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Prognostic value of a simplified method for periodontal risk assessment during supportive periodontal therapy

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RUNNING TITLE

Risk assessment with *Perio Risk*

KEY WORDS

Periodontitis; prognosis; risk assessment; tooth loss; alveolar bone loss; periodontal pocket.

SOURCE OF FINDINGS

The present study was supported by GABA International, Therwil, Switzerland, and by the Research Centre for the Study of Periodontal and Peri-implant Diseases, University of Ferrara, Italy.

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ABSTRACT

Aim: to evaluate the association between risk scores generated with a simplified method for periodontal risk assessment (*Perio Risk*) and tooth loss as well as bone loss during supportive periodontal therapy (SPT).

Materials & Methods: Data related to 109 patients (42 males; mean age: 42.2 ± 10.2 years, range 22-62) enrolled in a SPT program for a mean period of 5.6 years were retrospectively obtained at two specialist periodontal clinics. Patients were stratified according to *Perio Risk* risk score (on a scale from 1 - low risk to 5 - high risk) as calculated at the end of active periodontal therapy. Risk groups were compared for tooth loss as well as the changes in radiographic bone levels occurred during SPT.

Results: The mean number of teeth lost per patient during SPT varied from 0 to 1.8 ± 2.5 for patients with a risk score of 1 and 5, respectively ($p= 0.041$). Mean radiographic bone loss during SPT was ≤ 0.5 mm in all risk groups, without significant inter-group differences.

Conclusions: Periodontal risk assessment according to *Perio Risk* may help to identify patients at risk for tooth loss during SPT.

CLINICAL RELEVANCE

Scientific background: During the last two decades, different patient-based periodontal risk assessment tools have been proposed. Amongst the latter, however, few have been validated in longitudinal studies.

Principal findings: Risk scores generated according to the *Perio Risk* tool (Trombelli et al. 2009) were associated with the mean number of teeth lost during a mean period of 5.6 years of supportive periodontal therapy (SPT).

Practical implications: The use of the *Perio Risk* tool for periodontal risk assessment may help clinicians to identify of patients at risk for tooth loss during maintenance and to personalize strategies to deliver effective supportive therapy.

INTRODUCTION

In periodontology, the evaluation of risk determinants is fundamental for the early identification of high-risk subjects and the formulation of personalized preventive and therapeutic strategies to allow for the targeted control of risk factors (Heitz-Mayfield 2005). During the last two decades, different patient-based periodontal risk assessment tools have been proposed to allow for uniform and accurate information capable to optimize the clinical decision making, improve oral health status of the patients and reduce health care costs (Tonetti et al. 2015). Based on data from longitudinal studies, a recent systematic review supported the possibility to predict periodontitis progression and tooth loss using some of the proposed tools (Lang et al. 2015). In particular, risk scores were demonstrated to be associated with tooth loss and periodontal deterioration on the long term either in almost complete absence of periodontal treatment (Page et al. 2002, 2003) or under supportive periodontal therapy (SPT) (Persson et al. 2003, Jansson & Norderyd 2008, Matuliene et al. 2010, Costa et al. 2012).

In 2007, a simplified method for periodontal risk assessment (*Perio Risk*) was proposed. The method is based on 5 parameters which are derived from the patient medical history and clinical recordings. In a large cohort of randomly selected patients, a substantial level of agreement was observed between *Perio Risk* and the more complex DEP-PA, thus suggesting that *Perio Risk* may simplify the generation of risk scores while maintaining the necessary accuracy of the system (Trombelli et al. 2009). To date, however, no data from longitudinal studies are currently available on the association between risk scores generated with *Perio Risk* and the progression of periodontitis.

The goal of the present study was to evaluate the association between risk scores as assessed according to *Perio Risk* and tooth loss as well as bone loss in a large cohort of patients enrolled in a SPT program.

MATERIALS & METHODS

Experimental design

The study was a retrospective analysis of de-identified data derived from the record charts of patients seeking care at two centers specialized in the diagnosis and treatment of periodontal diseases (Research Centre for the Study of Periodontal and Peri-implant Diseases, University of Ferrara, Ferrara, Italy; and a private periodontal practice, Bologna, Italy).

Patient selection was based on selection criteria (see "*Study population*") and the availability of specific data (see "*Study parameters*") related to the following observation intervals:

- initial visit: performed ≤ 2 months before active periodontal therapy (consisting of non-surgical with/without surgical treatment and extraction of hopeless teeth);
- baseline visit: performed ≤ 12 months following the completion of active periodontal therapy;
- follow-up visit: performed ≥ 3.5 years from baseline.

Study population

Patient selection was based on inclusion and exclusion criteria as reported in Appendix 1. Briefly, adult patients undergoing active periodontal therapy (consisting of non-surgical instrumentation eventually followed by one or more sessions of periodontal surgery) and enrolled in a SPT program for ≥ 3.5 years were included for analysis.

Study parameters

Demographic, smoking status and diabetic status

The following data were derived from each clinical record chart:

- age (years);
- gender;
- race (caucasian, non-caucasian);
- smoking status (current smoker, former smoker, never smoked);
- number of cigarettes per day;
- diabetic status (diabetic, non-diabetic);
- metabolic control of diabetes (plasma level of HbA1c).

While age was referred to the initial visit, data regarding smoking status and diabetic status were recorded for each observation interval.

Periodontal therapy

The following data related to the history of periodontal therapy were extracted from the clinical record chart of each patient:

- number of attended sessions of non-surgical periodontal instrumentation during active therapy;
- number of sessions of periodontal surgery during active therapy;
- number of attended sessions of supra- and sub-gingival mechanical plaque removal during SPT (i.e., between baseline and follow-up visits).

Clinical parameters

For each observation interval, the following clinical parameters were extracted from the clinical record chart:

- number of teeth present;
- probing depth (PD): distance (in mm) between the gingival margin and the bottom of the pocket as assessed using a manual periodontal probe (PCP 11 or CP12; Hu-Friedy, Chicago, Illinois, USA) at 6 aspects (mesio-buccal, buccal, disto-buccal, mesio-lingual, lingual, disto-lingual) for each tooth including fully erupted third molars;
- bleeding on probing (BoP): recorded as positive (BoP+) when gingival bleeding had been detected at the site level after PD assessment.

Radiographic parameters

On full-mouth sets of periapical radiographs taken at each observation interval, two examiners performed all radiographic measurements. The examiners were kept blinded as to the patient-related data and observation interval of the radiographs. Radiographic assessments were preceded by a calibration phase, performed on radiographs of patients not included in the study. The evaluation of intra- and inter-examiner agreement revealed good consistency of radiographic measurements (intra-class correlation coefficient ≥ 0.70). At the mesial and distal aspect of each tooth, the distance (in mm) between the cementum-enamel junction (CEJ) and the bone crest (BC) was measured (CEJ-BC) with a digital caliper. At sites where the CEJ could not be identified due to the presence of restorations, the distance between the apical margin of the restoration and the bone crest was measured. Measurements were rounded to the nearest 0.1 mm. All sites where the CEJ, the restoration margin and/or the bone crest profile could not be identified, were excluded from the analysis.

Periodontal risk assessment

At baseline, the patient risk profile was evaluated according to the *Perio Risk*, as proposed by Trombelli et al. (2009). Risk assessment according to *Perio Risk* method is based on 5 parameters which are derived from the patient medical history and clinical recordings (i.e., smoking status, diabetic status, number of sites with PD \geq 5 mm, BoP score, and extent of bone loss/age). Risk calculation according to *Perio Risk* is described in details in Appendix 2. Briefly, each parameter received different scores (“parameter score”), as shown in Tables 1a-e. The algebraic sum of the parameter scores was calculated and then referred to 5 “risk profiles”: profile 1 (low risk), 2 (low-medium risk), 3 (medium risk), 4 (medium-high risk), and 5 (high risk) (Table 2).

Statistical analysis

The patient was considered as the statistical unit for analysis. Data were expressed as mean \pm standard deviation (SD).

For each patient, the following parameters related to the SPT were calculated:

- number of teeth lost;
- extent of bone loss ($\%_{\text{losing}}$), calculated as the % prevalence of sites showing an increase in CEJ-BC \geq 2 mm;
- extent of bone loss per year ($\%_{\text{losing*year}}$), calculated as the ratio between $\%_{\text{losing}}$ and the duration (in years) of SPT;
- severity of bone loss ($\text{CEJ-BC}_{\text{loss}}$), calculated as the mean change (mm) in CEJ-BC.

Statistical comparisons between groups with different risk profiles at baseline were performed with analysis of variance (ANOVA). In case of a statistically significant result, a sensitivity analysis was performed using the non-parametric k-sample Savage score test. Post-hoc comparisons were performed with Tukey–Kramer test. The level of statistical significance was set at 5%.

A *stepwise backward* regression analysis was conducted as a secondary analysis using %_{losing*year} as response variable and the following parameters (related to baseline) as predictive variables: age, gender, smoking status and number of cigarettes/day, number of teeth present, number of sites with PD \geq 5 mm, mean PD (mm), BoP score, number of teeth with CEJ-BC \geq 4 mm, mean CEJ-BC (mm). Based the results of the stepwise regression, a simplified version of the *Perio Risk* (which was named *Smart Risk*) was created, and its R² in the prediction of %_{losing*year} and number of teeth lost during SPT was evaluated.

RESULTS

Study population

One hundred nine patients (42 males and 67 females; mean age: 42.2 \pm 10.2 years, range 22-62) were included for analysis. Patient characteristics at initial visit are described in Appendix 3 and Table 3.

Active and supportive periodontal therapy

Active periodontal therapy consisted of 5.4 \pm 2.9 sessions of non-surgical instrumentation, followed by 2.9 \pm 1.7 (range: 0 - 7) sessions of periodontal surgery.

One hundred twenty-two teeth were extracted between initial visit and baseline, with a mean of 1.1 \pm 1.5 (range: 0 - 7).

At baseline, one smoker changed his smoking exposure from 10-19 to ≥ 20 cigarettes/day, while all other patients did not change their smoking status or exposure.

Diabetic status remained unaltered when compared to initial visit. At baseline, patients had 7.6 ± 8.8 sites (range: 0 - 63) with $PD \geq 5$ mm and a mean PD of 2.71 ± 0.38 mm (range: 1.66 - 3.91). BoP score was 7.1 ± 10.4 % (range: 0 - 55). The distribution of patients according to the number of sites with $PD \geq 5$ mm and BoP score at baseline is reported in Table 3. Mean CEJ-BC was 3.19 ± 1.33 mm (range: 1.20 - 7.56), and patients had a mean number of teeth with $CEJ-BC \geq 4$ mm of 11.2 ± 7.6 (range: 0 - 28).

The mean duration of SPT was 5.6 ± 2.2 years (range: 3.7 - 15.6). SPT consisted of 13.8 ± 6.3 sessions of supra- and sub-gingival mechanical plaque removal, with one session every 3.4 ± 1.1 months. The distribution of patients according to the frequency of attended SPT visits is reported in Table 4. During SPT, 45 patients (41%) lost a total of 93 teeth (13 of which were third molars), with a mean of 0.9 ± 1.5 teeth (range: 0 - 8) lost per patient. The tooth loss rate per year of SPT was 0.15 ± 0.26 teeth/year. $CEJ-BC_{loss}$ was 0.14 ± 0.64 mm (range: -1.31 - 4.14), and $\%_{losing}$ was 12.7 ± 13.8 % (range: 0 - 89.3).

At follow-up visit, 6 patients had quit smoking. Diabetic status remained unaltered compared to baseline. At follow-up visit, patients had 14.8 ± 16.7 sites (range: 0 - 86) with $PD \geq 5$ mm and a mean PD of 3.01 ± 0.51 mm (range: 1.88 - 4.52). BoP score was 10.9 ± 16.6 % (range: 0 - 78). The distribution of patients according to the number of sites with $PD \geq 5$ mm and BoP score at follow-up visit is reported in Table 3. Mean CEJ-BC was 3.33 ± 1.37 mm (range: 1.14 - 10.86), and patients had a mean number of teeth with $CEJ-BC \geq 4$ mm of 11.6 ± 7.0 (range: 0 - 25).

Distribution according to *Perio Risk* profile at baseline and SPT characteristics in each risk group

The distribution of patients according to the *Perio Risk* profile at baseline is reported in Table 5. At baseline, the majority (78%) of patients still showed a risk of 3 or 4. No significant differences in either the duration of SPT or the number of attended SPT sessions were observed between groups with different risk profiles at baseline (Table 5).

Association between *Perio Risk* profile and severity and extent of bone loss during SPT

Tooth loss as well as the extent (as expressed by %_{losing} and %_{losing*year}) and severity (as expressed by CEJ-BC_{loss}) of bone loss occurred during SPT in patients with different *Perio Risk* profile at baseline are reported in Table 6.

The mean number of teeth lost during SPT varied from 0 to 1.8 ± 2.5 teeth for patients with a risk score of 1 and 5, respectively, with a statistically significant difference between score 3 and score 5 ($p = 0.041$). A sensitivity non-parametric analysis also yielded a statistically significant result ($p = 0.044$). The tooth loss rate per year of SPT varied from 0 to 0.32 ± 0.51 teeth/year for patients with a risk score of 1 and 5, respectively, with a borderline significant difference between risk groups ($p = 0.053$). Third molars lost during SPT belonged to patients with risk score of 4 (8 third molars lost in 5 patients) or 5 (5 third molars lost in 4 patients).

The severity of bone loss was limited (< 0.5 mm) in all risk groups, without significant inter-group differences. The extent of bone loss was comprised between 10.8% and 15.9% for risk groups 1 and 5, respectively, without significant inter-group differences.

Prognostic value of the parameters of the *Perio Risk* method

The *stepwise backward* regression secondary analysis identified the number of cigarettes/day and the number of sites with $PD \geq 5$ mm at baseline as the parameters of *Perio Risk* that significantly contributed to predict $\%_{\text{losing*year}}$ ($p = 0.012$ and $p = 0.006$, respectively). R^2 of the model was 0.13.

A simplified version of the *Perio Risk* (which was named as *Smart Risk*) was also evaluated. Risk profiles of the *Smart Risk* were generated by adding the number of cigarettes per day and the number of sites with $PD \geq 5$ mm at baseline. The *Smart Risk* showed a significantly greater prognostic value for $\%_{\text{losing*year}}$ compared to the *Perio Risk* proposed by Trombelli et al. (2009) ($p < 0.0001$, $R^2 = 0.13$). In particular, when applied dichotomously (sum ≤ 10 : low risk; sum > 10 : high risk), the *Smart Risk* maintained a significant prognostic value for $\%_{\text{losing*year}}$ ($p = 0.0014$, $R^2 = 0.09$) and showed a significant prognostic value also for the number of teeth lost during SPT ($p = 0.0001$; $R^2 = 0.13$).

DISCUSSION

The present study was performed to evaluate the association between risk scores generated with a simplified method for periodontal risk assessment (*Perio Risk*, Trombelli et al. 2009), tooth loss and the deterioration of periodontal conditions under SPT. De-identified data related to 109 patients enrolled in a SPT program for a mean period of 5.6 ± 2.2 years were retrospectively obtained. A *Perio Risk* score (on a scale

from 1 - low risk to 5 - high risk) was calculated for each patient using data at re-evaluation visit following active periodontal therapy. Patients with different risk scores were grouped and compared for tooth loss as well as changes in radiographic bone levels occurred during SPT.

The *Perio Risk*, as elaborated by Trombelli et al. (2009), was proposed as a simplified method for periodontal risk assessment. The method shares some parameters, including the number of sites with $PD \geq 5$ mm, BoP score, and bone loss/age, with the PRA proposed by Lang & Tonetti (2003). While the risk calculation according to the PRA may be partly based on the results of laboratory tests (e.g., genetic test) at the operator's discretion, the *Perio Risk* is based entirely on parameters derived from the patient medical history and clinical recordings. Also, patient risk as assessed by the *Perio Risk* is segmented into 5 profiles, which should allow clinicians for a detailed categorization of patient prognosis and estimation of the impact of periodontal treatment on patient prognosis. In addition, the *Perio Risk* scores are generated by an algebraic sum of 5 parameter scores, thus simplifying the risk calculation procedure. In this respect, the *Perio Risk* has been externally validated against more complex methods supported by longitudinal data (Page et al. 2002, Page & Martin 2007), thus suggesting that *Perio Risk* may simplify the generation of risk scores while maintaining the necessary accuracy of the system (Trombelli et al. 2009).

Due to the retrospective nature of our study, it was not possible to retrieve information on the causes for tooth loss or extraction. In absence of this information, it is uncertain whether tooth loss may represent here a true indicator of periodontitis progression. Periodontal disease, however, was often reported as the main reason for tooth loss in

several prospective (Lindhe & Nyman 1975, Isidor & Karring 1986, Ramfjord et al. 1987, Costa et al. 2014) and retrospective (Hirshfeld & Wasserman 1978, McFall 1982, Goldman et al. 1986, Wood et al. 1989, McLeod et al. 1997, Checchi et al. 2002) studies on the efficacy of periodontal maintenance programs in patients treated for periodontitis.

At the completion of active periodontal therapy, 58% and 26% of patients showed ≥ 5 sites or ≥ 10 sites, respectively, with $PD \geq 5$ mm, and 19% of patients showed a BoP score $\geq 17\%$. Moreover, 22% of patients still smoked ≥ 10 cigarettes/day at baseline. Smoker patients with high percentage of bleeding pockets were particularly clustered in Group 5, and significantly less represented in Groups 1-3 (data not shown). These data seem to reinforce the concepts that a pre-requisite for a successful SPT is the substantial reduction of BoP+ sites associated with $PD > 4$ mm during the active phase of therapy (Matuliene et al. 2008) along with an effective smoking cessation program (Costa et al. 2014), and that SPT should be tailored on clinical conditions which inform the patient risk assessment at the end of active therapy (Tonetti et al. 2015, Trombelli et al. 2015).

Over a mean period of 5.6 years of SPT, patients lost on average 0.15 teeth per year of SPT. This finding is consistent with the results of a recent systematic review (Trombelli et al. 2015), which reported a weighted mean tooth loss rate of 0.15 teeth/year as derived from prospective studies with a 5-year follow-up (Lindhe & Nyman 1975, Isidor & Karring 1986, Ramfjord et al. 1987, Costa et al. 2014). Our results therefore reinforce the importance of SPT for the secondary prevention of periodontitis (Sanz et al. 2015), but also showed that the number of teeth lost during SPT was significantly associated

with *Perio Risk* profile assigned at the beginning of SPT. In particular, the mean number of teeth lost varied from 0 to 1.8 teeth and the mean tooth loss rate per year of SPT varied from 0 to 0.32 teeth/year for patients with a risk score of 1 (low risk) and 5 (high risk), respectively. These data on tooth loss are consistent with those reported for low-to-moderate and high risk groups identified with other risk assessment methods (Leininger et al. 2010). Also, the magnitude and rate of tooth loss observed in our high risk group is in line with that reported for patients exposed to risk factors affecting SPT outcomes, such as smoking (Baumer et al. 2011), or erratic compliance to the maintenance regimen (Costa et al. 2014). Overall, these findings indicate that periodontal risk assessment according to the *Perio Risk* method may contribute the identification of patients at risk for tooth loss during SPT. Since high risk groups experienced greater tooth loss during SPT compared to the other risk groups, it is reasonable to hypothesize that their greater disease severity at the beginning of SPT, including the amount of bone loss, may have favored tooth loss for periodontal reasons. Differences in tooth loss among cohorts with varying risk profile, but receiving a similar frequency of recall session, also seems to reinforce the need for tailoring the secondary prevention program (recall frequency, type of intervention, etc) according to the estimated prognosis following APT.

The results of the regression analysis indicated that smoking and the number of sites with $PD \geq 5$ mm (both referred to baseline visit) significantly contributed to predict the subject prevalence of sites showing radiographic bone loss during SPT, thus suggesting that these factors, rather than others (i.e., diabetes, BoP score, bone loss/age), may account for the predictive value for bone loss of the *Perio Risk* method. Unfortunately, the low prevalence of diabetic subjects observed in our study population prevented the

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evaluation of the contribution of diabetes to the prognostic value of the investigated method. Moreover, previous studies demonstrated that BoP is strongly associated with PD. At the site-level, the probability for a site to be BoP+ increased with increasing PD (Farina et al. 2013, 2016), while the BoP score was significantly associated with the number of sites with $PD \geq 5$ mm as assessed at the patient-level (Farina et al. 2011). Therefore, the prognostic value of BoP score could have been masked, at least at sites with the deepest PD values, by the prognostic value of PD (Claffey et al. 1990). In general, these results support the need for future studies based on sufficiently homogeneous patient sample to investigate the contribution of all *Perio Risk* parameters (including diabetes) to the prognostic value of the method. On the other hand, our data suggest that the method could be even further simplified. In this respect, when risk profiles were generated by adding the number of cigarettes per day and the number of sites with $PD \geq 5$ mm at baseline (thus avoiding the use of parameter scores), this simplified version of the method (which was named as *Smart Risk*) showed a significantly greater prognostic value compared to the original version of the *Perio Risk*. The accuracy and reliability of the *Smart Risk*, however, need to be explored and consolidated in future longitudinal trials.

The present findings on the *Perio Risk* must be considered within some limitations, which are partly shared with previous studies on different assessment tools during SPT. First, patients have been retrospectively selected at two centers specialized in the diagnosis and treatment of periodontal diseases. This selection bias has determined an unbalanced distribution of patients according to risk scores, thus limiting the power of our analysis and the possibility to detect significant differences (if any) in SPT outcomes between lowest (scores 1-2) and highest (scores 3-5) risk groups. Similarly, previous

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studies evaluating the prognostic value of the PRA during SPT at a specialist clinic reported a high (>90%) prevalence of subjects with moderate to high risk at the end of active therapy (Matuliene et al. 2010, Costa et al. 2012). Second, the site where SPT was performed differed between patients, with some patients being followed at the study sites while other being referred back to their general practitioners. Although a previous study demonstrated that the dental setting where SPT is performed is a relevant factor to determine the long-term tooth survival and periodontal stability (Axelsson & Lindhe 1981), the limited size of some risk groups in our study prevented the possibility to conduct a sub-analysis to control for the potential effect of the dental setting. In the study by Matuliene et al. (2010), patients attended the SPT program either at University of Berne or they were referred back to private practitioners for SPT, while in the study by Costa et al. (2012) the site for SPT was not explicitly reported. Third, no information is available on patient compliance with the suggested SPT protocol. In this respect, a recent systematic review evaluated the effect of patient compliance on the clinical effectiveness of SPT on the basis of the results from 8 studies with at least a 5-year follow-up. Regularly complying patients showed significantly lower risk of tooth loss than erratic compliers (pooled risk ratio: 0.56) (Lee et al. 2015). The impact of patient adherence to the SPT program on tooth loss was also demonstrated over a 10-year follow-up interval (Pretzl et al. 2008). Differently from our study, previous Authors dedicated part of their analyses to evaluate the impact patient compliance on tooth loss and periodontitis progression during SPT, considering compliance as an independent variable separate from the risk profile (Costa et al. 2012) or as a covariate (Matuliene et al. 2010). Interestingly, compliance to SPT had no significant impact on tooth loss in patients with moderate or high risk profile after active therapy, the lack of significance

being attributed by the Authors to the small number of cases in these risk subgroups (Matuliene et al. 2010).

In conclusion, the results of the present study indicate that periodontal risk assessment according to the *Perio Risk* method (Trombelli et al. 2009) may contribute the identification of patients at risk for tooth loss during SPT.

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CONFLICT OF INTERESTS

The Authors have no conflict of interest to declare related to this study.

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TABLES

Table 1a. *Perio Risk* method: generation of the score related to smoking status.

Table 1b. *Perio Risk* method: generation of the score related to diabetic status.

Table 1c. *Perio Risk* method: generation of the score related to the number of pockets with probing depth ≥ 5 mm.

Table 1d. *Perio Risk* method: generation of the score related to the Bleeding on Probing Score.

Table 1e. *Perio Risk* method: generation of the score related to the extent of bone loss/age.

Table 2. *Perio Risk* method: determination of the risk score. The parameter scores obtained from Tables 1a-e are added and the sum (in parenthesis) is referred to a risk score ranging from 1 to 5.

Table 3. Distribution of patients (number and percentage, in parentheses) according to number of sites with PD ≥ 5 mm and BoP score at each observation interval.

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Table 5. Distribution of patients according to the *Perio Risk* score at the completion of active therapy (baseline) and SPT characteristics in each risk group.

Table 6. Tooth loss and deterioration of periodontal conditions (as expressed by CEJ-BC_{loss}, %_{losing}, and %_{losing*year}) occurred during SPT in patients with different *Perio Risk* risk score at baseline. Data are expressed as mean (\pm SD). A positive value of CEJ-BC_{loss} indicates bone loss.

APPENDIX LEGEND

Appendix 1. Patient selection criteria.

Appendix 2. Calculation of the risk profile according to the *Perio Risk* (Trombelli et al. 2009).

Appendix 3. Patient characteristics at initial visit.

Table 1a. *Perio Risk* method: generation of the score related to smoking status.

smoking status	parameter score
never smoked	0
former smoker	1
1-9 cigarettes per day	2
10-19 cigarettes per day	3
≥20 cigarettes per day	4

Table 1b. *Perio Risk* method: generation of the score related to diabetic status.

diabetic status	parameter score
non diabetic	0
controlled diabetic (sieric HbA1c < 7,0%)	2
poorly controlled diabetic (sieric HbA1c ≥ 7,0%)	4

Table 1c. *Perio Risk* method: generation of the score related to the number of pockets with probing depth ≥ 5mm.

number of pockets with probing depth ≥ 5mm	parameter score
0-1	0
2-4	1
5-7	2
8-10	3
>10	4

Table 1d. *Perio Risk* method: generation of the score related to the Bleeding on Probing Score.

Bleeding on Probing Score (%)	parameter score
0-5%	0
6-16%	1
17-24%	2
25-36%	3
>36%	4

Table 1e. *Perio Risk* method: generation of the score related to the extent of bone loss/age.

		bone loss (n° of teeth with CEJ-BC ≥ 4 mm)				
		0	1-3	4-6	7-10	>10
age (years)	0-25	0	8	8	8	8
	26-40	0	6	6	8	8
	41-50	0	4	4	6	8
	51-65	0	2	4	6	8
	>65	0	0	2	4	6

Table 2. *Perio Risk* method: determination of the risk score. The parameter scores obtained from Tables 1a-e are added and the sum (in parenthesis) is referred to a risk score ranging from 1 to 5.

risk score: 1 LOW risk	risk score: 2 LOW-MEDIUM risk	risk score: 3 MEDIUM risk	risk score: 4 MEDIUM-HIGH risk	risk score: 5 HIGH risk
(0 - 2)	(3 - 5)	(6 - 8)	(9 - 14)	(15 - 24)

Table 3. Distribution of patients (number and percentage, in parentheses) according to number of sites with PD \geq 5 mm and BoP score at each observation interval.

	initial visit	baseline (end of active therapy)	follow-up (last SPT visit)
number of sites with PD\geq 5 mm			
0-1	3 (3)	22 (20)	19 (17)
2-4	3 (3)	26 (24)	19 (17)
5-7	3 (3)	26 (24)	14 (13)
8-10	3 (3)	9 (8)	7 (6)
> 10	97 (89)	26 (24)	50 (46)
BoP score (%)			
0-5	1 (1)	70 (64)	62 (57)
6-16	8 (7)	19 (17)	19 (17)
17-24	11 (10)	12 (11)	12 (11)
25-36	25 (23)	4 (4)	8 (7)
> 36	64 (59)	4 (4)	8 (7)

Table 4. Distribution of patients (number and percentage, in parentheses) according to the mean frequency of attended visits per year of SPT.

Mean frequency of attended visits per year of SPT	n (%)
No SPT	1 (0.9%)
< 1	7 (6.4%)
≥ 1, < 2	20 (18.3%)
≥ 2, < 3	38 (34.9%)
≥ 3	43 (39.5%)

Table 5. Distribution of patients according to the *Perio Risk* score at the completion of active therapy (baseline) and SPT characteristics in each risk group.

<i>Perio Risk</i> score	n of patients	% of patients	SPT duration (years)	n° of SPT sessions
1	5	4	6.2 (± 2.7)	15.2 (± 12.3)
2	6	6	6.2 (± 1.6)	15.3 (± 3.4)
3	20	18	4.7 (± 1.2)	11.9 (± 4.7)
4	65	60	5.7 (± 2.4)	13.7 (± 6.2)
5	13	12	6.1 (± 1.8)	15.8 (± 7.5)
<i>p</i> value (ANOVA)			0.281	0.472

Table 6. Tooth loss and deterioration of periodontal conditions (as expressed by CEJ-BC_{loss}, %_{losing}, and %_{losing*year}) occurred during SPT in patients with different *Perio Risk* risk score at baseline. A positive value of CEJ-BC_{loss} indicates bone loss.

<i>Perio Risk</i> score at baseline	n° of subjects	mean n° of teeth at baseline (± SD)	n° of subjects losing ≥1 teeth (% of subjects within the same risk group)	mean n° of teeth lost (± SD)	mean tooth loss rate per year of SPT (± SD)	CEJ-BC _{loss} (± SD)	% _{losing} (± SD)	% _{losing*year} (± SD)
1	5	25.2 (± 1.5)	0 (0%)	0 (± 0)	0 (± 0)	0.37 (± 0.64)	10.8 (± 22.0)	2.5 (± 5.4)
2	6	25.2 (± 1.4)	3 (50%)	0.8 (± 1.2)	0.17 (± 0.27)	0.40 (± 0.48)	13.6 (± 8.6)	2.3 (± 1.3)
3	20	24.2 (± 0.8)	6 (30%)	0.3 (± 0.6)	0.07 (± 0.12)	0.14 (± 0.44)	11.1 (± 11.8)	2.5 (± 2.8)
4	65	25.6 (± 0.4)	29 (45%)	0.9 (± 1.4)	0.14 (± 0.21)	0.09 (± 0.75)	12.7 (± 14.4)	2.3 (± 2.4)
5	13	25.4 (± 3.3)	7 (54%)	1.8 (± 2.5)	0.32 (± 0.51)	0.17 (± 0.30)	15.9 (± 13.2)	2.8 (± 2.6)
p value (ANOVA, Tukey- Kramer)		0.642	0.102 (χ^2 test)	0.041 (R3 ≠ R5)	0.053	0.753	0.905	0.979