Periodontal Maintenance Therapy in a Public University: A Six-Year Prospective Study

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Abstract

Background: Few prospective studies have reported results of periodontal status and tooth loss in public/academic periodontal maintenance therapy (PMT) programs. This prospective study aimed to evaluate the periodontal retreatment needs and progression of periodontitis, as well as tooth loss, in individuals under PMT in a public/academic environment.

Materials and methods: From a PMT program at a public university, 39 individuals determined to be regular compliers (RC) and 52 irregular compliers (IC) were monitored over the course of 78 months [mean interval between visits of 6.2 ± 0.6 and 13.1 ± 1.9 months, respectively]. Complete periodontal examinations were conducted to evaluate probing depth (PD), clinical attachment level (CAL), and bleeding on probing (BOP) at baseline and final examinations. Biological, demographic, and behavioral predictive risk variables were collected. Univariate and multivariate logistic regressions were performed when appropriate.

Results: At final examination, periodontal retreatment needs and progression of periodontitis, as well as tooth loss, were significantly higher among IC when compared to RC ($p < 0.05$). Multivariate logistic regression analysis showed that: 1) age and > 30% of sites with CAL ≥ 4 mm were associated with the progression of periodontitis; 2) smoking, co-habitation status, family income, and > 30% of sites with BOP were associated with periodontal retreatment needs; 3) age, family income, low frequency of tooth brushing, and diabetes were associated with tooth loss.

Conclusion: RC individuals in public/academic PMT programs presented with lower periodontal retreatment needs and progression of periodontitis, as well as tooth loss when compared to IC individuals.

Key words: Periodontal maintenance, epidemiology, risk factors, periodontitis

Introduction

Periodontal maintenance therapy (PMT) is a program of regular visits in order to maintain the homeostasis of periodontal tissues achieved after completed active periodontal treatment, and thus prevent retreatment needs and progression of periodontitis, as well as minimize tooth loss (Lorentz *et al.,* 2009; Costa *et al.,* 2014). Thus, several PMT longitudinal studies reported that the maintenance of periodontal health requires a regular program of dental visits (Kocher *et al.,* 2000; Carnevalle *et al.,* 2007; Fisher *et al.,* 2008; Costa *et al.,* 2014).

Recent systematic reviews pointed out that most PMT studies reported in the literature used a retrospective design (Lee *et al.,* 2015). As a consequence, they may provide limited conclusions inherent with this type of design (Renvert and Persson, 2004; Chambrone *et al.,* 2010). On the other hand, PMT prospective studies (Axelsson *et al.,* 2004; Preshaw and Heasman, 2005; Fisher *et al.,* 2008; Kakudate *et al.,* 2008; Lorentz *et al.,* 2009; Costa *et al.,* 2012a; Costa *et al.,* 2014) have shown conflicting data generated by the lack of standardization in the recall visits, different patterns of compliance, and the use of different diagnostic criteria in the definition of periodontitis, in addition to the traditional bias related to temporality and selection of participants.

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Therefore, despite the large number of PMT studies, there are still few prospective studies with more than five years of monitoring, as well as standardized methodology for active periodontal treatment and procedures performed during PMT visits (Renvert and Persson, 2004, Costa *et al.,* 2015). Moreover, reports of PMT programs in the public/academic environment are still sparsely reported in the literature (Wilson *et al.,* 1993; Costa *et al.,* 2012b).

The aim of the present study was to evaluate periodontal status, periodontal retreatment needs and progression of periodontitis and tooth loss occurring over a period of 78 months in a public/academic PMT program, as well as analyze the impact of predictive risk variables for these outcomes.

Methods

Study design and sampling strategy

The present open cohort study presented a prospective design in which an initial sample of 150 subjects treated in the Clinic of Periodontology of the Dentistry School from the Federal University of Minas Gerais – Brazil (public institution, i.e., periodontal treatment and PMT free of charge) were recalled to a baseline clinical examination and invited to participate in a PMT program.

All individuals with good general health who had undergone non-surgical and/or surgical procedures were recruited. These individuals presented with the following initial criteria: a) diagnosis of chronic moderate to advanced periodontitis, before active periodontal treatment, with at least four sites with probing depth (PD) ≥ 5 mm and clinical attachment level (CAL) ≥ 3 mm with bleeding on probing (BOP) and radiographic evidence of bone loss (American Academy of Periodontology, 2000); b) conclusion of active periodontal treatment in a period of ≤ 4 months for entry in the study; c) have at least 14 natural teeth (Papantonopoulos, 2004).

Individuals were excluded if they: a) were pregnant; b) had debilitating diseases that could impair the immune system; c) had gingival overgrowth due to the use of immunosuppressive agents or calcium-channel blockers; d) were absent from PMT recall visits for more than 18 months (non-compliant individuals).

Individuals were determined to be regular compliers (RC) if intervals between PMT visits were ≤ 7 months and irregular compliers (IC) if intervals were > 7 and < 15 months, based on previous studies (König *et al.,* 2002; Costa *et al.,* 2012a, 2014). Hence, from the initial sample of 150 compliant individuals, 91 individuals remained in the PMT program during a 78-month period. Thus, two groups were established: RC (n = 39; average time between recall visits 6.2 ± 0.6 months) and IC (n = 52; average time between recall visits 13.1 ± 1.9 months). Non-compliant individuals were excluded from the study (n = 39). In the present follow-up study, the analysis of the outcomes (retreatment needs and progression of periodontitis and tooth loss) were performed by comparing the first PMT visit (baseline periodontal maintenance therapy – BPMT) and the last visit (final periodontal maintenance therapy – FPMT). It is important to emphasize that BPMT occurred at most four months after active periodontal treatment, as proposed by Renvert and Persson (2000).

Data collection

All periodontal procedures performed during every PMT visit, as well as the methodology for data collection, were identical to those reported by Lorentz *et al.* (2009). Periodontal diagnosis included the assessment of the periodontal parameters described below.

Probing depth (PD) and clinical attachment level (CAL)

The measurement of 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 buccal and one lingual, according to the aforementioned principle. As a result, four probing measurements were recorded (buccal, lingual, mesial, and distal) for each tooth.

Bleeding on probing (BOP)

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

Furcation involvement (FI) and suppuration (SU)

The presence and severity of FI in multi-rooted teeth was identified and recorded according to Hamp *et al.* (1975). Suppuration was analyzed by means of digital pressure on the gingiva in the coronal direction. Values were recorded in a dichotomized manner (presence/absence) for each site. These parameters were only used as auxiliary support for diagnosis and periodontal treatment.

Plaque index (PI)

Oral hygiene of each sextant was determined by means of PI using disclosing agents. The Quigley and Hein plaque index (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.

Radiographic examination

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

Data were collected for the following characteristics: sex, age, family income (≤ 1, 2, 3 - 4, and ≥ 5 times the Brazilian minimum wage), educational level, use of alcoholic beverages, co-habitational status (with/without companion), smoking (Tomar and Asma, 2000), presence of diabetes (American Diabetes Association, 2011), and frequency of tooth brushing.

During the PMT visits, the following procedures were performed: a) plaque control and dental hygiene instructions; b) coronal prophylaxis and fluoride application; and c) mechanical non-surgical or surgical debridement, when appropriate.

Determination of periodontal retreatment needs and progression of periodontitis

Periodontal retreatment needs during PMT were defined for recurrent sites that had PD ≥ 4 mm and CAL ≥ 3 mm with BOP at any subsequent recall visits (Costa *et al.,* 2012a).

Progression of periodontitis was defined as changes in the CAL ≥ 3 mm at the same site at any interval between recall visits (Tonetti and Claffey, 2005). In the present study, progression was assessed between BPMT and FPMT, based on previous studies (Matuliene *et al.,* 2010; Costa *et al.,* 2012a).

Inter- and intra-examiner agreement

In BPMT, data collection was performed by a single examiner (T.C.M.L.). In FPMT, data collection was performed by a second examiner (B.N.A.), who was trained and calibrated by the baseline examiner. All PMT periodontal procedures were checked by the researchers (T.C.M.L. and B.N.A.). Inter- and intra-examiner agreement values for PD and CAL revealed values greater than 0.89 (kappa test).

Statistical analysis

Parametric and nonparametric tests (Chi-square, Fisher's exact, Student's *t*, and Kruskal-Wallis) were used when appropriate. When equal variances were assumed, means were compared by analysis of variance (ANOVA) and Bonferroni post-hoc test. When unequal variances were assumed, means were compared by the Welch and Tamhane post-hoc test. Comparisons were performed only for teeth and sites matched between BPMT and FPMT.

Logistic regression analysis was performed to investigate the association between tooth loss (≥ 1 tooth lost due to periodontal reasons), periodontal retreatment needs, and progression of periodontitis, and the all independent variables as risk predictors. Odds ratio (OR) estimates and their confidence interval (95% CI) were calculated and reported.

The present study was conducted in accordance with the Helsinki Declaration, 1975, revised in 2013, and was approved by the Ethics Research Committee of the Federal University of Minas Gerais, Brazil (protocol #ETIC 0410.0.203.000-10). A signed informed consent was obtained from all individuals prior to their participation and all subjects' rights were protected at all times.

Results

Differences were observed between the RC and IC groups only in terms of educational level ($p = 0.04$), number ($p = 0.002$) and average time ($p = 0.031$) between PMT visits. Thus, it is important to emphasize that groups were homogeneous regarding risk variables (*Table 1*).

Periodontal status of RC and IC groups in BPMT and FPMT are reported in *Table 2*. Overall, significant differences between the clinical parameters of BOP, PD, CAL, and PI in BPMT were not observed. However, significant differences for PD 5 - 7 mm and > 7 mm were observed in FPMT (IC > RC; $p < 0.05$). It is noteworthy that the proportions and the number of sites with PD > 7 mm among IC were five times higher than the values reported among RC. In addition, there was significantly worse PI among IC (PI in RC = 38.2 ± 6.3 and PI in IC = 44.8 ± 9.7) and lower mean of present teeth when compared to RC (RC = 23.3 and IC = 22.2) in FPMT.

Periodontal retreatment needs and progression of periodontitis were significantly higher among individuals, teeth, and sites in the IC group when compared to the RC group in FPMT. In addition, IC individuals (n = 35; 63.5%) lost significantly more teeth when compared to RC individuals (n = 17; 36.5%; $p = 0.013$). The RC group lost 43 and IC lost 95 teeth (*Table 3*). The average annual rate of tooth loss was of 0.17 for RC and 0.29 for IC ($p = 0.031$).

Periodontal retreatment needs, progression of periodontitis, and tooth loss in relation to variables of interest are shown in *Tables 4* and *5*. The following variables were significantly associated with periodontal retreatment needs: irregular compliance, co-habitation status, and family income (*Table 4*). Those associated with progression of periodontitis were: irregular compliance and age > 51 years (*Table 4*). Variables associated with tooth loss were irregular compliance, age > 51 years, and diabetes (*Table 5*).

No significant difference in tooth loss by group of teeth (non-molar and molar) was observed. Additionally, no significant difference in the overall occurrence of tooth loss, as well as tooth loss in non-molar or molar teeth, between the RC and IC groups was observed when tooth loss was associated with progression of periodontitis and retreatment needs.

The final multivariate models of logistic regression (*Table 6*) revealed the following risk variables for progression of periodontitis: age ($p = 0.009$), and > 30% of sites with BOP ($p = 0.001$). Risk variables for retreatment needs included co-habitation status ($p = 0.020$), family income ($p = 0.014$), smoking ($p = 0.045$), and BOP in more than 30% of the sites ($p = 0.048$). Variables associated with tooth loss were age > 51 years ($p = 0.003$), diabetes ($p = 0.032$), frequency of tooth brushing ≤ 1 daily ($p = 0.015$), and >30% of sites with CAL ≥4 mm ($p = 0.022$).

Table 1. Characterization of regular compliers (RC) and irregular compliers (IC) regarding variables of interest.

Variables	RC Group (n = 39)	IC Group (n = 52)	*p*
Sex [n (%)]			
Female	31 (79.5)	32 (61.5)	0.066*
Male	8 (20.5)	20 (38.5)	
Group age [n (%)]			
Up to 40 years	7 (17.9)	7 (13.5)	0.444*
41 - 50 years	14 (35.9)	14 (26.9)	
More than 51 years	18 (46.2)	31 (59.6)	
Age (mean ± SD)	48.5 ± 9.8	51.5 ± 10.6	0.163†
Co-habitational status [n (%)]			
With companion	23 (59.0)	28 (53.8)	0.626*
Without companion	16 (41.0)	24 (46.2)	
Diabetes [n (%)]			
Yes	4 (10.3)	8 (15.4)	0.474*
No	35 (89.7)	44 (84.6)	
Frequency of tooth brushing [n (%)]			
≤ 2 times per day	8 (20.5)	10 (19.2)	0.387*
3 times per day	19 (48.7)	32 (61.6)	
≥ 4 times per day	12 (30.8)	10 (19.2)	
Smoking [n (%)]			
Yes	3 (7.7)	10 (19.2)	0.319*
Former smoker	22 (56.4)	25 (48.1)	
No	14 (35.9)	17 (32.7)	
Alcohol consumption [n (%)]			
Yes	20 (51.3)	25 (48.1)	0.762*
No/occasionally	19 (48.7)	27 (51.9)	
Educational level [n (%)]			
≤ 8 years	12 (30.8)	32 (61.5)	0.004*
> 8 years	27 (69.2)	20 (38.5)	
Family income [n (%)]			
≤ 1 BMW	1 (2.6)	5 (9.6)	0.211‡
2 BMW	5 (12.8)	12 (23.1)	
3 - 4 BMW	18 (46.2)	15 (28.8)	
≥ 5 BMW	15 (38.5)	20 (38.5)	
Average number of PMT visits (mean ± SD)	7.1 ± 2.8	5.5 ± 2.3	0.002
Average time between PMT visits in months (mean ± SD)†	6.2 ± 0.6	13.1 ± 1.9	0.031
Average time elapsed between BPMT and FPMT in months (mean ± SD)†	71.99 ± 5.6	72.8 ± 2.4	0.198

*Chi-square test; †Student's *t*-test; ‡Fisher's exact test. BMW, Brazilian minimum wage; PMT, periodontal maintenance therapy; BPMT, baseline periodontal maintenance therapy; FPMT, final periodontal maintenance therapy; SD, standard deviation

Discussion

The present prospective study of PMT in a public/academic program demonstrated that IC individuals had higher progression of periodontitis and retreatment needs, as well as tooth loss, when compared to RC individuals. The present study presented a prospective homogeneous cohort with similar periodontal conditions before and after active periodontal treatment, standard PMT procedures, and a significant period of monitoring (78 months). These conditions minimize the potential confounding factors reported in many PMT studies (Renvert and Persson, 2004; Lee *et al.,* 2015).

These features improve the relevance of our findings and can be considered as one of the great advantages of the study according to the systematic review by Renvert

Table 2. Periodontal status of regular compliers (RC, n = 39) and irregular compliers (IC, n = 52) groups at baseline (BPMT) and final (FPMT) periodontal maintenance therapy visits.

Clinical parameters	BPMT		FPMT	
	RC Group	IC Group	RC Group	IC Group
Number of teeth (n)	24.4 ± 4.0^{Aa}	24.1 ± 4.5^{Aa}	23.3 ± 4.3^{Bb}	22.2 ± 5.3^{Bb}
	952	1251	909	1,156
Number of sites	3,808	5,004	3,636	4,624
PD (mean % of sites)				
≤ 4 mm	97.4 ± 5.2^{Aa}	97.0 ± 7.1^{Aa}	96.6 ± 4.9^{Aa}	93.4 ± 7.0^{Bb}
5 - 7 mm	2.5 ± 5.1^{Aa}	2.8 ± 6.2^{Aa}	3.1 ± 3.6^{Ab}	5.4 ± 5.7^{Bb}
> 7 mm	0.1 ± 0.4^{Aa}	0.2 ± 1.4^{Aa}	0.3 ± 1.9^{Ab}	1.6 ± 2.1^{Bb}
CAL (mean % of sites)				
≤ 3 mm	63.9 ± 20.9^{Aa}	61.7 ± 23.5^{Aa}	67.3 ± 21.5^{Ab}	59.6 ± 24^{Ba}
4 - 5 mm	25.9 ± 13.7^{Aa}	26.9 ± 14.4^{Aa}	22.8 ± 13.2^{Ab}	28.6 ± 14.2^{Ba}
> 5 mm	10.3 ± 10.5^{Aa}	11.4 ± 12.1^{Aa}	9.9 ± 9.9^{Aa}	11.8 ± 13.7^{Bb}
BOP (mean % of sites)	31.8 ± 17.6^{Aa}	33.3 ± 18.8^{Aa}	13.8 ± 11.1^{Ab}	19.9 ± 13.7^{Bb}
Plaque index (%)	33.4 ± 6.4^{Aa}	35.6 ± 7.8^{Aa}	38.2 ± 6.3^{Ab}	44.8 ± 9.7^{Bb}

BOP, bleeding on probing; CAL, clinical attachment level; PD, probing depth. Comparison between RC and IC at each time point: groups followed by different capital letters in the row are significantly different ($p < 0.05$, Student's *t*-test for independent samples); Comparison between BPMT and FPMT in each group: groups followed by different lowercase letters in the row are significantly different ($p < 0.05$, Student's *t*-test for paired samples). Multiple comparisons adjusted using the Welch test and the Tamhane post hoc test ($p < 0.037$).

Table 3. Incidence of progression and periodontal retreatment needs and tooth loss in regular complier (RC) and irregular complier (IC) groups at the final periodontal maintenance (FPMT) examination.

	RC Group	IC Group
Progression of periodontitis		
% of teeth (mean ± SD)	0.8 ± 0.3^{A}	1.9 ± 1.5^{B}
% of sites (mean ± SD)	3.2 ± 1.9^{A}	7.6 ± 3.9^{B}
Individuals [n (%)]	13 (33.3)^{a}	33 (63.5)^{b}
Periodontal retreatment needs		
% of teeth (mean ± SD)	1.5 ± 3.2^{A}	2.9 ± 3.8^{B}
% of sites (mean ± SD)	6.4 ± 9.2^{A}	9.7 ± 12.5^{B}
Individuals [n (%)]	22 (56.4)^{a}	39 (75.0)^{b}
Tooth loss		
% of teeth (mean ± SD)	4.5 ± 0.2^{A}	8.2 ± 0.8^{B}
Individuals [n (%)]	17 (36.5)^{a}	35 (63.5)^{b}

Comparison between RC and IC in FPMT: groups followed by different capital letters in the row are significantly different by Student's *t*-test for independent samples ($p < 0.05$). Comparison between RC and IC in FPMT: groups followed by different lowercase letters in the row are significantly different by the Chi-squared test ($p < 0.05$).

and Persson (2004) that pointed out desirable items in prospective PMT studies. To the best of our knowledge, few prospective studies have reported results of periodontal status and tooth loss in public/academic PMT programs (Preshaw and Heasman, 2005; Lorentz *et al.,* 2009), as well as the comparison between private and public practices (Costa *et al.,* 2012b).

The American Academy of Periodontology (2005) suggested that the frequency of PMT visits in periodontally susceptible individuals should be based on individual assessments of periodontal risk. Recalls in a short period of time (4 - 6 months) are considered appropriate; however, they are very difficult to obtain in clinical practice over time (König *et al.,* 2002; Costa *et al.,* 2012a).

Thus, the interval time between recalls and the classification of RC for individuals with PMT visits within 6 months apart (mean 6.2 ± 0.6 months), and IC for individuals with PMT visits within 13 months apart (13.1 ± 2.4), in the present study can also be considered a reasonable period to establish the degree of compliance (Costa *et al,* 2012a).

Table 4. Periodontal retreatment needs and progression of periodontitis (yes/no) in relation to variables of interest.

Variables	Periodontal retreatment needs			Progression of periodontitis		
	Yes (n = 61)	No (n = 30)	*p*	Yes (n = 46)	No (n = 45)	*p*
Group [n (%)]						
RC	22 (30.0)	17 (56.7)	0.030*	13 (28.2)	22 (48.9)	0.021*
IC	39 (70.0)	13 (43.3)		33 (71.8)	23 (51.1)	
Sex [n (%)]						
Female	41 (67.2)	22 (73.3)	0.552*	32 (69.6)	31 (68.9)	0.944*
Male	20 (32.8)	8 (26.7)		14 (30.4)	14 (31.1)	
Age [n (%)]						
Up to 40 years	11 (18.0)	3 (10.0)	0.620‡	3 (6.5)	11 (24.4)	0.007*
41 - 50 years	19 (31.2)	9 (30.0)		20 (43.5)	8 (17.8)	
51 years or more	31 (50.8)	18 (60.0)		23 (50.0)	26 (57.8)	
Co-habitational status [n (%)]						
With companion	39 (63.9)	12 (40.0)	0.031*	26 (56.5)	25 (55.6)	0.926*
Without companion	22 (36.1)	18 (60.0)		20 (43.5)	20 (44.4)	
Alcohol consumption [n (%)]						
Yes	31 (50.8)	14 (46.7)	0.710*	22 (47.8)	23 (51.1)	0.754*
No/occasionally	30 (49.2)	16 (53.3)		24 (52.2)	22 (48.9)	
Diabetes [n (%)]						
Yes	9 (14.8)	3 (10.0)	0.744**	8 (17.4)	4 (8.9)	0.231†
No	52 (85.2)	27 (90.0)		38 (82.6)	41 (91.1)	
Frequency of toothbrushing [n (%)]						
≤ 2 times per day	14 (23.0)	4 (13.3)	0.554*	9 (19.6)	9 (20.0)	0.841*
3 times per day	33 (54.1)	18 (60.0)		27 (58.7)	24 (53.3)	
≥ 4 times per day	14 (23.0)	8 (26.7)		10 (21.7)	12 (26.7)	
Education level [n (%)]						
≤ 8 years	30 (49.2)	14 (46.7)	0.822*	25 (54.3)	19 (42.2)	0.247*
> 8 years	31 (50.8)	16 (53.3)		21 (45.7)	26 (57.8)	
Smoking [n (%)]						
Yes	10 (16.4)	27 (49.3)	0.159**	10 (21.7)	3 (6.7)	0.056†
Former smoker	3 (10.0)	20 (66.7)		17 (37.0)	14 (31.1)	
No	24 (39.3)	7 (23.3)		19 (41.3)	28 (62.2)	
Family Income ([n (%)]						
≤ 1 BMW	32 (52.5)	9 (30.0)	0.031**	23 (50.0)	18 (40.0)	0.653*
2 BMW	16 (26.2)	9 (30.0)		12 (26.1)	13 (28.9)	
3 - 4 BMW	6 (9.8)	10 (33.3)		8 (17.4)	8 (17.8)	
≥ 5 BMW	7 (11.5)	2 (6.7)		3 (6.5)	6 (13.3)	

*Chi-squared test; †Fisher's exact test, BMW, Brazilian minimum wage (equivalent to 300 American dollars)

In relation to periodontal clinical parameters, significant differences between RC and IC were reported in FPMT. Greater severity of PD and CAL were reported in IC when compared to RC. In RC, these findings can be explained by the regularity of PMT visits, more frequently repeated instructions about oral hygiene, and professional plaque control. In addition, recurrent periodontitis could be detected and treated early, and thus, bursts of progression of periodontitis could be prevented and/or minimized, corroborating previous findings of greater progression of periodontitis in IC (Miyamoto *et al.,* 2006; Fisher *et al.,* 2008).

The final multivariate models showed that BOP in more than 30% of the sites was associated with the periodontal retreatment needs and the progression of periodontitis, corroborating previous findings (Badersten *et al.,* 1990; Costa *et al.,* 2015). Studies have shown that sites with constant BOP during PMT visits were at greater risk for attachment loss compared to healthy sites (Lang *et al.,* 1990, Carnevale *et al.,* 2007; Teles *et al.,* 2008; Leininger *et al.,* 2010).

Tooth mortality can be considered an indisputable failure of periodontal therapy (Lee *et al.,* 2015). In the present study, an average annual tooth loss rate of 0.17 for RC and 0.29 for IC was reported, so a total of 138 teeth were lost in 78 months of monitoring. These findings were similar to those reported by previous prospective and retrospective studies, which reported 2.3 times more tooth loss/year in non-compliant individuals treated for periodontitis and up to 6 times higher in individuals without periodontal treatment (Novaes and Novaes, 2001; Checchi *et al.,* 2002; Miyamoto *et al.,* 2006; Costa *et al.,* 2014).

Table 5. Tooth loss in relation to variables of interest.

Variables	Tooth loss Yes	Tooth loss No	*p*
	n = 52	n = 39	
Group [n (%)]			
RC (n = 5 2)	17 (36.5)	20 (51.3)	0.011*
IC (n = 39)	35 (63.5)	19 (48.7)	
Sex [n (%)]			
Female	38 (73.1)	25 (64.1)	0.359*
Male	14 (26.9)	14 (35.9)	
Age [n (%)]			
Up to 40 years of age	5 (9.6)	9 (23.0)	0.031*
41 - 50 years of age	13 (25.0)	15 (38.5)	
51 years or more	34 (65.4)	15 (38.5)	
Co-habitational status [n (%)]			
With companion	28 (53.8)	23 (59.0)	0.626*
Without companion	24 (46.2)	16 (41.0)	
Diabetes			
Yes	10 (19.2)	2 (5.1)	0.049*
No	42 (80.8)	37 (94.9)	
Alcohol consumption			
Yes	25 (47.8)	20 (51.1)	0.754*
No/occasionally	27 (52.2)	19 (48.9)	
Frequency of tooth brushing [n (%)]			
≤ 2 times per day	7 (13.5)	11 (28.2)	0.208*
3 times per day	32 (61.5)	19 (48.7)	
≥ 4 times per day	13 (25.0)	9 (23.1)	
Educational level			
≤ 8 years	32 (54.3)	12 (42.2)	0.247*
> 8 years	20 (45.7)	27 (57.8)	
Family income [n (%)]			
≤ 1 BMW	23 (50.0)	18 (40.0)	0.653†
2 BMW	12 (26.1)	13 (28.9)	
3 - 4 BMW	8 (17.4)	8 (17.8)	
≥ 5 BMW	3 (6.5)	6 (13.3)	
Smoking [n (%)]			
Yes	9 (17.3)	4 (10.3)	0.559†
Former smoker	16 (30.8)	15 (38.5)	
No	27 (51.9)	20 (51.3)	

*Chi-squared test; †Fisher's exact test; BMW, Brazilian minimum wage (equivalent to 300 American dollars)

Surprisingly, the present study did not report greater tooth loss in molars when compared to non-molars. Different findings were previously reported (Miyamoto *et al.,* 2006; Leininger *et al.,* 2010; Lee *et al.,* 2015). However, tooth mortality findings in PMT should be analyzed with caution, because the decision of tooth extraction involves not only biological issues but philosophical options regarding strategies for periodontal treatment.

A characteristic of the present cohort sample is that most individuals exhibited lower education level and lower family income. Disparities in socioeconomic status and lack of equity in these aspects have been related to worse general health (Kerdvongbundit and Wikesjö, 2000; Williams *et al.*, 1995; Drury *et al.,* 1999; Borrell *et al.,* 2006; Kim *et al.,* 2014). In the present study, co-habitation status (without companion) and a lower income, reflecting a behavioral and social risk variable, respectively, were associated with periodontal retreatment needs. Previous studies with similar findings were reported (Drury *et al.,* 1999; Fisher *et al.,* 2008; Lorentz *et al.,* 2009; Costa *et al.*, 2012b; Kim *et al.,* 2014).

Another interesting aspect of the present study is the similarity of our results regarding tooth loss and the progression of periodontitis compared to those reported in prospective cohort studies in private practices, in which individuals were monitored and treated by a smaller group of specialists in periodontics and supposedly more attention was given to the individual (Costa *et al.,* 2012b).

Table 6. Final logistic regression models for progression, periodontal retreatment needs, and tooth loss at the final periodontal maintenance (FPMT) examination.

Progression of periodontitis		
Variables	*p*	OR (CI 95%)
Age > 51 years	0.009	4.1 (1.42 - 11.82)
30% sites with CAL ≥ 4 mm	0.001	4.60 (1.76 - 11.89)
Periodontal retreatment needs		
Variables	*p*	OR (CI 95%)
Status co-habitational	0.020	3.32 (1.21 - 9.16)
Smoking	0.045	2.87 (1.02 - 8.04)
Family income (≤ 1 BMW)	0.014	5.13 (1.39 - 18.97)
30% sites with BOP	0.048	8.65 (1.01 - 73.81)
Tooth loss		
Variables	*p*	OR (CI 95%)
Age > 51 years	0.003	5.18 (1.74 - 15.41)
Diabetes	0.032	7.46 (1.19 - 46.94)
Frequency of tooth brushing (≤ 2 times per day)	0.015	8.00 (1.48 - 42.79)
30% sites with BOP	0.022	6.20 (1.30 - 29.99)

BMW, Brazilian minimum wage (equivalent to 300 American dollars); BOP, bleeding on probing; CAL, clinical attachment level

However, there was little negative influence of different academic professionals performing procedures during PMT when they are all well monitored in a public/academic environment. These findings are relevant regarding the incentive for implementation of public strategies in PMT programs using fewer specialists in periodontics, which would reduce costs and logistics in the public oral health care domain.

In the present study, age > 51 years was a risk predictor variable significantly associated with tooth loss and progression of periodontitis. Longitudinal studies have revealed that very poor periodontal conditions and a lower number of teeth are common findings in older individuals, reflecting an additional attachment loss throughout life (Williams *et al.,* 1995; Borrell *et al.,* 2006), especially in periodontally susceptible individuals (Lorentz *et al.,* 2009; Costa *et al.,* 2014).

A large number of studies have shown that smoking and diabetes were associated with significantly increased risk for CAL, increased PD, bone loss, and tooth loss (Haffajee and Socransky, 2001; Labriola *et al.,* 2005; Shiloah *et al.,* 2014). In addition, studies have shown that smokers and individuals with poorly controlled diabetes negatively respond to different forms of periodontal treatment and have worse clinical parameters of PD and CAL (Teeuw *et al.,* 2010; Tamashiro *et al.,* 2016). In the present study, smoking was associated with greater progression of periodontitis in the final multivariate model. However, it was not associated with the retreatment needs or tooth loss. In contrast, diabetes was associated only with tooth loss. These findings may suggest a certain efficacy of PMT to minimize adverse effects of potential risk factors (Teeuw *et al.,* 2010; Costa *et al.,* 2015).

Conclusion

Ours findings showed that RC individuals had lower rates of periodontal retreatment needs, progression of periodontitis and tooth loss, when compared to IC individuals. These results demonstrate the influence of the regularity of recall visits during PMT in improving periodontal condition and minimizing tooth loss. Moreover, important risk variables such as age, smoking, and diabetes were associated with different periodontal undesirable outcomes, reinforcing the need to tailor periodontal risk in order to establish the frequency of PMT visits.

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