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Prospective study of complier individuals under periodontal maintenance therapy: analysis of clinical periodontal parameters, risk predictors and the progression of periodontitis

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Abstract

Aim: This prospective study aimed to evaluate the progression of periodontitis and the influence of risk variables among individuals attending a programme of periodontal maintenance treatment in an academic environment.

Material and Methods: A total of 150 individuals diagnosed with chronic moderate-advanced periodontitis, and who had finished active periodontal treatment, were incorporated into the periodontal maintenance therapy. Social, demographic and biological variables of interest from subjects were collected at quarterly recalls, over a 12-month period. The effect of variables of interest and confounding on the periodontal status and progression of periodontitis was tested by univariate and multivariate logistic analysis.

Results: A total of 130 subjects (86.7%) showed stable periodontal status, whereas 20 subjects (13.3%) presented periodontitis progression. Twenty-eight subjects (18.66%) presented tooth loss that resulted in a total of 47 lost teeth (1.38%). Diabetes was not found to be associated with periodontitis progression ($p = 0.67$). Smoking was significantly associated with a greater progression of periodontitis (OR = 2.7, 95% CI 1.01–7.22).

Conclusions: Periodontal maintenance programmes in academic environment can stabilize the periodontal condition obtained after active periodontal therapy as well as control the action of risk variables for the progression of periodontitis.

Key words: compliance; periodontal maintenance; progression of periodontitis; risk factors

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Conflict of interest and source of funding statement

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Periodontal diseases are common bacterial infections among humans. The most effective therapy towards these infections is the control of causative microorganisms (Haffajee 2006). The main goal of periodontal treatment is to inhibit the infectious inflammatory process of the disease through mechanical removal of the subgingival biofilm, consequently establishing a favourable environment and a microflora compatible with periodontal health (Ximénez-Fyvie et al. 2000).

Clinical parameters covering measures of probing depth (PD), clinical attachment level (CAL), bleeding on probing (BOP) and supurattion (SU) are commonly used to assess and moni-

tor the periodontal status. Periodontal treatment aims to reduce PD, to maintain or improve CAL and to reduce the incidence of BOP and SU, in an attempt to improve the periodontal status (Matuliene et al. 2008).

Periodontitis can be successfully controlled by non-surgical mechanical therapy or surgical procedures accompanied by adequate plaque control and periodontal maintenance therapy (PMT) (Tonetti et al. 2000, Axelsson et al. 2004). Individuals who receive regular PMT tend to keep their teeth for a longer period of time and enjoy greater periodontal health than those who do not receive periodontal maintenance assistance, especially because its purpose is to perpetuate the status of stability created by active therapy (Wilson et al. 1993).

The American Academy of Periodontology (2000) stressed that therapeutic goals of PMT are to minimize the recurrence of periodontal disease in individuals who have been previously treated for gingivitis and periodontitis; to reduce the incidence of tooth loss by monitoring the dentition and any prosthetic replacements of natural teeth when necessary; and to increase the probability of locating and treating, in a timely manner, other diseases or conditions found within the oral cavity.

PMT programmes have been well studied and, unanimously, the surveys concluded that they are crucial for the maintenance of periodontal stability. However, the majority of studies in the literature have a retrospective design (McFall 1982, Wood et al. 1989, Demetriou et al. 1995, Tonetti et al. 2000, Checchi et al. 2002, König et al. 2002, Chambrone & Chambrone 2006, Leung et al. 2006, Carnevale et al. 2007a, Faggion et al. 2007, Matuliene et al. 2008) and thus provide limited conclusions. Most of the studies evaluated periodontal clinical parameters collected by different professionals and in different public or private programmes. Consequently, data reported have shown conflicting findings due to the lack of standardization for recalls, inclusion of different profiles of compliance among the individuals, the use of different diagnostic criteria in the definition of periodontitis, as well as the traditional bias related to temporality.

Different designs of epidemiological studies have been of fundamental importance to gain a better understanding of the periodontal disease process. Accordingly, it is important to highlight the need for prospective studies in order to validate important information stemming from cross-sectional, case–control and retrospective studies. Despite the difficulties of prospective designs, this strategy is required when assessing the measurement of the incidence of periodontitis or when monitoring periodontal conditions (American Academy of Periodontology 2005).

Moreover, periodontal literature has often pointed out a lack of uniformity and difficulties in defining a case of periodontitis, as well as establishing criteria for the progression of periodontitis. However, regardless of these difficulties, it has been postulated that longitudinal changes in CAL $\geqslant 3$ mm are required and accepted to define the progression of periodontitis in at least three subsequent assessments (Beck 1994, American Academy of Periodontology 2005).

Prospective studies in PMT (Axelsson et al. 2004, Preshaw & Heasman 2005) are scarce, most likely due to difficulties inherent within their realization. Moreover, few studies have reported data related to compliers, have standardized recall periods, or have performed appropriate statistical treatment of risk variables. Therefore, this lack of standardization may have a great impact on the results reported.

Hence, the purpose of the present study was to monitor a subset of Brazilian complier individuals included in a regular PMT programme and to assess the influence of this programme on the periodontal status, as well as to analyse the impact of predictor risk variables on this status over a 12-month period. The hypothesis under testing is that PTM programmes can promote periodontal stability, that is, minimize the recurrence and progression of periodontitis.

Methods

The present study was approved by the Federal University of Minas Gerais' Ethics Research Committee, Brazil (ETIC 060/05). Individuals were informed of the aim of the present study, and all provided a written informed consent.

Cohort study

The present open cohort study had a prospective design. A sample of 250 patients, who had finished active periodontal therapy, from June 2004 to March 2006, at the Periodontology Clinic of the School of Dentistry from the Federal University of Minas Gerais – Brazil, were recalled for a baseline clinical examination (PMT1) and invited to participate in a maintenance programme to monitor clinical periodontal parameters. According to the criteria proposed by Demirel & Efeodlu (1995), subjects were considered: (a) compliers, if they presented 100% of cooperation with recall visits; (b) erratic cooperators, if they missed any of the scheduled recall visits, but continued to appear irregularly; and (c) non-compliers, if they did not return for any maintenance visit.

During the 12-month monitoring period, the quarterly recalls ranged from 105 to 132 days (average 108 ± 9.8 days). As a result, from the first 250 selected individuals included in the programme, 150 were determined to be compliers (60%), 38 individuals were erratic cooperators (15.2%) and 62 were non-compliers (24.8%). Therefore, the sample for this prospective study was composed of 150 completely cooperative subjects (compliers) who were monitored in four subsequent recall visits, named PMT1, PMT2, PMT3 and PMT4. It is important to emphasize that a great effort was made to ensure maximum attendance at the recall visits, including letters and phone calls with constant reminders of previously scheduled appointments.

Inclusion criteria

Individuals with good general health who had undergone basic periodontal therapy composed of non-surgical and/or surgical procedures were recruited and included in the sample. In addition, these individuals presented the following criteria: (i) diagnosis of chronic moderate-advanced periodontitis before the active periodontal treatment, with at least four sites with PD $\geqslant$4mm and CAL $\geqslant$3mm with BOP and/or SU, and radiographic evidence of bone loss; (b) completion of active periodontal therapy in a period of less than 4 months for entry in the programme; and (c) have at least 14 teeth in the oral cavity (Papantonopoulos 2004).

Exclusion criteria

Subjects were excluded from the study if they (a) were pregnant; (b) showed debilitating diseases that impaired the

immune system (such as AIDS, cancer and auto-immune diseases); (c) presented gingival hyperplasia due to the use of immunosuppressive drugs or calcium -channel blockers; and (d) had used systemic antibiotics within 4 months before the beginning of the programme.

Sample characteristics

Data related to the following characteristics were collected: gender, age, family income, education level, plaque index, number of teeth present, smoking with a cut-off point according to Tomar & Asma (2000) and the presence of diabetes (glycemic values of >110 mg made in PMT1 and repeated in PMT4) (American Diabetes Association 2003). It is important to stress that there was no intention to characterize the sample according to ethnicity due to the difficulties in determining race in the Brazilian population (Parra et al. 2003).

Periodontal clinical examination

In all periodontal clinical examinations during the recall visits, data composed of PD, CAL, furcation involvement (FI), BOP and SU were recorded for each patient. The full-mouth periodontal examination was performed with manual probes (North Carolina PCPUNC15BR and Nabers PQ2NBR, Hu-Friedy, USA) by only one periodontist (T.C.M.L.) in an attempt to improve examiner agreement. Data were recorded for each individual in appropriate files.

All present teeth were evaluated regarding periodontal parameters, not including third molars (except when they occupied the position of second molars and were functioning and in complete eruption). Teeth were also excluded from the examination when the cementoenamel junction could not be properly determined; when they were already in the erupting process; when they presented unsatisfactory restorations, extensive caries lesions or fracture.

Determination of clinical periodontal status

Periodontal diagnoses included the assessment of the following periodontal parameters:

1. PD and CAL

The measurement of the PD and CAL in non-interproximal areas (vestibular and lingual) was performed in at least three sites by area, and the highest value was assigned. Measurements in interproximal areas were taken at two sites, one at the buccal and the other at the lingual sides, according to the aforementioned principle. As a result, four probing measurements were recorded (buccal, lingual, mesial and distal) for each tooth.

2. BOP

BOP was assessed when the probing measurements were taken and recorded within a 15-s time interval (Muhlemann & Son 1971) in a dichotomized manner (presence/absence) at four sites per tooth (buccal, distal, mesial and lingual).

3. FI

The presence and severity of furcation in multirooted teeth were identified and recorded according to Hamp et al. (1975).

4. SU

SU was analysed by means of digital pressure on the gingiva towards coronary direction. Values were recorded in a dichotomized manner (presence/absence) for each site.

5. Plaque index

Oral hygiene of each sextant was determined by means of the plaque index using disclosing agents. The Quigley & Hein index plaque (1962), modified by Turesky et al. (1970), was used for this purpose and also included the evaluation of proximal sites. Therefore, buccal, lingual, mesial and distal areas of each tooth were evaluated and assigned values from 0 to 5. Mean values per subjects were obtained and recorded. Plaque control and oral hygiene instructions were then provided, and dental prophylaxis was performed in each individual.

6. Radiographic examination

Radiographs using the long-cone paralleling technique were taken at the stage of active periodontal therapy and PMT4 for all the present teeth. Radiographs were used as auxiliary support for periodontal diagnosis.

Periodontal monitoring

In each recall visit (PMT1, PMT2, PMT3 and PMT4), the following procedures were performed:

1) Interviews: variables of interest (demographic, biological and behavioural) were collected and confirmed through patient questionnaires, paying particular attention to those variables likely to change over time; 2) periodontal assessment through the evaluation of clinical parameters described elsewhere; 3) the application of disclosing agents and oral hygiene instructions, using the Bass technique, interproximal toothbrushes and dental floss; 4) mechanical debridement, when appropriate, including coronal prophylaxis and fluoride application. All procedures were performed by a group of trained and calibrated professionals.

Intra-examiner reliability

Measurements of PD and CAL were recorded and repeated within a 1-week interval for 12 subjects randomly selected from the original sample ($n = 250$). Data were tested through a non-parametric kappa test. The presence and absence of periodontal alterations (dichotomized) were determined by a cut-off point of $\geqslant 4$ mm (Janson et al. 2003). Results showed satisfactory kappa values for PD and CAL ($\kappa = 0.83$ and $\kappa = 0.81$, respectively; $p < 0.001$).

In PMT3 visits, measurements of clinical parameters were repeated with another 12 randomly selected subjects, and satisfactory kappa values were again assigned ($\kappa = 0.79$ for PD, and $\kappa = 0.82$ for CAL). In both evaluations, intra-class correlation coefficients of $\geqslant 0.82$ were attained.

Interviews were conducted by only one researcher, and the data were recorded in appropriate form. Before the beginning of the study, a training process was performed through pre-test questionnaires with easy and understandable speech. Interviews were repeated on 12 individuals to verify the quality of the categorical data obtained. Because prior literature had reported a high inconsistency and biased data concerning these variables (Spiekerman et al. 2003), special attention was given to questions regarding smoking and alcohol and/or illegal drug use. Kappa coefficients obtained for smoking and alcohol/drug questions were 0.84 and 0.87, respectively. In addition, all data collected by the questionnaire which may present temporal changes were confirmed at each interval (PMT2, PMT3 and PMT4).

Determination of recurrent sites and re-treatment needs

Sites were determined as applicant re-treatment needs if they showed PD $\geqslant 4$ mm and CAL $\geqslant 3$ mm, together with the presence of BOP and/or SU, in any of the subsequent recall evalua-

tions (PMT1 to PMT4) (American Academy of Periodontology 2000). Individuals diagnosed with recurrent sites were re-treated with mechanical debridement or surgical procedures, where necessary.

Determination of the progression of periodontitis

The progression of periodontitis was defined as changes in the CAL of $\geqslant 3$ mm at the same site, within the period of 12 months (that is, between PMT1 and PMT4) (Beck 1994, American Academy of Periodontology 2000).

Statistical analysis

Data were first grouped into database tables and subsequently revised by two independent analysts. An exploratory analysis was conducted to summarize and organize the data collected. Statistical analysis included a characterization of the sample and descriptive analysis of variables of interest (tables of frequency, averages and percent values), a univariate analysis and a multivariate logistic regression. Independent variables of interest (behavioural, biological and social) were tested to determine which of these could be associated with the additional loss of periodontal attachment over the 12-month interval of PMT. The parametric and non-parametric tests (chi-square, Friedman, Fisher's exact and Mann–Whitney) were used, where appropriate.

A logistic regression analysis was performed to investigate the association between the progression of periodontitis and the following independent predictor risk variables: gender (male/female), age (up to 30/31, 40/41, 49/50 or more years), marital status (companion/no companion), diabetes (yes/no), smoking (smokers/former smokers, report of having smoked or having smoked more than 100 cigarettes throughout their lives and non-smokers), alcohol use (yes/no), family income [less/equal and greater than 2 Brazilian minimum salaries (BMS)], BOP (in more than 30% of sites), PD $\geqslant 4$ mm in more than 30% of the sites, PD between 4 and 6 mm in up to 10% of sites and CAL $\geqslant 3$ mm in 30% of sites. All predictive variables presenting a p-value of <0.25 in the univariate analysis were included in the multiple regression model. Variables were then removed manually step by step, until the log-likelihood ratio test indicates that no variable should be removed. Confounding variables were determined if their removal from the model caused changes greater than 15% in the B coefficient. All variables included in the final multivariate model were determined to be independent through the assessment of their co-linearity. The plaque index was excluded from the final model because of its covariance with BOP, and the number of remaining teeth was determined to be a co-variable due to its association with other predictive variables. Odds ratio estimates and their confidence interval were calculated and reported.

All tests were performed using statistical software (SPSS Inc., version 14.0, Chicago, IL, USA). Results were considered significant if a p-value lower than 5% was attained ($p<0.05$).

Results

Characteristics of the sample regarding social, demographic and biological variables of interest are shown in Table 1. Subjects (99 women and 51 men) had a mean age of 44.9 years ($\pm$ 9.5). In relation to marital status, the majority (60.67%) of the sample reported having companions, 16 subjects (10.7%) were diabetic, and 61 subjects (40.7%) were smokers/former smokers. It is important to highlight that most of the sample had low socioeconomic levels.

Table 1. Characterization of the sample as regards variables of interest ($n = 150$)

Characteristic	*n*	%
Gender		
Female	99	66.0
Male	51	34.0
Age group (range 18–74 years)		
Up to 30 years of age	16	10.7
31–40 years of age	33	22.0
41–50 years of age	61	40.7
More than 50 years of age	40	26.6
Marital status		
With companion	91	60.67
Without companion	59	39.33
Smoking		
Non-smoker	89	59.3
Smoker/former smoker	61	40.7
Family income		
$\leqslant 2$ BMS*	95	63.3
>2 BMS*	55	36.7
Educational level		
Higher education	12	8
High school to low level	135	90
Illiterate	3	2
Diabetics	16	10.7

*BMS, Brazilian minimum salary equivalent to 160 euros.

Periodontal status, with values expressed for sites, at intervals from PMT1 to PMT4 is reported in Table 2. At baseline examination (PMT1), 12,109 sites (89.2%) were observed with PD $\leqslant 3$ mm, 1,152 (8.5%) with PD $\geqslant 4$ to 5 mm and 311 (2.3%) with PD $\geqslant 6$ mm. At PMT4, 12,836 sites (95.9%) were diagnosed with PD $\leqslant 3$ mm, showing an increase of 6.7% in healthy sites and a reduction of 4.7% in sites with PD $\geqslant 4$ to 5 mm. At PMT1, 311 sites (2.3%) showed PD $\geqslant 6$ mm, whereas upon final examination (PMT4), only 36 sites (0.3%) were diagnosed with PD $\geqslant 6$ mm, showing a reduction of 2%.

In relation to CAL at PMT1, 8,766 sites (64.6%) presented values of $\leqslant 3$ mm, 3,407 sites (25.1%) presented values of $\geqslant 4$ to 5 mm and 1,399 sites (10.3%) presented values of $\geqslant 6$ mm. In PMT4, there was an increase of 7.2% in the number of sites with CAL $\leqslant 3$ mm, of 20.8% in the number of sites with CAL $\geqslant 4$ to 5 mm and a substantial reduction in measurements of CAL $\geqslant 4$ mm. During the interval between PMT1 and PMT4, an increase in the number of sites with PD and CAL $\leqslant 3$ mm, and a consequent reduction in sites with measurements of $\geqslant 4$ mm (Table 2), could be observed.

At PMT1, approximately half of the evaluated sites ($n = 7{,}220$; 53.2%) showed BOP. At PMT4, there was a decrease of 24.2% in the number of sites with BOP ($n = 3{,}886$; 29.0%). At PMT1, few sites showed suppuration ($n = 227$; 1.7%), while at PMT4, their frequency was reduced ($n = 30$; 0.2%).

The total number and average per subject of teeth present in PMT1, PMT2, PMT3 and PMT4 was 3,393 (22.62), 3,376 (22.51), 3,362 (22.41) and 3,346 (22.31), respectively. There were 807 teeth lost in PMT1 and 854 teeth lost in PMT4. There was incidence rate regarding subjects with tooth loss ($n = 28$) and missing teeth ($n = 47$) of 18.66% and 1.38%, respectively, during the monitoring period.

Also during the monitoring period, according to the diagnostic criteria proposed, 130 individuals were diagnosed with periodontal stability, whereas 20 subjects were diagnosed with the progression of periodontitis. This demonstrates an incidence rate of 13.3% ($n = 20$) in the progression of periodontitis during the monitoring period.

Table 2. Periodontal condition of sample in the PMT1, PMT2, PMT3 and PMT4 intervals ($n = 150$ individuals)

Periodontal parameters	PMT1		PMT2		PMT3		PMT4	
	Sites ($n = 13,572$)		Sites ($n = 13,504$)		Sites ($n = 13,448$)		Sites ($n = 13,384$)	
	n	%	*n*	%	*n*	%	*n*	%
Probing depth (mm)								
⩽3	12,109	89.2	12,755	94.5	12,818	95.3	12,836	95.9
⩾4 and 5	1,152	8.5	679	5.0	587	4.4	512	3.8
⩾6	311	2.3	70	0.5	43	0.3	36	0.3
Clinical attachment loss (mm)								
⩽3	8,766	64.6	9,248	68.5	9,446	70.2	9,597	71.8
⩾4 and 5	3,407	25.1	3,199	23.7	2,942	21.9	2,799	20.8
⩾6	1,399	10.3	1,057	7.8	1,060	7.9	988	7.4
Bleeding on probing								
No	6,352	46.8	7,957	58.9	8,900	66.2	9,498	71.0
Yes	7,220	53.2	5,547	41.1	4,548	33.8	3,886	29.0
Suppuration								
No	13,345	98.3	13,447	99.6	13,414	99.7	13,354	99.8
Yes	227	1.7	57	0.4	34	0.3	30	0.2

PMT, periodontal maintenance therapy.

Table 3. Periodontal clinical variables from PMT1 to PMT4 in individuals with (yes) and without (no) the progression of periodontitis

Clinical variables	Individuals (*n*)	PMT1	PMT2	PMT3	PMT4
Probing depth ⩾4 mm*	150	10.7 (± 9.4)	5.7 (± 5.8)	4.8 (± 5.2)	4.2 (± 4.7)
No	130	10.3 (± 9.6)	5.5 (± 6.0)	4.3 (± 5.1)	3.5 (± 4.2)
Yes	20	13.6 (± 8.1)	7.0 (± 4.3)	7.7 (± 4.8)	8.7 (± 5.6)
Clinical attachment level ⩾3 mm*	150	13.1 (± 8.3)	7.2 (± 6.1)	6.5 (± 4.8)	6.1 (± 4.1)
No	130	12.6 (± 9.2)	6.1 (± 6.8)	5.7 (± 6.2)	5.5 (± 4.5)
Yes	20	14.3 (± 9.1)	8.3 (± 4.5)	8.5 (± 5.1)	9.3 (± 6.2)
Bleeding on probing*	150	53.0 (± 19.6)	41.2 (± 16.5)	33.9 (± 14.5)	29.0 (± 14.5)
No	130	52.4 (± 19.6)	40.9 (± 16.8)	33.5 (± 14.6)	28.7 (± 14.8)
Yes	20	56.7 (± 20.3)	43.0 (± 14.9)	36.6 (± 13.9)	31.6 (± 12.1)
Suppuration*	150	1.7 (± 2.9)	0.4 (± 1.1)	0.2 (± 0.8)	0.2 (± 0.8)
No	130	1.6 (± 3.0)	0.4 (± 1.1)	0.2 (± 0.8)	0.2 (± 0.7)
Yes	20	2.3 (± 2.3)	0.6 (± 0.9)	0.3 (± 0.7)	0.7 (± 1.0)
Plaque index (%)	150	65.9 (± 19.0)	55.6 (± 19.4)	51.3 (± 19.4)	50.5 (± 19.4)
No	130	65.8 (± 19.2)	56.3 (± 19.6)	52.7 (± 19.8)	51.1 (± 19.5)
Yes	20	66.7 (± 18.0)	51.0 (± 17.8)	42.6 (± 13.2)	47.0 (± 18.7)

Friedman test for comparisons between intervals of periodontal maintenance therapy (PMT) (p-values $< 0,001$).
*Mean % of affected sites ± standard deviation.

In Table 3, when comparing the mean percentage of affected sites with PD ⩾4 mm, CAL ⩾3 mm and BOP, individuals with the progression of the disease had progressively higher averages in these measurements from PMT1 to PMT4 as compared with those without the progression of periodontitis ($p < 0.01$). Moreover, the average values reported for these variables in all individuals significantly reduced over time, thus reflecting the beneficial effect of PMT. It is important to note that even though individuals were determined to be compliers with the recalls visits, the mean plaque index of the sample at PMT1 was high, 65.9 ± 19%. A reduction of only 15.4% was observed during the maintenance period (PMT4 = 50.5 ± 19.4%). Little difference regarding suppuration was observed when comparing subjects with and without progression.

In Table 4, when analysing the association between independent variables and the progression of periodontitis, a significant association was found only in family income ($p = 0.004$). No significant differences were observed for the other tested variables (gender, age, race, marital status, diabetes, smoking, drug use, alcohol and educational level; $p > 0.05$).

Also analysed were individuals and sites with a recurrence of periodontitis between the intervals of PMT1 and PMT4, that is, individuals presenting PD ⩾4 mm with BOP and/or SU in any of the recall evaluations. Observed were 100, 95, 87, 107, 103 and 99 individuals, and 298, 273, 243, 397, 449 and 378 sites with re-treatment needs between PMT1 and PMT2, PMT1 and PMT3, PMT1 and PMT4, PMT2 and PMT3, PMT2 and PMT4, and PMT3 and PMT4, respectively. Although 247 surgical procedures were performed between PMT1 and PMT4 (preferably Widman Modified flap surgery), it is important to highlight that the majority of the sites responded favourably to procedures of mechanical debridement.

A logistic regression model was created to evaluate the influence of the following predictor variables of risk for periodontitis progression between PMT1 and PMT4: gender, age, marital status, diabetes, smoking, alcohol/drug

Table 4. Association between independent variables and the progression of periodontitis (from PMT1 to PMT4)

Variables	Progression of periodontitis				Total	*p*-value
	No		Yes			
	n	%	*n*	%		
Gender						
Female	85	85.9	14	14.1	99	0.685*
Male	45	88.2	6	11.8	51	
Age group						
Up to 30 years of age	16	100.0	0	0.0	16	0.406†
31–40 years of age	29	87.9	4	12.1	33	
41–50 years of age	45	83.3	9	16.7	54	
50 or more	40	85.1	7	14.9	47	
Diabetes						
No	116	86.6	18	13.4	134	1.000‡
Yes	14	87.5	2	12.5	16	
Marital status						
With companion	76	83.5	15	16.5	91	0.159*
Without companion	54	91.5	5	8.5	59	
Smoking habits						
Non-smoker	81	91.0	8	9.0	89	0.059*
Former smoker/smoker	49	81.6	12	18.4	61	
Drug use						
No	128	86.5	20	13.5	148	1.000‡
Yes	2	100.0	0	0.0	2	
Alcohol consumption						
No	64	88.9	8	11.1	72	0.442*
Yes	66	84.6	12	15.4	78	
Family income						
>2 BMS	52	94.5	3	5.5	55	0.004*
$\leqslant 2$ BMS	78	82.1	17	17.9	95	
Educational level						
Higher education	8	66.7	4	33.3	12	0.102‡
Medium to low level	119	88.1	16	11.9	135	
Illiterate	3	100.0	0	0.0	3	
Total	130	86.7	20	13.3	150	

*Chi-square test.
†Mann–Whitney test.
‡Fisher's exact test.
PMT, periodontal maintenance therapy; BMS, Brazilian minimum salary equivalent to 160 euros.

use, family income, BOP in $>30\%$ of sites, PD $\geqslant 4$ mm in $>30\%$ of sites, PD $\geqslant 4$ mm in 10% of sites, and $\leqslant 6$ mm, and CAL $\geqslant 3$ mm in 30% of sites. Smoking was maintained in the final model to control possible confounding effects. The final model showed that individuals with family income $\leqslant 2$ BMS, and smokers presented, respectively, 4 (OR = 4.09, 95% CI 1.12–14.88) and 2.7 (OR = 2.7, 95% CI 1.01–7.22) times higher chances to develop the progression of periodontitis (Table 5).

Discussion

The present study, in accordance with most studies regarding PMT programmes, underscored the crucial role of supportive periodontal therapy in the stability of periodontal status and homeostasis of periodontal tissues after active therapy. In relation to the degree of compliance of individuals, preliminary reports indicated that approximately 20–40% of the individuals abandon maintenance therapy at the start of the programme. The proportion of non-complier individuals at the baseline reported in the prospective study by Wilson et al. (1993) was 34.1%, which, after 10 years, was reduced to 20%. Demetriou et al. (1995), Novaes et al. (1996) and Soolari & Rokn (2003) reported rates of 19.6%, 25.2% and 39.1%, respectively, for non-compliers. In the present study, the rate of non-compliance was 24.8%, similar to the lower rates reported in previous studies. However, the assessment of the compliance was estimated for a 12-month period, and great effort has been spent on all recalls.

Most of the longitudinal studies on this issue showed a predominance of the female gender among individuals in maintenance programmes. In the present study, 66% of the subjects were female, a finding that is similar to that reported by Wood et al. (1989) – 65.07%, Preshaw & Heasman (2005) – 57%, Chambrone & Chambrone (2006) – 60.8% and Carnevale et al. (2007a) – 63.5%. Periodontal literature has demonstrated that this predominance is due to an increased demand for dentistry treatment by women as compared with men (American Academy of Periodontology 2005, Tonetti & Claffey 2005).

In the present study, individuals had a mean age of 44.9 years, similar to that reported previously in the literature for individuals included in PMT programmes (McFall 1982, Wood et al. 1989, Tonetti et al. 2000, König et al. 2002, Preshaw & Heasman 2005, Carnevale et al. 2007a, Faggion et al. 2007, Matuliene et al. 2008).

In general, studies of PMT have been evaluating traditional clinical periodontal parameters. This continuous clinical monitoring is crucial for the success of such maintenance programmes, including academic, public or private programmes. In relation to clinical periodontal parameters, the present study showed an average PD of 4.2 ± 4.7 mm over a 12-month period. These findings are in accordance with a similar study conducted by Preshaw & Heasman (2005). These authors showed improvements in clinical periodontal parameters among individuals with a previous history of periodontitis and non-surgical therapy over a 12-month maintenance period, considering recall visits of 3-month intervals. In addition, these authors pointed out that clinical improvement remained stable, with averages of PD from 3.0 to 3.2 mm and mean percent of sites with BOP from 36.7% to 44.1%. Thus, a great similarity in the data for PD reported here, as compared with that conducted by Preshaw & Heasman (2005), could be observed. However, data for BOP in the present study was slightly lower ($29.1 \pm 14.4\%$).

Lang et al. (1990) stated that the absence of BOP during periodontal maintenance is considered a good predictor of periodontal stability. The study of Claffey et al. (1990) provided evidence that percentages of BOP above 20% and 30% can determine a high risk for the progression of periodontitis. Joss

Table 5. Initial and final multivariate model of logistic regression for the progression of periodontitis (from PMT1 to PMT4)

Initial model	Coefficient	Wald	*p*-value	OR	LL*	UL†
Gender (male)	0.312	0.259	0.611	1.366	0.410	4.550
Age	–	0.159	0.984	–	–	–
Up to 30 years of age	− 18.388	0.000	0.998	0.000	0.000	–
31–40 years of age	0.123	0.027	0.869	1.131	0.264	4.840
41–49 years of age	− 0.163	0.067	0.796	0.850	0.248	2.916
Marital status	0.425	0.482	0.487	1.529	0.461	5.070
Diabetes (yes/no)	− 0.083	0.009	0.924	0.921	0.166	5.101
Smoking (smoker, former smoker and non-smoker)	0.779	1.668	0.197	2.179	0.668	7.110
Use of alcohol/drugs	0.150	0.067	0.796	1.162	0.371	3.636
Family income $\leqslant$2 WM	1.410	4.024	0.045	4.097	1.033	16.246
BOP in more than 30% of sites	− 0.789	0.929	0.335	0.454	0.091	2.258
PD $\geqslant$4 mm in more than 30% of sites	− 0.580	0.225	0.635	0.560	0.051	6.151
PD $\geqslant$4 and $\leqslant$6 mm in up to 10% of sites	0.884	2.159	0.142	2.420	0.745	7.868
CAL $\geqslant$3 mm in more than 30% of sites	19.012	0.000	0.999	–	0.000	–
Tooth loss during PMT (yes/no)	− 1.292	2.248	0.134	0.275	0.051	1.488
Constant	− 22.213	0.000	0.999	0.000	–	–
Final model						
Smoking	0.99	3.93	0.047	2.70	1.01	7.22
Family income ($\leqslant$2 BMS)	1.40	4.57	0.033	4.09	1.12	14.88
Constant	− 3.39	24.83	0.000	0.034	–	–

*Lower limit.

†Upper limit.

PMT, periodontal maintenance therapy; OR, odds ratio; BOP, bleeding on probing; PD, probing depth; CAL, clinical attachment level; BMS, Brazilian minimum salary equivalent to 160 euros.

et al. (1994), in a retrospective study conducted in a private clinic, revealed that a frequency of 25% of sites with BOP can be considered a limit among individuals with periodontal stability over a 4-year period as well as among individuals with the progression of periodontitis over the same period of time. In the present study, 150 subjects presented, at the baseline, an average of $53.0 \pm 19.6\%$ of bleeding sites and reached, after 12 months, an average of $29.1 \pm 14.4\%$, thus demonstrating an expressive reduction and a visible tendency towards periodontal stability. It should be emphasized that compliers can self-evaluate the presence of bleeding with the use of dental floss, which consists of important information in the perception of the need for regular visits to the PMT; however, this issue has yet to be dealt with methodologically.

In PMT1, this study presented an average of the plaque index of $65.9 \pm 19\%$, while in PMT4, it presented an index of $50.5 \pm 19.4\%$, showing a reduction of only $15.5 \pm 0.4\%$ in the average. The high scores of plaque index reported in the present study could be related to the inclusion of proximal sites during examination. These high scores are similar to those reported by Faggion et al. (2007) who used approximal plaque evaluation (mean plaque scores of $75.7 \pm 25.0\%$) and other previous reports (Mendoza et al. 1991, Preshaw & Heasman 2005). However, it is important to state that despite efforts on oral hygiene motivation during recall visits, these efforts proved to be little effective. Professionals included in PMT programmes must pay particular attention to this issue and guide efforts in attempt to not compromise the benefits of these programmes in maintaining periodontal health over time.

In general, subgingival debridement effectively reduces the population of gram-negative microorganisms, while it concomitantly allows for an increase in the population of gram-positive cocos and rods, which is related to the microbiota of healthy gingiva (Cugini et al. 2000, Haffajee 2006). The microbial counts in subgingival sites vary from 10^3 in shallow and healthy sites to more than 10^8 in deep periodontal pockets (Socransky & Haffajee 2002). As the re-colonization of previously treated periodontal pockets may occur if maintenance recall intervals of 3–4 months are not established, the elimination or reduction of the proportion of pathogens through periodic subgingival debridement (Magnusson et al. 1984, Shiloah & Patters 1996) can compensate inadequate plaque control among individuals and perhaps may justify the good results reported in the aforementioned studies which, despite showing high rates of plaque index, presented reductions in PD and in the number of sites with BOP. Therefore, we consider that the periodic professional assistance may have compensated the lack of a good control of plaque among the individuals in the present study.

In the field of periodontal disease epidemiology, criteria for the definition of ''case'' and the progression of periodontitis have generated many controversies and discussions. The progression of periodontitis has been defined by clinical parameters (PD and CAL) and by measurements of bone loss detected through radiographs (American Academy of Periodontology 2005, Costa et al. 2007). Beck (1994), in a study on methods for assessing risk in periodontology, defined that the progression of periodontitis should be established for individuals who experience changes in CAL $\geqslant$3 mm over an 18-month period. This criterion has also been postulated by a well-known article on the epidemiology of periodontal diseases, published by the American Academy of Periodontology in 2005.

The present study chose to define the progression of periodontitis based on this criterion, even though the monitoring period was 12 months. We believe that ordinal changes in PD which occurred between the intervals of

PMT1 and PMT4, even in the higher cut-off points, could not necessarily represent the actual loss of periodontal insertion, especially because this parameter is more susceptible to errors during measurement or because it simply reflects changes in periodontal marginal inflammatory tissues (Costa et al. 2007).

In this manner, the cut-off point adopted for changes in CAL $\geqslant$3 mm to define the progression of periodontitis seemed to be appropriate, because it allows for possible ordinal errors of measurement reproducibility of up to 1 mm and can still consider standard errors of approximately 0.84 mm, measures identified by previous studies (American Academy of Periodontology 2005). Additionally, CAL measurements may also reflect previous contact with periodontitis and are considered a gold standard in periodontal diagnoses. Therefore, we can conclude that the use of this criterion may prevent greater potential super estimation rates regarding the progression of periodontitis.

In studies with well-maintained individuals and compliers, the rate of recurrence of sites with PD $\geqslant$4 mm has been low. In the retrospective study of Carnevale et al. (2007a), upon initial examination, 98.5% of sites showed PD $\leqslant$3 mm. Most sites in PMT2 showed PDs of 4–5 mm (83.4%). At the same time, the total number of sites with PD $\geqslant$6 mm was 68 and limited to 41 individuals (13.8% of the sample). Currently, at baseline PMT1, 12,109 sites (89.2%) showed PD $\leqslant$3 mm, 1,152 sites (8.5%) showed a residual PD of 4–5 mm and 311 sites (2.3%) showed measures of PD $\geqslant$6 mm. In the final examination (PMT4), 12,836 sites (95.9%) presented PD $\leqslant$3 mm, 512 sites (3.8%) persisted with measures of 4–5 mm, while 36 sites (0.3%) showed PD $\geqslant$6 mm.

It was observed that, in relation to CAL, from PMT1 to PMT4, 7.2% of the sites showed some improvement in the attachment level, that is, the occurrence of measurements of CAL $\leqslant$3 mm. However, it should be emphasized that this analysis does not contemplate multilevel dependency. As a result, gains or reversals of measures of the site-specific CAL were not analysed. Confirming the findings from Carnevale et al. (2007a), our study showed that the progression of the disease was concentrated in a small group of individuals, when a strict regimen of maintenance was performed.

During the different intervals of PMT, some sites with PD $\geqslant$4 mm needed to undergo re-treatment. Thus, procedures of subgingival debridement or new surgeries were used, when appropriate. A conservative surgical technique (Widman modified flap surgery) was preferably used. These procedures comprise the most used technique in the academic environment, as reported by Tonetti et al. (1998b) and König et al. (2002), as a means of reducing PDs to physiological measurements. In the present study, differences in the clinical parameters of PD and CAL in relation to the type of procedure performed on PMT were not included.

In this study, tooth loss which occurred during PMT was used as a final stage of the diseases affecting the periodontal and dental tissues and is very similar to many studies (Tonetti et al. 2000, König et al. 2002, Faggion et al. 2007). It was observed that 28 subjects lost their teeth (18.66%), summing a total of 47 teeth lost (1.38%) between PMT1 and PMT4. It was also noted, in accordance with previous studies (McFall 1982, Axelsson et al. 2004, Fardal et al. 2004, Chambrone & Chambrone 2006, Leung et al. 2006, Faggion et al. 2007), that a minority of individuals were responsible for the majority of tooth loss.

The final statistical modelling showed that individuals with a family income of $\leqslant$2 BMS, even after having analysed possible confounding or protective effects, presented a greater chance of contracting the progression of periodontitis. However, this finding must be analysed with caution, as studies have reported different risk associations between demographic variables and the progression of periodontitis. This fact suggests the difficulty of establishing causal associations between environmental variables for multifactor diseases (American Academy of Periodontology 2005). It should be considered that, in general, the sample in question presents a low socio-economic status, because 2 BMS is equivalent to 160 euros, hence considered a low income. It was also important to establish that this variable still denotes family income, that is, the sum of financial income of individuals living together.

In addition, the logistic regression model revealed that smokers had 2.7 times more chance of presenting the progression of periodontitis. These findings are consistent with most available studies in prior periodontal articles which report that smoking is a well-recognized risk factor with a strong impact on the progression and recurrence of periodontal disease (Grossi et al. 1995, Kerdvongbundit & Wikesjö 2000, Haffajee & Socransky 2001, AAP 2005, Preshaw et al. 2005, Matuliene et al. 2008). In summary, despite the meticulous monitoring and short recall periods applied, smoking was associated with the progression of periodontitis ($p = 0047$).

The number of diabetic subjects found in the population under study was consistent with prevalence rates of diabetes reported worldwide (American Diabetes Association 2003), that is, 10.7% ($n = 16$) were diabetics, and three of these showed the progression of periodontal disease. Moreover, it should be emphasized that these diabetic subjects were not metabolically compensated. Several studies have confirmed a great influence of this risk factor on the susceptibility, severity and progression of periodontitis. In contrast, the present study found no association between diabetes and the progression of periodontitis ($p = 0.67$). Recently, Lim et al. (2007) reported an association between markers of metabolic control and the severity of inflammation of periodontal tissues in diabetic individuals. Thus, it seems reasonable to suggest that the periodontal monitoring can minimize or neutralize the deleterious effect of an important risk predictor for the progression for periodontal diseases.

Subjects in the present study were previously affected by periodontal disease and were treated in an academic environment with a strong emphasis on patient information, especially that which concerns the natural history of periodontitis and the need for self-care attitudes regarding oral hygiene. Subsequently, important issues when evaluating findings from the present study are related to the fact that the sample was composed of a restricted group of individuals, determined to be compliers, within an academic environment. Caution should be exercised when discussing external validity.

In conclusion, findings from the present study demonstrated a considerable improvement in clinical periodontal parameters, with a stability of periodontal status in the majority of individuals. In general, smokers showed a higher progression rate of periodontitis than did non-smokers. Hence, periodontal maintenance programmes primar-

ily aim towards the occurrence of low levels of the progression of periodontitis and tooth loss. In addition, their emphasis must be guided to minimize or neutralize the influence of predictor risk variables, which may reflect a better quality of life for susceptible individuals.

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Clinical Relevance

Scientific rationale for the study: Monitoring of individuals after active therapy must preserve periodontal tissues stability as well as guide strategies to control risk variables and improve compliance, thus minimizing the progression of periodontitis and tooth loss.

Principal findings: Out of 150 complier individuals, over a 12-month maintenance period, 130 (86.7%) were periodontally stable, while 20 (13.3%) presented progression of periodontitis ($p = 0.015$). There was a considerable improvement in periodontal parameters, with periodontal stability among the majority of individuals. Smokers showed a higher progression of periodontitis.

Practical implications: Maintenance programmes should be implemented to minimize or at least neutralize the influence of risk determinants.