

Periodontal Inflamed Surface Area (PISA) as a Predictor of Periodontitis: a comparative cross-sectional study

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Abstract

Background

Periodontal inflamed surface area (PISA) quantifies the surface area of bleeding pocket epithelium and reflects the systemic inflammatory burden of periodontitis. This study aimed to compare PISA values between patients with moderate-to-severe periodontitis and individuals without periodontitis, and to evaluate its diagnostic utility.

Methods

A comparative cross-sectional study was conducted at Obafemi Awolowo University Teaching Hospital, Ile-Ife, Nigeria. The test group comprised 27 adults with moderate-to-severe periodontitis (≥ 2 interproximal sites with probing pocket depth ≥ 5 mm, not on same tooth), and the control group comprised 24 non-periodontitis adults. Probing pocket depth (PPD), clinical attachment level (CAL), bleeding on probing (BOP), and gingival recession were recorded at six sites per tooth. PISA was calculated using the Nesse et al. (2008) algorithm. Oral hygiene was assessed using the Simplified Oral Hygiene Index (OHIS). Mann-Whitney U test, receiver operating characteristic (ROC) curve, and binary logistic regression were used for statistical analysis.

Results

Mean PISA was significantly higher in the periodontitis group (386.6 mm²) than in controls (86.4 mm²; $p < 0.001$). PPD and CAL were also higher in the test group (2.4 mm and 2.5 mm vs. 1.2 mm and 1.2 mm, respectively; $p < 0.001$). OHIS was higher in the test group (1.6 vs. 0.9; $p = 0.023$). ROC analysis showed excellent discriminatory ability for PISA (AUC = 0.9105). At a cut-off of > 79.39 mm², sensitivity was 92.59%, specificity 91.67%, and correctly classified 92.16% of cases. Binary logistic regression confirmed that PISA independently predicted periodontitis after adjusting for age and gender (OR = 1.005, $p = 0.013$).

Conclusion

PISA is a valid biomarker that distinguishes moderate-to-severe periodontitis from periodontal health with high accuracy. Its strong diagnostic performance supports its potential utility in clinical practice and research as a bridge between oral and systemic health.

INTRODUCTION

Periodontitis is a chronic inflammatory disease characterized by progressive destruction of the supporting structures of the teeth, resulting from complex interactions between pathogenic biofilms and the host immune-inflammatory response. The disease remains a major global oral health burden and has been strongly associated with systemic conditions such as diabetes mellitus, cardiovascular disease,

and chronic kidney disease.¹ The pathophysiological basis of these associations lies in the systemic dissemination of inflammatory mediators originating from periodontal tissues.²

Traditional clinical parameters used in the diagnosis and assessment of periodontitis—such as probing pocket depth (PPD), clinical attachment level (CAL), and bleeding on probing (BOP)—provide valuable information on disease severity and extent.³ However, these indices are largely site-specific and do not adequately quantify the total inflammatory burden posed by periodontal disease at the individual level. This limitation has prompted the development of more integrative indices capable of representing the overall inflammatory status of the periodontium.

Periodontal inflamed surface area (PISA) has emerged as a novel quantitative measure that estimates the surface area of bleeding pocket epithelium in square millimetres. It translates conventional clinical periodontal parameters into a single continuous variable reflecting the amount of inflamed periodontal tissue and, by extension, the systemic inflammatory burden attributable to periodontitis.⁴ Unlike traditional indices, PISA allows for direct comparison between individuals and populations and provides a biologically meaningful representation of periodontal inflammation.

Evidence suggests that PISA increases with the severity of periodontitis and may serve as a reliable indicator of disease burden. Studies have demonstrated significantly higher PISA values in individuals with moderate to severe periodontitis compared to periodontally healthy individuals, with proposed threshold values showing high sensitivity and specificity for disease detection.⁵ Furthermore, PISA has been shown to correlate with systemic inflammatory markers such as C-reactive protein (CRP) and interleukin-6 (IL-6), supporting its potential role as a bridge between oral and systemic health.⁶

Several studies have demonstrated a strong association between PISA values and the severity of periodontitis. Individuals with severe periodontitis exhibit significantly higher PISA values compared to those with mild disease or periodontal health. For example, markedly elevated mean PISA values have been reported in severe cases compared to minimal values in healthy individuals.⁵ Receiver operating characteristic (ROC) analyses have further shown that specific PISA thresholds can effectively discriminate between diseased and healthy states, suggesting its diagnostic utility.⁷ One of the most important attributes of PISA is its association with systemic inflammatory markers. Studies have shown positive correlation between PISA and HbA1c in diabetic patients, indicating a relationship between periodontal inflammation and glycemic control.⁸ Despite these advances, there remains a need for further comparative studies evaluating PISA between individuals with varying periodontal status, particularly between those with moderate to severe periodontitis and those without periodontitis. Establishing clear differences in PISA values between these groups would strengthen its validity as a biomarker and enhance its applicability in both clinical practice and research.

Therefore, this study aims to comparatively evaluate periodontal inflamed surface area in patients with moderate to severe periodontitis and those without periodontitis, with a view to determining its potential utility as a biomarker for periodontal disease.

MATERIALS AND METHODS.

This study is a comparative cross-sectional analytical study designed to evaluate and compare periodontal inflamed surface area (PISA) between patients with moderate-to-severe periodontitis and individuals without periodontitis. The study was conducted at the periodontology clinic of Obafemi Awolowo university teaching hospital complex, Ile-Ife, Nigeria, a tertiary healthcare institution.

The study population of the test group was made up of adult patients aged 18 years and above with moderate-to-severe periodontitis as evidenced by ≥ 2 interproximal sites with pocket depth ≥ 5 mm (not on same tooth) according to Centre for Disease Control and Prevention in partnership with the American Academy of Periodontology 2005, modified by Eke and Page.⁹ while the control group comprised of consenting participants aged 18 years and above without periodontitis. These participants were recruited consecutively in the Periodontology unit of the hospital. Inclusion criteria for the study includes participants who have never smoked tobacco and those who quit tobacco smoking more than five years ago, and participants with minimum of 20 teeth. While the exclusion criteria include current tobacco smokers and those who quit tobacco smoking within five years, pregnant and lactating women, participants who have undergone periodontal therapy in the last six months, long term use of anti-inflammatory medications e.g. NSAIDS, and patients with medical conditions such as diabetes mellitus, hypertension, anaemia, rheumatoid arthritis. A minimum sample size of 30 participants per group were recruited for the study.¹⁸ A consecutive sampling method was employed, where eligible participants are recruited until the desired sample size was achieved. All participants had comprehensive periodontal examination performed on them by the principal investigator, using a dental mirror and Williams periodontal probe. The following parameters were recorded at six sites per tooth: Probing Pocket Depth (PPD), Clinical Attachment Level (CAL), Bleeding on Probing (BOP), and Gingival recession (GR). Intra-examiner reliability was assessed using duplicate measurements in 10% of participants, resulting in a kappa coefficient score of 0.82. PISA was calculated using standard algorithms developed by Nesse et al. (2008), which involves conversion of CAL and GR into attachment loss, estimation of periodontal epithelial surface area (PESA) and multiplication of PESA by proportion of BOP-positive sites. A freely downloadable excel spread sheet available at www.parsprototo.info is used to translate linear measurement of CAL, PPD and GR into attachment loss, ALSA, PESA and RSA. PISA values is expressed in square millimetres (mm²). Oral hygiene status of each group was assessed using the simplified oral hygiene index score (OHIS).¹⁹ All the participants filled and signed a written informed consent form before the commencement of the study. This study was conducted in accordance with the ethical principle outlined in the Declaration of Helsinki. The research protocol was reviewed and approved by the Ethics and Research Committee of Obafemi Awolowo University Teaching Hospital Complex prior to the commencement of the study (Reference number IRB/IEC/0004553). Data was analyzed using IBM statistical package for social sciences software (IBM SPSS version 23) Chicago, Illinois, USA. Mann-Whitney U test, receiver operating characteristic (ROC) curve, and binary logistic regression were used for statistical analysis. Dataset generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

RESULTS

A total of 60 participants were recruited for the study, however 9 participants were lost to follow-up. Hence, a total of 51 participants completed the study comprising of 27 participants in the test group and 24 participants in the control group. The test group had significantly higher mean PISA values (386.6mm² vs 86.4mm²; $p < 0.001$, Mann-Whitney U test). There were also significant differences in the OHIS, PPD and CAL values between the test group and the control. ($P < 0.05$). (Table 1). ROC analysis for PISA as diagnostic marker yielded an area under the curve (AUC) of 0.8105. (Figure 1). The optimal cut point (≥ 79.39) demonstrated 92.59% sensitivity and 91.67% specificity with a correct classification rate of 92.16% (LR+ =11.11, LR- =0.08). (Table 2). Logistic regression shown in Table 3, identified PISA as a significant independent predictor of periodontitis (OR=1.005, 95% CI: 1.001-1.009; $p = 0.013$). Age and gender were not significant predictors ($p = 0.321$ and $p = 0.898$, respectively).

Table 1: Comparison of the mean values of PISA, OHI, PPD and CAL between test and control groups at baselines

Parameter	Group	Mean	SD	Rank sum	z-stat.	p-value
PISA (mm ²)	Test	386.6	407.7	968.0	5.029	<0.001*
	Control	86.4	243.1	358.0		
OHIS	Test	1.6	1.2	822.0	2.276	0.023*
	Control	0.9	0.4	504.0		
PPD (mm)	Test	2.4	0.7	1015.5	5.920	<0.001*
	Control	1.2	0.1	310.5		
CAL (mm)	Test	2.5	0.7	1016.0	5.929	<0.001*
	Control	1.2	0.1	310.0		

***Mann-Whitney U test; Significant when $p < 0.05$ at 95% confidence level (two-tailed)**

Table 2. Sensitivity and Specificity table

Cut point	Sensitivity	Specificity	Correctly classified	LR+	LR-
>56.9	92.59%	83.33%	88.24%	5.5556	0.0889
>78.92	92.59%	87.50%	90.20%	7.4074	0.0847
>79.39	92.59%	91.67%	92.16%	11.1111	0.0808
>109.84	88.89%	91.67%	90.20%	10.6667	0.1212
>136.58	85.19%	91.67%	88.24%	10.2222	0.1616

Table 3. Logistic regression

Form type	Odds ratio	Std err	Z	P> Z	(95% confi	Interval)
PISA	1.005228	.0021102	2.48	0.013	(1.0011-	1.009372)
Age	1.039013	.0400635	0.99	0.321	(.9633834-	1.120579)
Gender						
Female	1.085828	.69976	0.13	0.898	(.3070477-	3.839869)
Cons	.1322638	.1720722	-1.55	0.120	(.103287-	1.693694)

DISCUSSION

This study found that patients with moderate-to-severe periodontitis had significantly higher PISA values (386.6 mm²) than non-periodontitis controls (86.4 mm²; $p < 0.001$). PPD and CAL were also significantly higher in the test group (2.4 mm and 2.5 mm vs. 1.2 mm and 1.2 mm in controls). These findings are consistent with previous reports, although the absolute PPD/CAL values in our test group were lower than those reported by Chakraborty *et al* (3.30 mm and 3.93 mm)¹⁰ and Shirmohammadi *et al* (5.03 mm and 5.13 mm).¹¹ This discrepancy likely reflects differences in disease severity among recruited participants. PISA integrates multiple clinical parameters into a single continuous variable representing the surface area of bleeding pocket epithelium. Our findings align with Leira *et al*,⁵ who reported mean PISA values of 2309.42 mm² in severe periodontitis and 34.30 mm² in healthy individuals, confirming that PISA increases with disease severity. The relatively lower PISA in our test group reflects inclusion of moderate-to-severe rather than exclusively severe periodontitis.

Elevated PISA has important systemic implications. Kumari *et al*.¹² reported significant positive correlations between PISA and both CRP ($r = 0.4875$, $p = 0.000059$) and ESR ($r = 0.4089$, $p = 0.000968$). Leira *et al*.⁵ found that a PISA threshold of ≥ 130.33 mm² predicted periodontitis with 98% sensitivity and 100% specificity. Iwasaki *et al*.¹³ demonstrated that older adults in the highest PISA quartile had a multivariable-adjusted prevalence ratio of 1.90 (95% CI 1.08–3.34) for high composite inflammatory marker z-score (p trend = 0.01). A recent review by Himani *et al*.¹⁴ linked higher PISA to cardiovascular disease, diabetes, dementia, and rheumatoid arthritis, noting associations with hs-CRP and vascular stiffness. In Type 2 diabetes, PISA is positively associated with HbA1c, supporting a dose-response relationship between periodontal inflammation and glycaemic control.⁸ Regarding diagnostic utility, Zhao *et al*.⁷ reported an AUC of 0.959 (95% CI 0.928–0.990) for PISA in distinguishing periodontitis from health, compared to 0.905 for probing depth. Takeuchi-Hatanaka *et al*.¹⁵ proposed diagnostic thresholds of 300 mm² and 600 mm². Our test group mean of 386.6 mm² falls between these thresholds, consistent

with moderate-to-severe disease, while the control mean of 86.4 mm² is well below 300 mm², supporting its validity as a diagnostic measure.

Beyond systemic inflammation, Kemer Doğan *et al.*¹⁶ found that PISA negatively correlated with salivary omentin-1 and positively correlated with visfatin in overweight/obese patients, suggesting PISA may help assess links between periodontitis and obesity. A case-control study assessing depression in periodontitis patients reported PISA scores of 1069.50 ± 204.21 in cases versus 210.47 ± 76.80 in controls ($p < 0.0001$), further demonstrating PISA's discriminative ability across different research contexts.¹⁷ Our control group mean PISA (86.4 mm²) was slightly higher than the 34.30 mm² reported by Leira *et al.* for periodontally healthy individuals, possibly due to differences in the definition of periodontal health or the presence of mild gingivitis. We also observed significantly higher OHIS in the test group (1.6 vs. 0.9, $p = 0.023$), confirming that poorer oral hygiene is associated with greater periodontal inflammation as measured by PISA. Receiver operating characteristic (ROC) curve analysis, as shown in Fig. 1, demonstrated outstanding discriminatory ability of PISA in differentiating periodontitis patients from non-periodontitis controls, with an area under the curve (AUC) of 0.9105. This indicates excellent diagnostic performance and suggests that PISA possesses strong potential as a biomarker for identifying periodontitis. Furthermore, the sensitivity and specificity values (Table 2) obtained at different cut-off points showed that PISA could accurately classify diseased and non-diseased individuals. Binary logistic regression analysis (Table 3) revealed that PISA significantly predicted periodontitis even after adjusting for age and gender. This suggests that increased PISA values are independently associated with periodontitis and are not merely influenced by demographic factors. Although the odds ratio appeared numerically small, this is attributable to the unit measurement of PISA in mm², where cumulative increases become clinically meaningful. The findings of this present study therefore support the growing evidence that PISA may serve as a useful biomarker of periodontitis. Its ability to quantify inflammatory surface area and accurately discriminate diseased from healthy individuals makes it potentially valuable in periodontal diagnosis, disease monitoring, and assessment of systemic inflammatory impact.

CONCLUSION

PISA is a valid, reliable biomarker that distinguishes moderate-to-severe periodontitis from non-periodontitis cases. Its significant association with systemic inflammatory markers⁶ and its emerging role in diagnostic thresholding support its potential utility in both clinical practice and research, bridging oral and systemic health. Future prospective studies with larger samples and inclusion of systemic inflammatory markers are warranted to further establish PISA's predictive value.

Declarations

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References

1. Tonetti MS, Van Dyke TE. Working group1 of the joint EFP/AAP Workshop. Periodontitis and atherosclerotic cardiovascular disease: consensus report of the joint EFP? AAP Workshop on Periodontitis and Systemic Disease. *J Periodontol*. 2013;84(4 Suppl):S24–29.
2. Preshaw PM, Alba AL, Herrera D, Jepsen S, Konstantinidis A, Makrilakis K, et al. Periodontitis and diabetes: a two-way relationship. *Diabetologia*. 2012;55(1):21–31.
3. Papapanou PN, Sanz M, Budeneli N, Dietrich T, Feres M, Fine DH, et al. Periodontitis: consensus report of workgroup 2 of the 2017 World Workshop on the classification of periodontal and Peri-Implant Diseases and Conditions. *J Periodontol*. 2018;89(Suppl 1):S173–182.
4. Nesse W, Abbas F, van der Ploeg I, et al. Periodontal inflamed surface area (PISA): quantifying inflammatory burden. *J Clin Periodontol*. 2008;35(8):668–73.
5. Leira Y, Martín-Lancharro P, Blanco J. Periodontal inflamed surface area and periodontal case definition classification. *Acta Odontol Scand*. 2018;45:1024–32.
6. Onabanjo OA, Nwhator SO, Arogundade FA. Association between periodontal inflamed surface area and systemic inflammatory biomarkers among pre-dialysis chronic kidney disease patients. *Niger Postgrad Med J*. 2023;30(4):299–304.
7. Zhao D, Wu Y, Cao J, et al. Diagnostic accuracy of periodontal inflamed surface area for periodontitis. *J Clin Periodontol*. 2013;40(6):589–94.
8. Anil K, Vadakkekuttikal RJ, Radhakrishnan C, Parambath FC. Correlation of periodontal inflamed surface area with glycaemic status in controlled and uncontrolled type 2 diabetes mellitus. *World J Clin cases* 2021 Dec 26;(36):11300–10.
9. Eke PI, Page RC, Wei L, Thornton-Evans G, Genco RJ. Update of the case definitions for population-based surveillance of periodontitis. *Periodontol 2000*. 2012;83(12):1449–54.

10. Chakraborty S, Tewari S, Sharma RK, et al. Impact of iron deficiency anemia on chronic periodontitis and superoxide dismutase activity: a cross-sectional study. *J periodontal implant Sci.* 2014;44(2):57–64.
11. Shirmohamadi A, Chitsazi MT, Faramarzi M, et al. Effect of non-surgical periodontal treatment on transferrin serum levels in patients with chronic periodontitis. *J Dent Res.* 2016;10(3):169.
12. Kumari S, Rastogi P, Rastogi S, Singh N, Singh S. Correlation of periodontal inflamed surface area with systemic inflammatory markers. *J Indian Soc Periodontol.* 2024;28(1):45–50.
13. Iwasaki M, Usui M, Ariyoshi W, et al. Periodontal inflamed surface area and systemic inflammation in community-dwelling older adults. *J Clin Periodontol.* 2025;52(2):210–9.
14. Himani, Narula SC, Sharma RK, Tewari S, Singh N. Periodontal inflamed surface area and systemic diseases: a narrative review. *J Oral Biol Craniofac Res.* 2026;16(1):12–9.
15. Takeuchi-Hatanaka K, Yamamoto T, Matsumoto T, et al. Diagnostic thresholds for periodontal inflamed surface area combined with salivary biomarkers. *J Periodontal Res.* 2025;60(1):88–96.
16. Kemer Doğan E, Doğan M, Çetiner D, Kırzioğlu FY. Relationship between periodontal inflamed surface area and adipokines in overweight/obese patients. *J Periodontol.* 2022;93(8):1173–82.
17. Sundararajan S, Muthukumar S, Rangarao S. A case-control study assessing depression in patients with periodontitis. *Indian J Soc Psychiatry.* 2017;33(1):44–6.
18. Tamaki N, Tomofuji T, Ekuni D, et al. Short-term effects of non-surgical periodontal treatment on plasma level of reactive oxygen metabolites in patients with chronic periodontitis. *J Periodontol.* 2009;80(6):901–6.
19. Greene JG, Vermillion JR. The simplified oral hygiene index. *J Am Dent Assoc.* 1964;68(1):7–13.

Figures

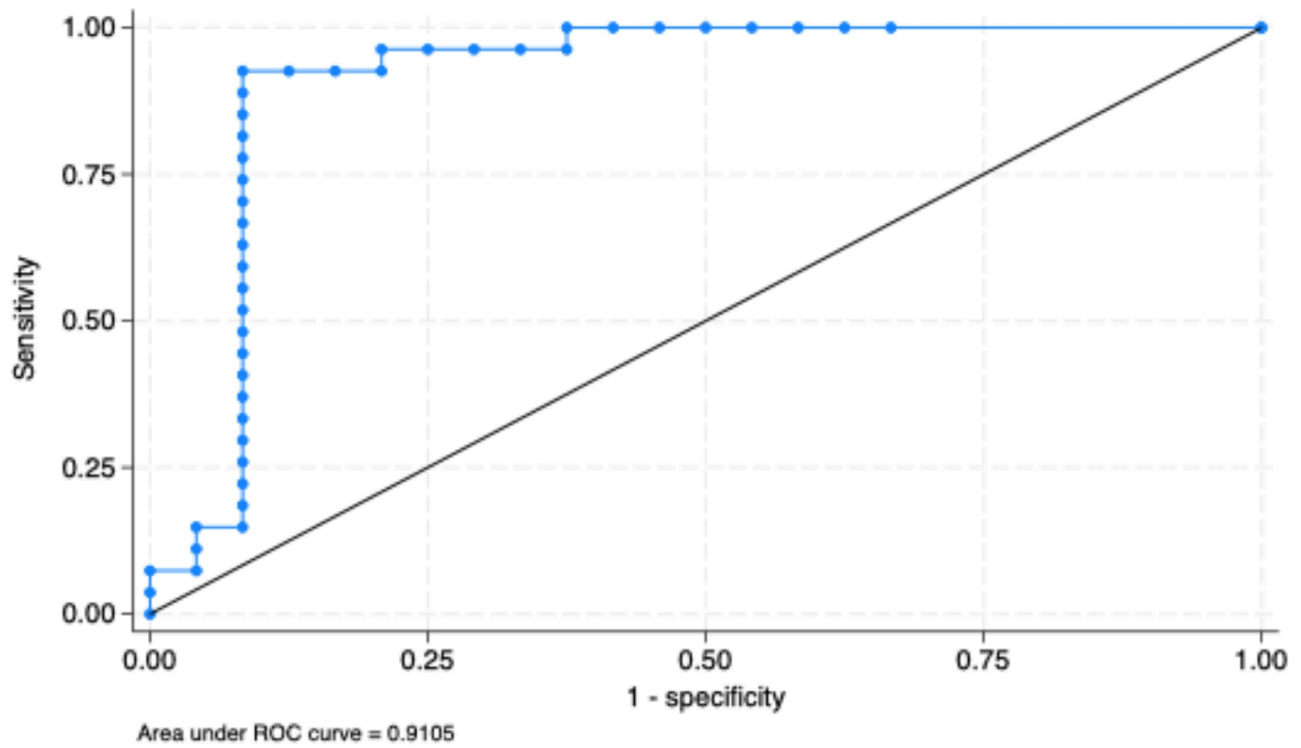


Figure 1

ROC CURVE GRAPH