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ORIGINAL ARTICLE

Metabolic syndrome as a risk indicator for periodontal disease and tooth loss

Marta L. Musskopf[1,2] · Luciana D. Daudt[1] · Patrícia Weidlich[1] · Fernando Gerchman[3] · Jorge L. Gross[3] · Rui V. Oppermann[1]

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Abstract
Objectives The aim of the present study was to evaluate the association of metabolic syndrome (MS) with periodontitis (PE) and tooth loss (TL).
Materials and methods A cross-sectional study was conducted with 363 individuals who underwent full-mouth periodontal examination, and the association between MS and PE was evaluated considering three outcomes: severe periodontitis, mean probing depth ≥2.4 mm, and mean clinical attachment loss ≥2.0 mm. The prevalence ratio (PR) between MS and PE was calculated using a model adjusted for gender, age, smoking, years of education, and socioeconomic status.
Results The adjusted model showed a PR for severe periodontitis of 1.17 (95 % CI 0.83–1.65). There was no significant association between MS and PE defined as mean probing depth ≥2.4 mm. MS was significantly associated with PE defined as mean attachment loss ≥2 mm in individuals aged 41–60 years (PR 1.47, 95 % CI 1.05–2.06). In addition, MS was associated with TL (>6 teeth) (PR 1.23, 95 % CI 1.02–1.49) for all ages, both in crude and adjusted analyses.
Conclusions We concluded that there is a weak association of MS with both attachment loss and TL.
Clinical relevance Patients with MS seem to have a higher risk of attachment loss and tooth loss and should be screened for periodontal disease.

Keywords Metabolic syndrome · Periodontitis · Periodontal attachment loss · Tooth loss

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✉ Marta L. Musskopf
martalmusskopf@gmail.com

[1] Department of Periodontology, Federal University of Rio Grande do Sul, Porto Alegre, Brazil

[2] Department of Periodontology, Lutheran University of Brasil, Canoas, Brazil

[3] Division of Endocrinology, Hospital de Clínicas de Porto Alegre, Federal University of Rio Grande do Sul, Porto Alegre, Brazil

Introduction

Metabolic syndrome (MS) has been given much attention recently [1–4]. This syndrome consists of a set of metabolic abnormalities, such as high blood pressure, altered glucose homeostasis, hypertriglyceridemia, low HDL cholesterol, and abdominal obesity [5]. MS may be considered a cluster of risk factors for cardiovascular diseases and diabetes [6], and its prevalence has been increasing according to several studies, [7–10] mainly in developing countries [10, 11]. Low-grade systemic inflammation may be the link between both conditions. Insulin resistance is a key point in the pathophysiology of MS, while diabetes and obesity are common risk factors between MS and periodontitis (PE) [6, 12, 13].

The association of MS with PE has been investigated over the past decade [8, 9, 14–22]. Cross-sectional studies [9, 16–18, 22–24] and a few case-control [8, 25] and cohort studies [14] have investigated the possible association of MS with PE, both in the sense of MS as a risk factor for PE or vice versa [14, 17, 22, 26]. Regardless of the cutoff points for the diagnosis criteria used for both the definition of MS and PE, some [16, 19, 24, 25, 27] studies have shown a positive association between these two diseases. A positive association has also been found in a recently published systematic review with meta-analysis [28].

Although the results of these [16, 19, 25, 27, 29] studies suggested an association between the two conditions, some aspects still need to be clarified. Most [2, 8, 19–21, 24, 25, 29, 30] studies were conducted in Asian countries with a predominantly Eastern population. Some studies have only found this association among women, [23] never smokers, or in a specific age group [17]. In addition, methodological issues, such as partial-mouth periodontal examination and definition of disease based on the community periodontal index, [31] may have provided biased results.

With that in mind, the objective of the present study was to investigate the association of MS, defined according to the 2009 criteria of the International Diabetes Federation (IDF), [5] and PE based on full-mouth periodontal examination and considering its main surrogate endpoints as well as tooth loss.

Methods

Study design

We conducted a cross-sectional study with a comparison group evaluating patients with and without metabolic syndrome regarding their periodontal status. Data report was performed according to STROBE [32] and Holtfreter et al. [33] recommendations.

Study population

A nonrepresentative sample composed of 363 individuals between 18 and 81 years, 232 women, included patients being treated at the outpatient clinic of the Department of Endocrinology and Metabolism of the Hospital de Clínicas de Porto Alegre from Federal University of Rio Grande do Sul, Porto Alegre, Brazil (Center A). The sample also included patients who sought dental care at the dental clinic of the School of Dentistry of the Federal University of Rio Grande do Sul (UFRGS) (Center B) between January 2012 and October 2013 (Fig. 1: flowchart). This study was approved by the Ethics Research Committees of the Hospital de Clínicas de Porto Alegre and UFRGS. Among the patients invited to participate in the study, those individuals who received a diagnosis of metabolic syndrome were allocated to the exposed group, whereas the participants without metabolic syndrome were included in the unexposed group.

Sample size estimate

Sample calculation

Considering a difference of 13 % [16] in the prevalence rates of periodontitis between individuals with and without metabolic syndrome, a power of 80 % and alfa error of 5 % (two-tailed), the estimated sample size was 308 individuals. After adding an attrition rate of 20 %, the required sample size was 369 individuals.

Eligibility criteria

In order to be able to participate in the study, patients had to fulfill the following criteria: age ≥18 years, no previous periodontal treatment (including subgingival scaling) in the past 6 months, no antibiotic therapy in the past 3 months, no need of antibiotic chemoprophylaxis for dental examination, and not being pregnant. In addition, individuals who used fixed orthodontic braces, were on systemic corticosteroids, and did not have at least six teeth were excluded from the study.

Data collection instruments

All participants had a guided face-to-face interview performed by a trained interviewer (Tuane Regina Grecchi—Department of Periodontology, Federal University of Rio Grande do Sul, Porto Alegre, Brazil). Data concerning sociodemographic and socioeconomic characteristics, smoking status, and previous medical history were collected. Age was stratified in three categories (19–40 years, 41–60 years, and >60 years); self-reported race/skin color was categorized into white and non-white. Socioeconomic status was assessed using the Brazilian Criteria for Economic Classification [34], and participants were categorized into low/medium socioeconomic status and high socioeconomic status. Education was stratified according to education system in Brazil in elementary school (≤8 years) and secondary school (≥9 years). Smoking was categorized in never smokers and current/former smokers. Data on alcohol consumption was collected dichotomously (yes/no).

All patients had blood samples collected at the same facility (Clinical Research Center of the Hospital) after fasting for 12 h. All patients' laboratory results were processed at the Pathology Department of the hospital. High-density lipoprotein cholesterol was analyzed by homogeneous enzymatic colorimetric assay, triglycerides were analyzed by enzymatic colorimetric assay, and glucose was analyzed by hexokinase enzymatic assay. All of them were performed in Siemens Advia 1800 Chemistry Analyzer (Erlangen, Germany) equipment. Participants' waist circumference was measured while the individuals were standing, without any piece of clothing around their waist. A tape measure was placed horizontally around the waist at the level of the navel. Blood pressure was measured while the individuals were seated after at least 5-min rest. A digital sphygmomanometer was used three times. The first measurement was not considered, and the mean value of the 2nd and 3rd measurements was recorded.

Metabolic syndrome was defined according to the criteria of the International Diabetes Federation [5]: increased waist circumference: ≥90 cm for men and ≥80 for women (cutoff

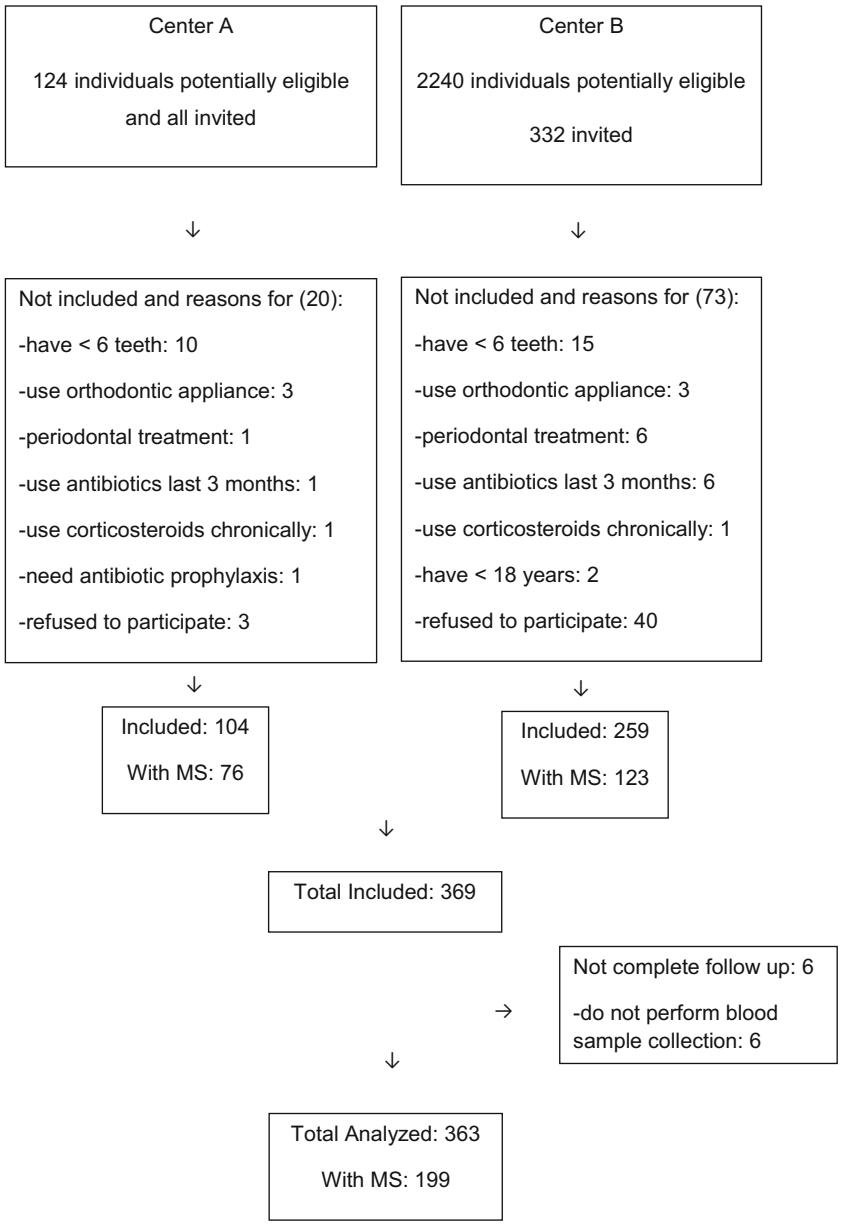

Fig. 1 Flowchart

points for South American populations), hypertriglyceridemia: triglycerides ≥150 mg/dL (1.7 mmol/L) or under treatment for hypertriglyceridemia, HDL cholesterol below 40 mg/dL for men and lower than 50 mg/dL for women or being under treatment, high blood pressure at the time of the examination (systolic ≥130 mmHg and diastolic ≥85 mmHg) or being under treatment for high blood pressure, and blood glucose ≥100 mg/dL or diagnosis of diabetes or use of medication for glycemic control. Those individuals showing three out of the five aspects mentioned above were diagnosed with metabolic syndrome.

Full-mouth periodontal examination was performed at six sites of every tooth, except for third molars using a manual periodontal probe (Neumar, North Caroline Probe 15, São Paulo, Brazil). The examination was performed by two trained and calibrated examiners (MLM and LDD) (weighted Kappa coefficient ± 1 mm above 0.8 and intraclass correlation coefficient above 0.9) and recorded in a standardized form. The following data were collected: number of teeth, visible plaque index (VPI) [35], gingival bleeding index (GBI) [33], plaque retentive factors, probing depth (PD), periodontal bleeding (PB), and attachment loss (AL).

Data analysis

The continuous variables were expressed as mean and standard deviation, whereas the categorical variables were expressed as absolute and relative frequencies. The groups were compared using independent *t* test for continuous variables with normal distribution, Mann-Whitney U test for

continuous variables with non-normal distribution, and chi-square test for categorical variables. The association between metabolic syndrome and periodontitis was assessed using univariate and multivariate analysis with Poisson regression with robust variance. Periodontitis was considered the dependent variable. All independent variables with $p < 0.25$ in the univariate analysis were included in the final model.

The association between metabolic syndrome and periodontitis was evaluated considering three different categorical outcomes: (1) AL ≥6 mm in at least two sites of different teeth and PD ≥5 mm in at least one proximal site [36] (yes/no), (2) mean PD ≥2.4 mm (yes/no), and (3) mean AL ≥2.0 mm (yes/no). Receiver operating characteristic (ROC) curves were performed to identify the best cutoff values for PD and AL for prediction of periodontitis based on the severe periodontitis definition [36]. Prevalence ratios were calculated and the final model was adjusted for gender, age, smoking status, years of education, and socioeconomic status. The inclusion of age in the model changed the estimates, suggesting that age was a confounding variable. The subgroup analysis was then stratified by age groups in the following categories: 19–40 years, 41–60 years, and ≥60 years.

The association between metabolic syndrome and tooth loss was also evaluated. The number of teeth lost was the dependent variable, and the participants were classified into two categories: those who had less than six teeth lost or those who had six or more teeth lost. This cutoff point was based on the median of the sample.

All statistical interaction models between metabolic syndrome and the other variables related to periodontitis and multicollinearity between the variables, such as years of education and socioeconomic status, were tested and discarded. Each individual was the unit of analysis and the significance level was set at 5 %.

Results

Table 1 shows sociodemographic variables and smoking status from the sample by MS status. Of the 363 participants, 199 (54.8 %) were diagnosed with MS and these individuals were older, had lower educational level, and were more exposed to tobacco when compared to individuals without MS. There were no significant differences in relation to gender, skin color, and socioeconomic status among individuals with and without MS.

Periodontal parameters, anthropometric data, and metabolic syndrome components are presented in Table 2. Those individuals with MS had fewer teeth, higher percentage of calculus, higher AL mean, and higher percentage of sites AL ≥3 mm in relation to subjects without MS. Severe periodontitis was present in a higher frequency in individuals with MS (32.6 %) when compared to the individuals without MS (20.1 %, $p < 0.01$). The same was true for body mass index; the MS group presented higher percentages of overweight and obese subjects. The components of MS evaluated individually showed statistically significant difference among the groups, indicating that MS patients had higher blood pressure, more abdominal obesity, lower levels of HDL, and higher levels of hypertriglyceridemia and hyperglycemia in relation to the individuals without MS.

Table 3 shows crude and adjusted data for the association of MS with the three outcomes assessed. The univariate analysis showed an association of MS with severe periodontitis and AL ≥2 mm. The association with AL ≥2 mm remained significant in the adjusted model.

When different age strata were considered, MS was not associated with severe periodontitis for all age groups. The same was true for the association with PD ≥2.4 mm. There was a significant weak association between MS and AL ≥2 mm in middle-aged adults 41–60 years in the adjusted model (Table 4), indicating that subjects with MS aged 41–60 years has a 44 % higher prevalence of attachment loss ≥2 mm when compared to individuals without MS.

The analysis of the relationship of MS with tooth loss (Table 5) showed that MS is associated with tooth loss with a prevalence ratio of 1.24 (95 % CI 1.03–1.49, $p = 0.02$) even after adjusting for gender, age, smoking, years of education, and socioeconomic status.

Discussion

This cross-sectional study showed that periodontal condition and tooth loss are associated with MS. Middle-aged adults with MS have 44 % higher prevalence of AL, and adults with MS have 23 % higher prevalence of tooth loss when compared with subjects without the systemic condition.

In agreement with our study, MS was associated with AL in other studies [2, 8, 18, 20]. Previous studies with similar populations in terms of gender and age have also found a relationship between MS and PE [17, 24, 27]. Some studies have also demonstrated that middle-aged adults are the most affected by periodontal diseases and by the presence of MS [17, 25]. Biological mechanisms linking metabolic syndrome and periodontitis include a low-grade systemic inflammation condition driven mainly by insulin resistance that generates an imbalance in lipids, triglycerides, and glucose metabolism. Obesity also contributes and exacerbates the dismetabolic and inflammatory state [6, 12, 13].

There was no significant association between MS and PE defined as PD ≥2.4 mm. Some studies have been conducted to evaluate only PD, especially studies using the community periodontal index for the definition of PE, and found an association between MS and PE [19, 21, 24–27]. Timonen et al. assessed the number of teeth with PD ≥4 mm and the number

Table 1 Sociodemographic variables, smoking status, and alcohol consumption from the sample by metabolic syndrome status

Variables	No metabolic syndrome *n* (%)	Metabolic syndrome[a] *n* (%)	*p**
Gender	54 (32.9)	78 (39.2)	0.23
Male	110 (67.1)	121 (60.8)	
Female			
Age (mean ± sd)	43 (±12.1)	51.9 (±11.8)	<0.001
19–40 years	70 (42.7)	35 (17.6)	<0.001
41–60 years	86 (52.4)	117 (58.8)	
>60 years	8 (4.9)	47 (23.6)	
Race/skin color	116 (70.7)	148 (74.4)	0.48
White	48 (29.3)	51 (25.6)	
Nonwhite			
Years of education	48 (29.3)	84 (42.2)	0.01
≤8 years	116 (70.7)	115 (57.8)	
≥9 years			
Smoking status	102 (62.2)	101 (50.7)	0.03
Non-smoker	62 (37.8)	98 (49.3)	
Former/current smoker			
Alcohol consumption	115 (70.1)	158 (79.4)	0.05
No	49 (29.9)	41 (20.6)	
Yes			
Socioeconomic status	61 (37.2)	78 (39.2)	0.74
High	103 (62.8)	121 (60.8)	
Low/medium			
Total	164 (100)	199 (100)	

*Independent *t* test for continuous variables and chi-square for categorical variables

[a] Metabolic syndrome according to International Diabetes Federation 2009 [5]

of teeth with PD ≥6 mm as the outcome. For the first criterion, they found a weak association (OR 1.19, CI 1.01–1.42) between MS and PE, whereas, for the second criterion, the association was not significant (OR 1.50, CI 0.96–2.36) [38]. In a recent study, Michalowicz et al. concluded that, except for sites with initially deep PD (>7 mm), changes in PD were not reliable predictors of increased AL [39]. A systematic review with meta-analysis evaluated part of the published studies and found a positive association for MS and PE, with OR=1.71 (95 % CI 1.42–2.03), but with heterogeneity of i^2 = 53.6 % (p = 0.004) [28]. These values show a high heterogeneity, above 50 %, according to the classification of Higgins and Thompson [40]. Such high values may be associated with different criteria to define PE and MS and lack of association measures adjusted for some studies. The authors concluded that, because of this heterogeneity, the results of this systematic review with meta-analysis should be interpreted with caution.

Conversely, some studies have not found a positive association between MS and PE [3, 16, 22]. The heterogeneous characteristics of the samples in investigated populations, such as ethnicity, age, socioeconomic status, and disease severity and extension, may lead to conflicting results. A higher socioeconomic status was highlighted by Benguigui et al. [16] as one of the possible reasons why no association was found between periodontitis and metabolic syndrome in their study. Borges et al. [22] emphasized the high prevalence of tooth loss found in their study. Such finding was possibly related to a history of AL. However, these authors did not find an association of metabolic syndrome with periodontitis, which was defined only according to PD (Community Periodontal Index [33]). La Monte et al. [3] investigated a sample of women in the postmenopausal period and did not find a positive association between metabolic syndrome and periodontitis based on the definition proposed by Page and Eke [36] using PD and AL separately or evaluating alveolar bone height. As possible explanations for their findings, La Monte et al. [3] considered the lower prevalence of metabolic syndrome compared with women of the same age in their country, the small number of smoking women, and the higher level of education of that sample.

Another factor that may be related with the different results of those studies investigating the association between metabolic syndrome and periodontitis is the drug treatment received by some patients with metabolic syndrome. Only one study clearly reported the inclusion of individuals with untreated metabolic syndrome [2]. In this study, an association was found in terms of PD and AL >4 mm.

Table 2 Periodontal, anthropometric, and metabolic characteristics from the sample

Variables	No metabolic syndrome (n = 164)	Metabolic syndrome[a] (n = 199)	p*
Number of teeth (mean ± sd)	22.2 (±5.9)	18.7 (±6.8)	<0.001
Visible plaque (% sites ± sd)	38.7 (±21.8)	42.7 (±19.7)	0.07
Gingival bleeding (% sites ± sd)	18 (±15.8)	17.8 (±13.8)	0.91
Calculus (% sites ± sd)	21.6 (±15.3)	27.5 (±17)	0.001
Probing depth mm (mean ± sd)	2.4 (±0.5)	2.4 (±0.6)	0.72
Probing depth 0–3 mm (% sites ± sd)	90.4 (±12.9)	88.9 (±14.1)	0.3
Probing depth 4–6 mm (% sites ± sd)	8.9 (±11.5)	9.9 (±12)	0.41
Probing depth ≥7 mm (% sites ± sd)	0.7 (±2.2)	1.2 (±3.4)	0.11
Attachment loss (mean ± sd)	1.4 (±1.3)	2.2 (±1.6)	<0.001
Attachment loss ≥3 mm (% sites)	20.1 (±26.4)	34 (±30.6)	<0.001
Bleeding on probing (% sites)	39.9 (±18.8)	42.7 (±19.2)	0.16
Severe periodontitis[b]	33 (20.1)	65 (32.6)	<0.01
High blood pressure n (%)	58 (24.7)	177 (75.3)	<0.001
Body mass index[c] kg/m^2 (mean ± sd)	26.7 (5.1)	31.1 (6.6)	<0.001
Underweight/normal n (%)	66 (40.2)	27 (13.6)	<0.001
Overweight n (%)	64 (39.1)	81 (40.7)	
Obese n (%)	34 (20.7)	91 (45.7)	
Waist circumference (mean ± sd)	92.7 (±13.2)	103.7 (±11.5)	<0.001
Men	90.4 (±12.4)	103.2 (±13)	<0.001
Women	121 (73.8)	194 (97.5)	<0.001
Abdominal obesity[d] n (%)			
High-density lipoprotein cholesterol	45.63 (±9.9)	39.6 (±8.1)	<0.001
Men (mean ± sd)	56.24 (±14.7)	44.3 (±8.9)	<0.001
Women (mean ± sd)	53 (32.3)	161 (80.9)	<0.001
Low high-density lipoprotein cholesterol[d] n (%)			
Triglycerides (mean ± sd)	89.2 (±35.9)	170.7 (±101.2)	<0.001
High triglycerides[d] n (%)	7 (4.3)	106 (53.3)	<0.001
Glucose (mean ± sd)	86.8 (±23.3)	101.6 (±32.1)	<0.001
High glucose/diabetes[d] n (%)	8 (4.9)	93 (46.7)	<0.001

*Metabolic syndrome according to the International Diabetes Federation 2009 [5]

[a] Independent t test for continuous variables and chi-square for categorical variables

[b] Severe periodontitis according to Page and Eke, 2007 [34]

[c] BMI classification according to WHO [37]

[d] Cutoff points according to the International Diabetes Federation, 2009

Table 3 Prevalence ratio (PR) of the association between metabolic syndrome and dependent variables: severe periodontitis, mean probing depth ≥2.4 mm, and mean attachment loss ≥2.0 mm

	Severe periodontitis		Mean probing depth ≥2.4 mm		Mean attachment loss ≥2.0 mm	
	Crude PR (95%CI) p value	Adjusted PR[a] (95%CI) p value	Crude PR (95%CI) p value	Adjusted PR (95%CI) p value	Crude PR (95%CI) p value	Adjusted PR (95%CI) p value
Metabolic syndrome	1.62 (1.13–2.34) <0.01	1.17 (0.83–1.65) 0.38	1.04 (0.83–1.33) 0.69	1.05 (0.82–1.34) 0.72	2.05 (1.49–2.82) <0.001	1.38 (1.03–1.84) 0.03

[a] Adjusted for gender, age, smoking status, years of education, and socioeconomic status

Table 4 Prevalence ratio (PR) of the association between metabolic syndrome and severe periodontitis (PE), mean probing depth ≥2.4 mm (PD), and mean attachment loss ≥2.0 mm (AL) by age strata

	19–40 years				41–60 years				>60 years			
	Crude PR (95%CI)	*p*	Adjusted[a]PR (95%CI)	*p*	Crude PR (95%CI)	*p*	Adjusted PR (95%CI)	*p*	Crude PR (95%CI)	*p*	Adjusted PR (95%CI)	*p*
PE	2 (0.42–9.4)	0.38	1.41(0.39–5.04)	0.6	1.25(0.85–1.84)	0.25	1.13(0.77–1.68)	0.52	0.9(0.34–2.42)	0.85	1.06(0.52–2.17)	0.87
PD	1.31 (0.87–1.98)	0.20	1.21 (0.80–1.82)	0.37	0.99 (0.72–1.35)	0.93	0.98 (0.71–1.34)	0.88	1.08 (0.41–2.81)	0.88	1.04 (0.50–2.14)	0.91
AL	1.33 (0.23–7.62)	0.75	0.78 (0.14–4.23)	0.78	1.47 (1.05–2.06)	0.03	1.44 (1.04–1.99)	0.03	1.28 (0.62–2.64)	0.51	1.28 (0.67–2.46)	0.46

[a] Adjusted for gender, smoking status, years of education and socioeconomic status

Metabolic syndrome was also associated with tooth loss even after adjusting for the same variables (gender, age, smoking, years of education, and socioeconomic status). A few studies used the number of teeth as a variable for adjusting the relationship models between metabolic syndrome and periodontitis [20, 21]. This measure is essential to assess the relationship between metabolic syndrome and periodontal condition, particularly in older populations, because, as a consequence of a higher prevalence of tooth loss, the history of periodontitis is underestimated if assessed based only on AL. In addition, tooth loss is a true outcome of periodontitis [41]. Our findings related to tooth loss are confirmed by other studies showing that individuals with metabolic syndrome have more teeth lost [42, 43] and that there is an inverse relationship between the presence of metabolic syndrome and the number of teeth [1]. Few studies, such as the one by Holmlund et al. using self-reported tooth loss, evaluated this relationship [42]. Recently, Zhu et al. found a positive association between smaller number of teeth and higher prevalence of metabolic syndrome [1].

Some limitations of the present study should be mentioned. The cross-sectional design does not allow determining the direction of the causal relations. Our sample is not representative of the population. In an epidemiological survey with a representative sample from the same geographical region, a higher prevalence of periodontitis (42 %) was found [44]. Higher proportion of women, higher socioeconomic status, and different age group seem to be the factors that explain these differences. Our adjusted association estimates may be considered low if compared to the results reported by other studies [8, 18, 19, 26]. It is important to point out that interpretation of the estimates for the age stratified analysis should be drawn with caution considering that these *p* values are dependent on the number of cases in each stratum. Methodological issues related to the protocol of periodontal examination (partial or full) and the criteria used for diagnosis

Table 5 Prevalence ratio (PR) of the association between metabolic syndrome and tooth loss

Variables	Crude PR (95%CI)	*p*	Adjusted PR (95%CI)	*p*
Gender				
Female	1		1	
Male	0.82(0.66–1.02)	0.07	0.93(0.78–1.11)	0.42
Age				
19–40 years	1		1	
41–60 years	3.92(2.5–6.14)	<0.001	3.55(2.28–5.52)	<0.001
>60 years	5.39(3.45–8.43)	<0.001	4.24(2.69–6.68)	<0.001
Smoking status				
Non-smoker	1	1	1	
Former/current smoker	1.19(0.99–1.44)	0.07	1.14(0.97–1.34)	0.1
Years of education				
≥9 years	1	1	1	
≤8 years	2.03(1.57–2.64)	<0.01	1.22(1.04–1.42)	0.01
Socioeconomic status				
High	1	1	1	
Low and medium	1.89(1.35–2.65)	<0.001	1.65(1.31–2.08)	<0.01
Metabolic syndrome				
No	1	1	1	
Yes	1.64(1.32–2.03)	<0.001	1.23(1.02–1.49)	0.03

Dichotomous outcome: tooth loss <6/tooth loss ≥6

of periodontitis and metabolic syndrome may have contributed to this low prevalence. It is worth mentioning that, despite the outcome periodontitis has a higher prevalence than 10 % in most studies [8, 15–17, 19, 20, 22, 24, 25, 29] investigating the relationship of metabolic syndrome and dichotomous outcome of periodontitis, a large number of these studies [16, 19, 22, 24, 25, 27, 29] used logistic regression as an alternative method to multivariate analysis. In studies with dichotomous outcomes where the outcome prevalence is greater than 10 %, the use of logistic regression leads to an overestimation of the odds ratio. Therefore, alternative methods of analysis, such as Poisson regression, produce more reliable estimates [45]. In this sense, the method of statistical analysis used may also be responsible for some differences in the results, although it does not seem to have an influence on the statistical significance.

Conclusion

Thus, it is possible to conclude that there is a weak association among metabolic syndrome and both periodontitis and tooth loss. The association is observed in the age group between 41 and 60 years. It may also be found in older individuals; however, high occurrence of tooth loss in this age strata may underestimate past periodontitis experience measure by AL, thus making it more difficult to demonstrate the association. In this scenario, considering the limitations of the design of the present study, individuals with metabolic syndrome should have their periodontal condition closely investigated because metabolic syndrome seems to be a risk indicator for AL and tooth loss.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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