had a mean duration of 93.8 months ($\pm$ 38.8), ranging from 36 (3 years) to 204 months (17 years). The mean frequency of SPC recall was 3.4 months ($\pm$ 0.8), ranging from 0.9 to 12 months. All the patients were divided into three groups considering the time in SPC. In group 1 (110 patients) the recall time ranged from 36 to 75 months; the mean was 52 months ($\pm$ 13.7; $\sim$4.3 years). In group 2 (102 patients) the recall time ranged from 76 to 119 months; the mean was 96 months ($\pm$ 13.1; $\sim$8 years). In group 3 (92 patients) the recall time ranged from 120 to 204 months; the mean was 140 months ($\pm$ 19.1; $\sim$11.6 years).

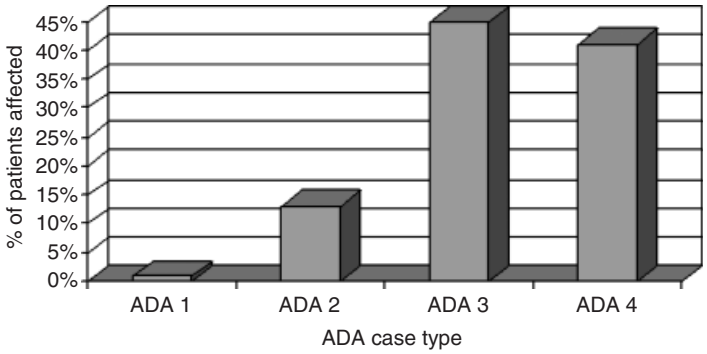

Fig. 1. Initial periodontal diagnosis classified according to American Dental Association case type classification.

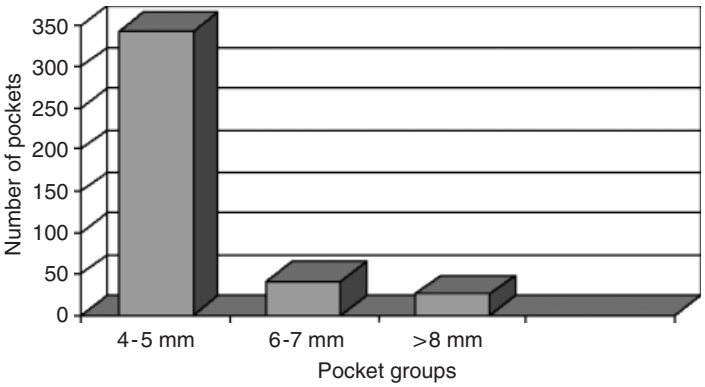

Fig. 2. Prevalence of pockets at the last SPC visit.

Prevalence of pockets at the last SPC visit

At T2 a total of 28,212 sites were reanalysed. Mean FMPS was 13% ($\pm$ 11.3) and mean FMBS 2% ($\pm$ 3). The majority of sites showed a PD $\leqslant 3$ mm (27,802 sites, corresponding to 98.5% of the total sites); 410 sites (1.5% of the total sites) showed PD > 3 mm; 342 sites showed a PD of 4–5 mm (1.2% of the total sites, 83.4% of the pockets), 42 sites (0.1% of total sites, 10.2% of the pockets) had PD between 6 and

© 2007 The Authors. Journal compilation © 2007 Blackwell Munksgaard

7 mm, 26 sites (0.1% of the total sites, 6.3% of the pockets) showed PD ⩾ 8 mm (Fig. 2).

The majority of pockets (59.8%) were localized at prosthetic abutments (2.5% of 9952 sites at prosthetic abutments) while 40.2% at natural teeth (0.9% of 18,360 sites at natural teeth); 313 pockets (76.3%) were localized at surgically treated teeth (2.3% of 13,840 sites at surgicallytreated teeth) and 97 pockets (23.7%) at non-surgically treated teeth (0.7% of 14,372 sites at non-surgically treated teeth); 198 pockets were localized at single-rooted teeth (0.9% of 21,188 total sites), 212 pockets at multi-rooted teeth (3.1% of 6948 total sites) and 41 pockets at furcated molars (53.9% of 76 total sites).

The 410 recurrent pockets were distributed in 137 patients (45.1% of the sample). Pockets with PD ⩾ 6 mm were detected in only 41 patients (13.8% of patients). These deep pockets were in 82% of the cases (58 pockets) at prosthetic abutments and 18% (12 pockets) at natural teeth. The odds ratio for prosthetic abutments to show pocket ⩾ 6 mm was 4.8 compared with natural teeth.

The distribution of pockets at the last SPC visit was also analysed considering initial periodontal diagnosis according to ADA case type. No pocket in previously ADA case type 1 was detected, 38 pockets in previously ADA type 2 cases (1% of sites; 0.97 pocket/patient), 116 pockets in previously ADA type 3 cases (0.86% of sites; 0.83 pocket/patient), 256 pockets in previously ADA type 4 cases (2.39% of sites; 2.06 pocket/patient). This distribution of pockets at T2 was also examined considering three subgroups of pockets (Table 1).

Pockets distribution at T2 was also examined assessing the mean time in SPC programme. In group 1 (110 patients, mean recall time 4.3 years) 115 pockets were detected in a total of 10,404 sites (1.10%; amounting to an incidence of 0.24 pocket/patient per year of SPC). In group 2 (102 patients, mean recall time ~ 8 years) 147 pockets were detected in a total of 9236 sites (1.59%; 0.18 pocket/patient per year). In group 3 (92 patients, mean recall 11.6 years) 148 pockets were reported in a total of 8572 sites (1.77%; 0.14 pocket/patient per year). No significant difference in the incidence of pockets was observed comparing these three groups. The distribution of pocket types considering the different subgroups of maintenance is represented in Table 2.

Table 1. Distribution of pockets at T2 considering three subgroups of pockets and the initial ADA case type

	ADA 1 at T0 (2 patients)	ADA 2 at T0 (39 patients)	ADA 3 at T0 (139 patients)	ADA 4 at T0 (124 patients)
Total sites at T2	212	3872	13,456	10,672
PD 4–5 mm	0	35 (0.9%)	91 (0.67%)	216 (2.02%)
PD 6–7 mm	0	2 (0.05%)	11 (0.08%)	29 (0.27%)
PD > 8 mm	0	1 (0.02%)	14 (0.1%)	11 (0.1%)
Total pockets	0	38 (1%)	116 (0.86%)	256 (2.39%)

PD, probing depth; ADA, American Dental Association.

Table 2. Distribution of pockets with different probing depths at T2 by length of participation into SPC program

	Group 1 (110 patients, mean recall time ~ 4.3 years)	Group 2 (102 patients, mean recall time ~ 8 years)	Group 3 (92 patients, mean recall ~ 11.6 years)
Total sites	10404	9236	8572
PD 4–5 mm	98 (0.94%)	120 (1.3%)	124 (1.45%)
PD 6–7 mm	10 (0.1%)	11 (0.12%)	21 (0.24%)
PD > 8 mm	7 (0.07%)	16 (0.17%)	3 (0.03%)
Total pockets	115 (1.11%)	147 (1.59%)	148 (1.77%)

PD, probing depth.

Table 3. Multivariate analysis explaining the number of pockets (PD > 3 mm) at T2

Independent variables	Parameter estimate	T for H_0	Probability
Intercept	2.857	2.74	0.006
Periodontal diagnosis (case 4/case2)	− 1.168	− 3.14	**0.0019**
Periodontal diagnosis (case 4/case3)	− 0.822	− 3.35	**0.0009**
Smoking habits	− 0.797	− 3.43	**0.0007**
Gender	− 0.414	− 1.77	0.0778
Age	− 0.022	− 1.87	0.0629
FMBS at T2	0.297	7.52	**0.0001**
FMPS at T2	− 0.009	− 0.89	0.3740
Tooth loss during SPC	− 0.113	− 0.67	0.5032
Tooth survival at T2	− 0.085	− 1.97	**0.0493**
Time on SPC	0.010	− 0.67	0.503
Surgical treatment (yes/no)	0.080	3.08	**0.0023**
Prosthetic abutments at T1	− 0.001	− 0.05	0.96
Furcation involvements	1.463	4.96	**0.0001**
Multi-rooted teeth	0.184	2.21	**0.0277**

This model was significant ($p < 0.0001$) and explained 35% of variability in the number of pockets. PD, probing depth; FMBS, full-mouth bleeding scores; FMPS, full-mouth plaque scores; SPC, supportive periodontal care.
Statistically significant values are given in bold.

A multivariate analysis was performed to identify parameters associated with the number of pockets at T2. This significant model ($p < 0.0001$; R^2 0.359) demonstrated that initial periodontal diagnosis of severe periodontitis (case type 4), smoking habit, FMBS, number of teeth at T1, number of surgically treated teeth, presence of furcation involvement and multi-rooted teeth were associated with the number of pockets at T2 (Table 3).

BOP at the last SPC visit

At T2 a total of 598 sites displayed the presence of BOP (2.1% of the overall sites). Four-hundred and six sites with PD ⩽ 3 mm were BOP positive (1.4% of the total sites and 1.5% of the sites with PD ⩽ 3 mm). One-hundred and ninety-two sites with PD > 3 mm showed presence of BOP at T2. This represented

© 2007 The Authors. Journal compilation © 2007 Blackwell Munksgaard

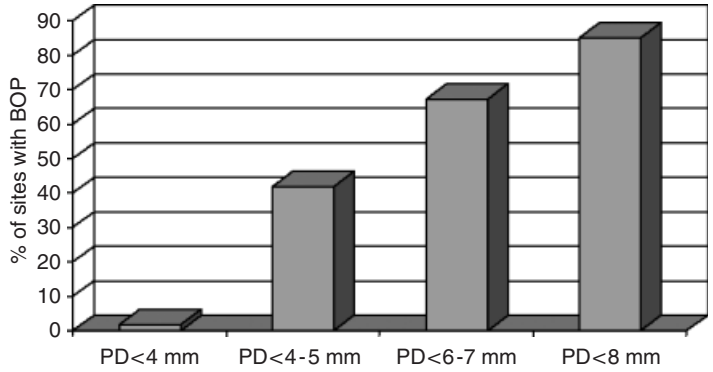

Fig. 3. Prevalence of BOP at different pocket groups at T2.

Table 4. Multivariate analysis explaining the number of BOP positive pockets (PD > 3 mm) at T2

Independent variables	Parameter estimate	T for H_0	Probability
Intercept	0.093	0.22	0.823
Smoking habits	− 0.12	− 1.37	0.172
Sex	− 0.21	− 2.27	**0.024**
Age	0.0001	0.04	0.971
FMBS at T2	0.160	9.40	**0.0001**
FMPS at T2	0.010	− 2.50	**0.013**
Time in SPC	− 0.003	− 1.03	0.303
Teeth loss during SPC	− 0.109	− 1.63	0.103
Teeth at T1	0.01	0.61	0.545
Surgical treatment (yes/no)	− 0.006	− 0.62	0.535
Prosthetic abutments at T1	0.004	0.41	0.684
Furcation involvements	− 0.259	− 2.14	**0.033**
Number of pockets	0.417	17.96	**0.0001**

This model was significant ($p < 0.0001$) and explained 74% of variability in the number of BOP positive pockets.
PD, probing depth; FMBS, full-mouth bleeding scores; FMPS, full-mouth plaque scores; SPC, supportive periodontal care; BOP, bleeding on probing.
Statistically significant values are given in bold.

46.8% of total pockets and 0.7% of the overall sites at T2.

One-hundred and forty-two pockets with PD 4–5 mm at T2 demonstrated the presence of BOP (41.5% of the subgroup 4–5 mm pockets at T2); 28 pockets with PD 6–7 mm at T2 were BOP associated (66.7% of the subgroup 6–7 mm pockets at T2); 22 pockets with PD ⩾ 8 mm at T2 showed BOP (84.6% of the subgroup ⩾ 8 mm pockets at T2; Fig. 3). The difference in the rate of BOP-positive pockets among the three groups based on PD depth was highly significant and indicated a dose-dependent effect of PD on the BOP rates of pockets.

The probability of having BOP in pockets ⩾ 8 mm was about twice that of the 4–5 mm ones (odds ratio = 2, Mantel Hansel χ^2: $p < 0.0001$). Moreover, the odds ratio for BOP at sites with PD > 3 mm was 32.9 times that of sites with PD ⩽ 3 mm.

A multivariate analysis was then performed to identify parameters associated with the number of bleeding pockets (PD > 3 mm) at T2. This highly significant model ($p < 0.0001$, $R^2 = 0.736$) indicated that gender (male), FMBS, FMPS, furcation involvements and the overall number of pockets were associated with the presence of BOP in pockets (Table 4).

Tooth loss

During APT, 576 teeth were extracted in these patients [7.5% of the original sample; 1.9 teeth/patient, (± 2.5)]. Tooth extraction showed a higher prevalence in ADA case 3 (26.5%) and ADA case 4 type (63.7%). The main reason for tooth extraction during APT was the presence of advanced periodontal lesions (44%).

During SPT, a total of 67 teeth were removed (0.9% of total teeth and corresponding to 0.22 ± 0.6 teeth/patient). Tooth extractions were limited to a subgroup of 50 patients (16% of the patients in SPC). The clinical problems for teeth extracted during the SPC programme were first related to the incidence of root fracture (48%) and second to the progression of periodontal disease (30%). In the total number of teeth lost during maintenance, 50 (74% of teeth lost during SPC) were surgically treated during APT and 17 were treated with non-surgical therapy only; 60 teeth were prosthetic abutments and represented 2.38% of the total sample of prosthetic abutments at T1. When analysing for initial ADA case type, no teeth were lost in previous ADA case 1, two teeth (0.2%) in previous ADA case 2, 23 teeth (0.67%) in previous ADA case 3 and 42 teeth (1.54%) in previous ADA case 4 (Table 5).

Table 5. Summary of tooth survival from baseline (T0), first SPC visit (T1) and last SPC visit (T2) considering the initial periodontal diagnosis

	T0	T1	T2
ADA 1	55	53	53
ADA 2	1022	970	968
ADA 3	3542	3387	3364
ADA 4	3077	2710	2668
Total	7696	7120	7053

ADA, American Dental Association; SPC, supportive periodontal care.

When combining tooth extraction during APT and SPC, a cumulative tooth loss of 8.3% was observed. Specific data analysis on tooth loss are reported in a companion paper (Carnevale et al. 2007)

Discussion

The long-term benefits of participating in an individual SPC programme at the end of active therapy have been firmly established (Axelsson & Lindhe 1981, Axelsson et al. 2004). These include reductions in the rate of periodontitis progression and tooth loss (Lindhe & Nyman 1984, Tonetti et al. 2000). The incomplete adherence of a significant segment of the patient population to the recommended regimen, however, is a well-identified problem that is still subject of active investigations (Mendoza et al. 1991, Wilson et al. 1987, Fardal et al. 2004, Fardal & Linden 2005).

© 2007 The Authors. Journal compilation © 2007 Blackwell Munksgaard

The main finding of this study was that this well-maintained and compliant patient population had a very low rate of periodontitis recurrence and tooth loss, 3–17 years following completion of APT. Deep recurrent pockets (PD $\geqslant$6 mm) were detected at T2 in a minority of patients (13.8%) and only 16% of subjects experienced tooth loss during SPC. Given the retrospective design of this study, these results do not apply to the non-compliant portion of the population that discontinued participation into the SPC programme and a degree of possible bias must be kept in mind while interpreting the results.

In this study, initial periodontal examination demonstrated a high prevalence of severe periodontitis cases (40.8% of patients) of which 95% showed generalized lesions. The applied treatment approach was aimed at obtaining minimal plaque accumulation, absence of BOP and sites with PD $\leqslant$3 mm. Cause-related therapy was able to reduce PD at 51% of the overall teeth in this group of patients. In sites where PD was $\geqslant$4 mm at revaluation, a surgical treatment was planned. While the presence and/or depth of residual pockets as an absolute indication for surgical treatment is still a controversial topic, Claffey & Egelberg (1995) analysed the use of clinical parameters for prediction of future attachment loss in a population treated for chronic periodontitis with non-surgical therapy. The authors identified a significant correlation between residual PD $\geqslant$6 mm and the risk of loss of attachment at 3 months. Grbic & Lamster (1992) tested different risk indicators for future attachment loss in non-surgically treated patients. The hazard ratio demonstrated a progressive increase in the risk of future attachment loss at an increasing level of PD at 6 months. Sites with PD$\geqslant$8 mm had a significantly higher hazard rate compared with sites with 4–7 mm of depth. Pockets with 4–7 mm of depth had a significantly greater hazard rate when compared with sites with PD $\leqslant$3 mm, which showed minimal risk for attachment loss.

In the present material, surgical treatment was aimed at obtaining a PD $\leqslant$3 mm in all sites. The selected surgical treatment was an apically positioned flap with osseous resective surgery aimed at eliminating defects and restoring a positive bony architecture. In this material, a single application of the treatment allowed reduction of pocket probing depth to $<$4 mm in the absence of BOP. This technique has been associated with achievement of the best clinical results in terms of pocket-depth reduction in the short (Smith et al. 1980, Kaldahl et al. 1988) and long period (Townsend Olsen et al. 1985, Kaldahl et al. 1996a). In the Nebraska study, sites treated with this approach and maintained over time showed a lower incidence of recurrent periodontal breakdown when compared with sites treated with different, more conservative techniques (Kaldahl et al. 1996b). Furthermore, pockets treated with apically positioned flap and bone recontouring showed effective eradication of *Porphyromonas gingivalis* and *Actinobacillus actinomycetemcomitans* when compared with sites treated with a similar approach without osseous resection (Tuan et al. 2000). Moreover, a surgical procedure with soft tissue resection allows the reformation of a regenerated gingival unit with smaller inflammatory infiltrate compared with an open-flap procedure at 6 months. This histological finding was similarly demonstrated following stringent maintenance (Zitzmann et al. 2005a) and experimental gingivitis conditions (Zitzmann et al. 2005b).

In the present study, the osseous resective technique was applied in conjunction with fibre retention (FibReORS), shifting the bottom of the defect in a more coronal position at the level of the connective tissue attachment. This approach considers mineralized and non-mineralized connective tissue as a unit and changes the classical vision of the osseous defect resulting in more conservative removal of supportive bone (Carnevale 2007). In this sample of patients, at the end of active therapy, this technique was able to achieve minimal PD at all sites. During the maintenance phase, a stringent control was performed (mean recall frequency: 3.4 $\pm$ 0.8 months) and at T2 a minimal prevalence of FMPS (13% $\pm$ 11.3) and FMBS (2% $\pm$ 3) was detected.

At the experimental examination (T2), the vast majority of sites were shallow (98.5%) and the prevalence of pockets was minimal with few, isolated 4–5 mm pockets detected in 82% of cases. The total number of pockets $\geqslant$6 mm at T2 was very small (68 pockets) and distributed in 41 patients (13.8% of sample). This finding confirms that recurrent periodontal disease is clustered in few patients when a stringent regimen of maintenance care is performed.

Concerns about the validity and external applicability of these results need to be addressed. Even though no formal assessment of the representativeness of the population has been performed, these data report on consecutive patients treated by a single periodontist operating in a perio-restorative practice. Applicability to other settings and multiple clinicians has not been examined.

In this study, after a mean of 7.8 years of SPC, the prevalence of pockets (1.5% of the total sites) was smaller than those reported by other long-term surveys with similar design. Konig et al. (2002), reported 33% of sites with PD $>$4 mm after a mean of 8 years of SPC; Tonetti et al. (1998a, b) described an average of 18.7% of sites with PD $\geqslant$4 mm following a mean of 5.6 years of maintenance. Few possible reasons for this 10-fold difference must be considered: (i) A different severity and/or extent of periodontitis at baseline; (ii) a different risk profile of the population; (iii) possible differences in the SPC regimen; (iv) possible different attrition rates in the SPC programmes leading to different degrees of recruitment bias; (v) different skills of the operators; (vi) differences in the proportion of teeth extracted during APT; and (vii) differences in the objectives and type of surgical treatment performed. The design of the present study does not allow a definitive answer to these questions. Nevertheless, comparisons of this population with those reported by Tonetti et al. (1998b) and Konig et al. (2002) do not support the concept that this population had milder periodontitis or a lower baseline risk profile, and the SPC regimens employed at the periodontal clinic of the University of Berne (Tonetti et al. 1998b) and in this study were very similar. A companion paper will discuss in detail the possible bias arising from the different proportion of teeth extracted during APT in this study and in others (Carnevale et al. 2007).

In this study, one of the objectives of surgical treatment was the achievement of minimal PD allowing easier and more effective oral hygiene procedures during the maintenance programme. In other studies (Tonetti et al. 1998b, Konig et al. 2002) the selected surgical approach was a more ''conservative'' one (modified Widman flap procedure) that in general did not achieve shallow

© 2007 The Authors. Journal compilation © 2007 Blackwell Munksgaard

PD at all sites in a given patient before the beginning of SPC. It is suggested that this difference may be the critical element differentiating the results obtained in this study.

A multivariate analysis showed that initial periodontal diagnosis of severe periodontitis, smoking habits, FMBS, number of teeth at T1, number of surgically treated teeth, presence of furcation involvements and multi-rooted teeth were associated with the presence of pockets at T2. However, this model was able to explain only a small portion of the variability observed in the recurrence of pockets and other, possibly unknown factors may be associated with a significant portion of this variability. Interestingly, statistical analysis did not show any correlation between time on SPC and recurrence of pockets. This finding may be related to the type of maintenance protocol. In each SPC visit a full-mouth professional prophylaxis and a cautious subgingival debridement of all sites were performed.

Absence of BOP during SPC is considered a highly predictable indicator of periodontal stability (Lang et al. 1990). On the other hand, repeated presence of BOP during maintenance may predict further attachment loss (Baderstein et al. 1985, Claffey et al. 1990, Lang et al. 1990). Moreover, the presence of deep bleeding pockets is associated with an increased risk-progression of periodontal disease (Armitage 1996). In this study, a minimal amount of sites displaying BOP (2.12%) was reported at T2. In contrast, pockets were very frequently associated at T2 with the presence of BOP (46.8% of total pockets at T2). This finding is in agreement with previous data (Tonetti et al. 1998b). A progressive increase in the prevalence of BOP with increasing depth of probing was detected. Pockets $\geqslant 8$ mm showed an odds ratio of 2 for the presence of BOP when compared with 4–5 mm pockets. Moreover, the odds ratio for BOP in sites with PD > 3 mm was about 33 times that of sites with PD $\leqslant 3$ mm. A multivariate analysis demonstrated that gender, FMBS, FMPS, furcation involvements and overall number of pockets were associated with the presence of BOP in sites with PD > 3 mm.

It has been hypothesized that a different susceptibility to comparable plaque accumulation may exist among individuals showing gingivitis (Trombelli et al. 2004). Moreover, other authors reported a high level of plaque in periodontal patients during SPC or a reduced number of compliant patients over time (Wilson et al. 1987, Mendoza et al. 1991). The results of this study indicated that gingival inflammation can be minimal, irrespective to the possible individual risk pattern, in highly compliant patients treated with supragingival prophylaxis and regular cautious subgingival debridement during SPC.

Long-term tooth retention is a fundamental objective of periodontal therapy. In this study, the prevalence of tooth extraction during APT (7.5%) was higher than that reported by others (4.8% from Tonetti et al. 2000 and 4.9% from Konig et al. 2002). This finding may be due to: (i) the high prevalence of severe periodontal case type in this group of patients; (ii) the need to extract more severely compromised teeth in order to achieve shallow pockets; and/or (iii) the choice of different options in treatment plan. During SPC tooth extractions were minimal (0.9%), lesser than other long-term reports (Tonetti et al. 2000, Konig et al. 2002) and mainly due to root fracture. A smaller number of teeth were extracted due to progression of periodontal disease, as previously reported in other studies (Tonetti et al. 2000 and Cattabriga et al. 2001).

The definition of success in periodontal therapy is a controversial matter. Recently, some authors have re-focused the attention on tooth survival as the main endpoint to assess efficacy of periodontal therapy (Hujoel 2004, Greenstein 2005) because it is the most tangible clinical effect for the patient (true endpoint). Primary endpoints of therapy should be distinguished by surrogate endpoints, indicators of periodontal health and proxy measures of the true endpoint but untangible for the patient. Different surrogate variables have been applied in periodontal studies for measuring success of the treatment and this has often led to a difficult comparison of treatment outcomes. In this study, preestablished endpoints of therapy were: tooth retention over time with negligible gingival inflammation and minimal pocket depth. The outcomes of this study indicate that tooth loss in periodontal patients is minimal if stringent SPC is performed and the reduction of pocket depth to a physiological measure following active therapy is stable over time.

References

Armitage, G. (1996) Periodontal disease: diagnosis. *Annals of Periodontology* **1**, 37–215.

Axelsson, P. & Lindhe, J. (1981) Effect of controlled oral hygiene procedures on caries and periodontal disease in adults. Results after 6 years. *Journal of Clinical Periodontology* **8**, 239–248.

Axelsson, P., Nystrom, B. & Lindhe, J. (2004) The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults. Results after 30 years. *Journal of Clinical Periodontology* **31**, 749–757.

Baderstein, A., Nilveus, R. & Egelberg, J. (1985) Effect of non surgical periodontal therapy. (VII) bleeding, suppuration and probing depths in sites with probing attachment loss. *Journal of Clinical Periodontology* **12**, 432–440.

Becker, W., Becker, B., Caffesse, R., Kerry, G., Ochseinbein, C., Morrison, E. & Prischard, J. (2001) A longitudinal study comparing scaling, osseous surgery, and modified Widman procedures: results after 5 years. *Journal of Periodontology* **72**, 1675–1684.

Carnevale, G. (2007) Fibre retention osseous resective surgery. A novel conservative approach for pocket elimination. *Journal of Clinical Periodontology* **34**, 182–187.

Carnevale, G., Cairo, F. & Tonetti, M. S. (2007) Long-term effects of supportive therapy in periodontal patients treated with fibre retention osseous resective surgery. II. Tooth extractions during active and supportive therapy. *Journal of Clinical Periodontology* **34**, 342–348.

Cattabriga, M., Rotundo, R., Muzzi, L., Nieri, M., Verrocchi, G., Cairo, F. & Pini Prato, G. (2001) Retrospective evaluation of influence of il-1 genotype on radiographic bone levels in treated periodontal patients maintained over 10 years. *Journal of Periodontology* **72**, 767–773.

Claffey, N. & Egelberg, J. (1995) Clinical indicators of probing attachment loss following initial periodontal treatment in advanced periodontitis patients. *Journal of Clinical Periodontology* **22**, 690–696.

Claffey, N., Nylund, K., Kiger, R., Garrett, S. & Egelberg, J. (1990) Diagnostic predictability of scores of plaque, bleeding, suppuration, and probing depths for probing attachment loss. 3 1/2 years of observation following therapy. *Journal of Clinical Periodontology* **17**, 108–114.

Fardal, Ø., Johannensen, A. C. & Linden, G. J. (2004) Tooth loss during maintenance following periodontal treatment in a periodontal practice in Norway. *Journal of Clinical Periodontology* **31**, 550–555.

Fardal, Ø. & Linden, G. J. (2005) Re-treatment profiles during long-term maintenance therapy in a periodontal practice in Norway. *Journal of Clinical Periodontology* **32**, 744–749.

Grbic, J. & Lamster, I. (1992) Risk indicators for future clinical attachment loss in adult

© 2007 The Authors. Journal compilation © 2007 Blackwell Munksgaard

periodontitis. Tooth and site variables. *Journal of Periodontology* **63**, 262–269.
Greenstein, G. (2005) The use of surrogate variables to reflect the long-term tooth survivability. *Journal of Periodontology* **76**, 1398–1402.
Hujoel, P. (2004) Endpoints in periodontal trials: the need for an evidence-based research approach. *Periodontology 2000* **36**, 196–204.
Kaldahl, W., Kalkwarf, K., Patil, K., Molvar, M. & Deyr, J. (1996a) Long-term evaluation of periodontal therapy. I. Response to 4 therapeutic modalities. *Journal of Periodontology* **67**, 93–102.
Kaldahl, W., Kalkwarf, K., Patil, K., Molvar, M. & Deyr, J. (1996b) Long-term evaluation of periodontal therapy. II. Incidence of sites breaking down. *Journal of Periodontology* **67**, 103–108.
Kaldahl, W., Kalkwarf, K., Patil, K., Molvar, M., Deyr, J. & Bates, R. (1988) Evaluation of four modalities of periodontal therapy: mean probing depth, probing attachment level and recession changes. *Journal of Periodontology* **59**, 783–793.
Knowles, J., Burgitt, F., Nissle, R., Shick, R., Morrison, E. & Ramfjord, S. (1979) Results of periodontal treatment related to pocket depth and attachment level. Eight years. *Journal of Periodontology* **50**, 225–233.
Konig, J., Plagmann, H. C., Ruhling, A. & Kocher, T. (2002) Tooth loss and pocket probing depths in compliant periodontally treated patients: a retrospective analysis. *Journal of Clinical Periodontology* **29**, 1092–1110.
Lang, N., Adler, R., Joss, A. & Nyman, S. (1990) Absence of bleeding on probing. An indicator of periodontal stability. *Journal of Clinical Periodontology* **17**, 714–721.
Lang, N. & Tonetti, M. (1996) Periodontal diagnosis in treated periodontitis. Why, when and how to use clinical parameters. *Journal of Clinical Periodontology* **23**, 240–250.
Lindhe, J. & Nyman, S. (1984) Long-term maintenance of patients treated for advanced periodontal disease. *Journal of Clinical Periodontology* **11**, 504–511.
Mendoza, A., Newcomb, G. & Nixon, K. (1991) Compliance with supportive periodontal therapy. *Journal of Periodontology* **62**, 731–736.
Nyman, S., Lindhe, J. & Rosling, B. (1977) Periodontal surgery in plaque – infected dentitions. *Journal of Clinical Periodontology* **4**, 240–249.
Rosling, B., Nyman, S., Lindhe, J. & Jern, B. (1976) The healing potential of periodontal tissue following different techniques of periodontal surgery in plaque-free dentitions. *Journal of Clinical Periodontology* **3**, 233–250.
Smith, D., Ammons, W. & van Belle, G. (1980) Longitudinal study of periodontal status comparing osseous recontouring with flap curettage. *Journal of Periodontology* **51**, 367–375.
Tonetti, M., Cortellini, P., Suvan, J. et al. (1998a) Generalizability of the added benefits of the guided tissue regeneration in the treatment of the deep infrabony defects. Evaluation in multi-center randomized controlled split mouth study. *Journal of Periodontology* **69**, 1183–1192.
Tonetti, M., Muller-Campanile, V. & Lang, N. (1998b) Changes in prevalence of residual pockets and tooth loss in treated periodontal patients during a supportive periodontal care program. *Journal of Clinical Periodontology* **25**, 1008–1016.
Tonetti, M., Steffen, P., Muller-Campanile, V. & Lang, N. (2000) Initial extraction and tooth loss during supportive care in a periodontal population seeking comprehensive care. *Journal of Clinical Periodontology* **27**, 824–831.
Townsend Olsen, C., Ammons, W. & van Belle, G. (1985) A longitudinal study comparing apically repositioned flap with and without osseous surgery. *International Journal of Periodontics Restorative Dentistry* **5**, 1–33.
Trombelli, L., Tatakis, D., Scapoli, C., Bottega, S., Orlandini, E. & Tosi, M. (2004) Modulation of clinical expression of plaque-induced gingivitis. II. Identification of ''high-responder'' and ''low-responder'' subjects. *Journal of Clinical Periodontology* **31**, 239–252.
Tuan, M., Nowzari, H. & Slots, J. (2000) Clinical and microbiologic study of periodontal surgery by means of apically positioned flaps with and without osseous recontouring. *International Journal of Periodontics Restorative Dentistry* **5**, 468–475.
Westfelt, E., Bragd, L., Socransky, S., Haffajee, A., Nyman, S. & Lindhe, J. (1985) Improved periodontal conditions following therapy. *Journal of Clinical Periodontology* **12**, 283–293.
Wilson, T., Glover, M., Malik, A., Schoen, A. & Dorsett, D. (1987) Tooth loss in maintenance patients in a private periodontal practice. *Journal of Periodontology* **58**, 231–235.
Zitzmann, N., Berglundh, T. & Lindhe, J. (2005a) Inflammatory lesions in the gingiva following resective/non resective periodontal therapy. *Journal of Clinical Periodontology* **32**, 139–146.
Zitzmann, N., Lindhe, J. & Berglundh, T. (2005b) Host response to microbial changes following resective/non resective periodontal therapy. *Journal of Clinical Periodontology* **32**, 1175–1180.

Address:
Dr. Gianfranco Carnevale
via Ridolfino Venuti 38
Roma
Italy
E-mail: gi.carnevale@libero.it

Clinical Relevance

Scientific rationale for the study: Different long-term studies reported high rates of pocket recurrence and gingival inflammation in treated and well-maintained periodontal patients.
Principal findings: The prevalence of recurrent pockets and BOP-positive sites was negligible ($<1.5\%$) in patients maintained in the long-term following the re-establishment of shallow PD in all sites of the dentition.
Practical implications: This study suggests that long-term outcome of FibReORS in carefully maintained patients is associated with minimal pocket recurrence and excellent tooth retention an average of 7.8 years after completion of active therapy. Furthermore, prospective investigations are needed.

© 2007 The Authors. Journal compilation © 2007 Blackwell Munksgaard

This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.