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ORIGINAL ARTICLE

Periodontal inflamed surface area and periodontal case definition classification

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ABSTRACT

Objective: To assess whether a higher periodontal inflamed surface area (PISA) may reflect more severe periodontitis, and if so, to calculate which cut-off point should be used to classify a patient as suffering from periodontitis.

Material and methods: Eighty subjects were selected based on their periodontal status and were divided into 4 groups of 20 each; periodontally healthy, mild periodontitis, moderate periodontitis and severe periodontitis. In addition, demographic data, smoking status and socioeconomic status were also recorded.

Results: The highest mean PISA value was obtained for the severe periodontitis group ($2309.42 \pm 587.69\,mm^2$) and the least for the periodontally healthy ($34.30 \pm 16.48\,mm^2$). The PISA values corresponding to the three categories of periodontitis severity were significantly higher than the periodontally healthy group. When receiver operating characteristic (ROC) analysis was performed, a PISA value $\geq 130.33\,mm^2$ predicted the presence of periodontitis with a sensitivity of 98% and a specificity of 100%.

Conclusions: PISA is a periodontal parameter that may be used in conjunction with the Centers for Disease Control and Prevention – American Academy of Periodontology case definition classification in periodontal medicine research.

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Introduction

The estimation of the prevalence of chronic periodontitis is influenced by case definitions of this disease as well as recording protocols [1]. Diagnosis of periodontitis is based on severity and extent of clinical attachment level (CAL) and probing pocket depth (PPD). In 2007, the Centers for Disease Control and Prevention (CDC) in collaboration with the American Academy of Periodontology (AAP) developed case definitions for moderate and severe periodontitis for use in epidemiological research [2]. In addition, the same working group published in 2012 an updated paper, where they introduced the definition of mild periodontitis cases [3].

The lack of a universal periodontal case definition has led both European and American experts in this field to publish a consensus paper in which they suggest that the case definitions developed by the CDC-AAP is the one that has to be used in periodontal epidemiological studies [4]. However, this classification is based on linear measures (i.e. PPD and CAL) and may not quantify the amount of inflamed periodontal tissue. Periodontal inflammation, which occurs locally but can disseminate systemically, is the biological basis for the plausibility of any potential association between periodontitis and several other diseases. In this sense, any classification of periodontitis as a potential risk factor of any systemic condition should quantify the inflammatory burden posed by periodontitis. For this reason, in 2008, a new classification was developed, namely the periodontal inflamed surface area (PISA), which is based not only on linear measures such as CAL and gingival recession (GR) but also on a sign of periodontal disease activity [i.e. bleeding on probing (BOP)]. Thus, PISA reflects the surface area of bleeding pocket epithelium in square millimetres (mm^2) [5].

This study was conducted with the aim of assessing whether a higher PISA may reflect more severe periodontitis, and if so, to calculate which cut-off point should be used to classify a patient as suffering from periodontitis.

Material and methods

Randomly from the patients who attended the School of Dentistry, University of Santiago de Compostela, Spain, between November 2016 and February 2017, per group 20 patients periodontally healthy, mild periodontitis, moderate periodontitis and severe periodontitis were selected. Therefore, in total 80 subjects were included in the study (mean age 54.2 ± 8.3 years; 62.5% male) and all of them underwent a full-mouth periodontal examination performed by a calibrated dentist (Y.L.) [6]. Exclusion criteria for all subjects were as follows: (1) known systemic diseases; (2) < 15 teeth (excluding third molars); (3) aggressive periodontitis

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diagnosis (i.e. rapid attachment loss and bone destruction proven by radiographs in subjects <30 years of age at the time of the initial diagnosis as well as familial aggregation of the cases) [7,8]; 4) patients who had received periodontal treatment in the previous 12 months; 5) systemic antibiotics, corticosteroids, and/or immunosuppressant therapy within 3 months prior to periodontal assessment; and 6) chronic use of non-steroidal anti-inflammatory drugs (NSAIDs).

The presence of periodontitis was defined according to the CDC-AAP consensus for epidemiologic studies [3,4]. Therefore, mild periodontitis was defined as ≥2 interproximal sites with CAL ≥3 mm and ≥2 interproximal sites with PPD ≥4 mm (not on the same tooth) or 1 site with PPD ≥5 mm. Moderate periodontitis was defined as ≥2 interproximal sites with CAL ≥4 mm (not on the same tooth) or ≥2 interproximal sites with PPD ≥5 mm, also not on the same tooth. Severe periodontitis was defined as the presence of ≥2 interproximal sites with CAL ≥6 mm (not on the same tooth) and ≥1 interproximal site with PPD ≥5 mm.

In addition, a recently introduced measure of periodontitis severity, the PISA was calculated. PISA reflects the surface area of bleeding pocket epithelium in mm^2. Briefly, PISA was calculated with a Microsoft Excel spreadsheet in the following steps: 1) Mean CAL and GR for each particular tooth is calculated; 2) Linear mean CAL and GR is translated into the periodontal epithelial surface area (PESA) for each specific tooth [9]. The PESA for a particular tooth consists of the root surface area of that tooth measured in mm^2, which is covered with pocket epithelium; 3) The PESA for a specific tooth is then multiplied by the proportion of sites around the tooth that was affected by BOP, resulting in the PISA for that particular tooth; and 4) The sum of all individual PISAs around individual tooth is calculated, rendering the full-mouth PISA value in mm^2 of each participant [5].

Besides periodontal parameters, demographic data, smoking habits as well as socioeconomic status (SES) were recorded from the patient's clinical history.

The research was performed in accordance with the Declaration of Helsinki of the World Medical Association (2008) and approved by the Ethics Committee of the Servizo Galego de Saúde. Informed consent was obtained from each patient or their relatives after full explanation of the periodontal examination.

Statistical analysis

The sample size calculation was performed using the Macro! NSize for PASW Statistics (http://www.metodo.uab.cat/macros.htm.), based on PISA mean values of a previous report [5]. To detect a difference in the PISA value of 1020 mm^2 between periodontally healthy and severe periodontitis patients, assuming α-risk = .05 and β-risk = .20, a sample of 20 subjects per group was needed to achieve a significance level of .05 and a statistical power of 80%.

Analysis was performed with IBM SPSS Statistics 20.0 software for Mac (SPSS Inc., Chicago, IL). Mean values and standard deviation (mean ± SD) were calculated for continuous variables, after the method of Kolmogorov–Smirnov was applied to confirm that the data were sampled from a Gaussian distribution. Categorical data were reported as percentages (%) and compared by X^2 test. One-way analysis of variance (*ANOVA*) was used to compare the mean PISA values among the study groups. Additionally, Bonferroni *post-hoc* tests for multiple comparisons between groups were used. To calculate the best discriminant cut-off point of the mean PISA to identify periodontitis, a receiver operating characteristic (ROC) analysis was carried out. A significant difference was set to be at $p < .05$.

Results

No differences were observed between groups in relation to demographic data (i.e. age and gender), smokers and SES (Table 1).

The results depicted in figure indicate that mean PISA value was the lowest in the periodontally healthy group (34.30 ± 16.48 mm^2). The highest value corresponds to the most severe periodontitis group (2309.42 ± 587.69 mm^2), followed by the moderate (645.66 ± 86.29 mm^2) and mild group (292.74 ± 98.08 mm^2). Differences among groups were statistically significant (*ANOVA* test, $p < .0001$).

Attention should be drawn to the minimum and maximum of each study group in order to establish an approximated range of PISA values according to each CDC-AAP category. Severe periodontitis group values ranged from 934.71 to 3274.96 mm^2; moderate periodontitis group ranged from 521.58 to 790.30 mm^2; mild periodontitis group values

Table 1. Characteristics of the study sample.

Variables	Healthy ($n = 20$)	Mild periodontitis ($n = 20$)	Moderate periodontitis ($n = 20$)	Severe periodontitis ($n = 20$)	p Value
Age	51.6 ± 9.1	52.2 ± 8.2	56.4 ± 8.9	56.7 ± 5.7	.095[a]
Gender					.504[b]
–Male, *n* (%)	12 (60.0)	10 (50.0)	14 (70.0)	14 (70.0)	
–Female, *n* (%)	8 (40.0)	10 (50.0)	6 (30.0)	6 (30.0)	
Smoker					.087[b]
–Never, *n* (%)	14 (70.0)	12 (60.0)	12 (60.0)	8 (40.0)	
–Former, *n* (%)	4 (20.0)	2 (10.0)	0 (0.0)	2 (10.0)	
–Current, *n* (%)	2 (10.0)	6 (30.0)	8 (40.0)	10 (50.0)	
SES					.110[b]
–High, *n* (%)	2 (10.0)	2 (10.0)	4 (20.0)	2 (10.0)	
–Middle, *n* (%)	13 (65.0)	8 (40.0)	13 (65.0)	7 (35.0)	
–Low, *n* (%)	5 (25.0)	10 (50.0)	3 (15.0)	11 (55.0)	

SES: socio-economic status.
[a]*ANOVA* test with Bonferroni *post-hoc* analysis.
[b]X^2 test.

were between 110.16 and 447.01 mm^2; and; the group without periodontitis showed PISA values between 10.22 and 62.78 mm^2. All periodontitis groups showed significantly higher values compared with the periodontally healthy group. When the comparison of mean PISA between the three categories of the CDC-AAP case definition was done, a highly significant difference was found between moderate periodontitis versus mild periodontitis ($p = .002$), Severe periodontitis versus mild periodontitis ($p < .0001$), and severe periodontitis versus moderate periodontitis ($p < .0001$) (Figure 1).

Finally, the ROC analysis showed an area under the curve of 1.000 (95% CI: 1.000–1.000, $p < .0001$), which suggests that a value $\geq$130.33 mm^2 identify periodontitis presence, with a sensitivity of 98% and a specificity of 100%.

Discussion

Results from the present study provided the PISA values for the different categories of CDC-AAP periodontal case definition classification. As was expected, the severe periodontitis group showed the highest PISA values ranging from 934.71 to 3274.96 mm^2.

It is believed that periodontitis may be associated with some of the most worldwide prevalent diseases such as atherosclerotic vascular disease [10,11], diabetes mellitus [12] or Alzheimer's disease [13]. Nevertheless, due to variability in periodontal case definitions and the lack of an adequate tool to quantify the inflammatory burden posed by periodontitis, PISA was developed to be used as the key parameter in periodontal medicine studies [5]. Previously, it has been shown a dose–response association between PISA and HbA_{1c} levels in diabetics [14]. Moreover, high values of PISA were associated with decreased kidney function [15].

In our study, we have calculated PISA values from 80 individuals, who were classified according to the CDC-AAP case definition consensus, in an attempt to give the approximated range of PISA for each group. Although in the paper written by Nesse et al. they describe the corresponding PISA value for a periodontally healthy subject as well as for a severe periodontal patient [5], data showed from the present study is in relation to the different categories of periodontitis severity proposed by the CDC-AAP consensus. However, in our investigation the minimum and maximum PISA values for healthy subjects and for severe periodontitis patients did not differ from the ones obtained in the aforementioned study [5]. Indeed, they presented PISA from a healthy periodontium with a value of 28.6 mm^2, which is in our periodontally healthy PISA range (10.22–62.78 mm^2). Furthermore, PISA from localized and generalized severe periodontitis in the study by Nesse et al. [5] was 1048.6 mm^2 and 3704.2 mm^2, respectively; both of them almost within our PISA advanced group range (934.71–3274.96 mm^2).

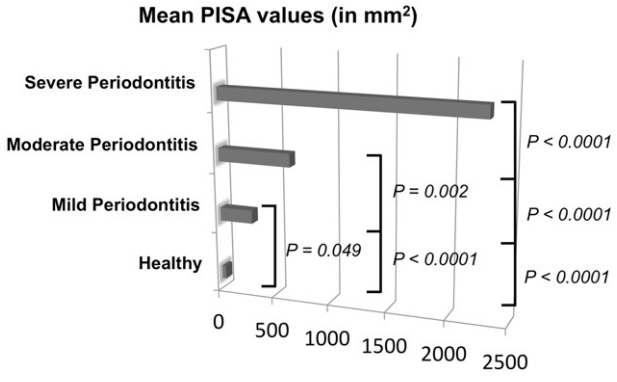

Figure 1. Mean PISA values according to periodontal status.

We also compared PISA values between the different CDC-AAP groups. Statistically significant differences were observed when each of the three CDC-AAP periodontal categories was compared with periodontally healthy patients. Moreover, results from the ROC analysis showed that a cut-off value of PISA $\geq$130.33 mm^2 could be a strong predictor of periodontitis presence, showing a sensitivity of 98% and a specificity of 100%. Hence, this method could be used in addition to the CDC-AAP classification, due to PISA is a continuous periodontal variable that can be easily quantify rather than dichotomous measures (i.e. CAL and PPD categorized).

PISA tool has several limitations. The formulas that transform CAL and GR into surface area are based on mean values of both root surface area and root lengths, therefore, leading to bias when PISA is calculated [5]. Patients with gingival overgrowth may also influence PISA calculation, resulting in an underestimation of the real value. Wisdom teeth must be excluded from the analysis [16], due to the fact that pseudopockets are highly frequent and they could also lead to a slight underestimation of true PISA. Nevertheless, in periodontitis it appears that the host overreacts to infectious stimuli by releasing increased amount of inflammatory mediators that may be disseminated to systemic circulation [17,18], which may contribute to pathogenesis of other diseases far beyond the mouth [19]. Because PISA reflects the amount of periodontal inflamed tissue, it could be an accurate method to assess both infectious and inflammatory burden posed by periodontitis and, therefore, may be used as a parameter in periodontal medicine research.

Within the limitations of the present study, it can be concluded that a PISA value $\geq$130.33 mm^2 could identify patients with periodontitis according to the CDC-AAP classification. It seems that PISA is a periodontal parameter that may be used in conjunction with the CDC-AAP case definition classification when periodontitis is investigated as a potential risk factor of systemic diseases. Furthermore, we provided estimates of PISA values in relation to each CDC-AAP category in order to facilitate researchers an approximated range. Further epidemiological studies are warranted to verify our results. Moreover, future research is needed to evaluate PISA as a periodontal variable in periodontal medicine studies.

Disclosure statement

The authors report no conflicts of interest.

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