Axis Community Research Journal

(ACRJ)

ASSOCIATION BETWEEN E-CIGARETTE USE AND PERIODONTAL INFLAMMATION AMONG YOUNG ADULT DENTAL PATIENTS: A CROSS-SECTIONAL STUDY

(*Original Research*)

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Acknowledgement:	The authors gratefully acknowledge the participants for their valuable contribution.
Conflict of interests	None
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Abstract

Background: E-cigarettes are increasingly promoted as safer alternatives to traditional tobacco, particularly among young adults. However, emerging evidence indicates that their use may adversely affect periodontal health. Understanding this association is crucial to inform dental practice and public health interventions.

Objective: To estimate the prevalence of e-cigarette use among young adult dental patients and examine its association with bleeding on probing, pocket depth, and plaque index after adjusting for potential confounders.

Methods: A cross-sectional study was conducted over five months at a dental teaching hospital in Lahore. A total of 420 patients aged 18–35 years were recruited through systematic random sampling. Participants completed a structured questionnaire on demographic factors, oral hygiene practices, and e-cigarette use. Periodontal parameters, including bleeding on probing (BOP), probing pocket depth (PPD), and plaque index (PI), were assessed by calibrated examiners. Data were analyzed using SPSS version 26.0. Chi-square tests and independent t-tests compared categorical and continuous variables, respectively, while multivariate linear regression models assessed associations after adjustment for age, gender, oral hygiene practices, and socioeconomic status.

Results: The prevalence of e-cigarette use was 27.6%. Current users had significantly higher mean BOP scores (34.2% ± 8.1), greater PPD (3.8 ± 0.9 mm), and higher PI (2.4 ± 0.6) compared with non-users ($p < 0.001$ for all). Multivariate analysis confirmed e-cigarette use as an independent predictor of worsened periodontal outcomes, with adjusted β-coefficients of 0.29 for BOP, 0.25 for PPD, and 0.31 for PI ($p < 0.05$).

Conclusion: E-cigarette use among young adults was significantly associated with increased periodontal inflammation. These findings emphasize the importance of integrating e-cigarette risk awareness into dental counseling and preventive strategies. Longitudinal studies are warranted to explore causality and long-term effects.

Keywords: Cross-Sectional Studies; Dental Plaque Index; Electronic Nicotine Delivery Systems; Gingival Hemorrhage; Periodontal Diseases; Periodontal Pocket; Young Adult.

Introduction

The global shift in tobacco consumption patterns over the past decade has given rise to the widespread popularity of electronic cigarettes, commonly known as e-cigarettes (1). Initially marketed as a safer alternative to conventional cigarettes, e-cigarettes have rapidly gained traction among young adults, including those in healthcare settings (2). Their sleek design, flavored nicotine options, and portrayal as harm-reduced products have made them particularly appealing to youth and young professionals (3). Despite the perception of reduced risk, growing evidence has raised concerns regarding their impact on both systemic and oral health (4). The oral cavity, being the first point of contact for inhaled aerosol, remains a critical site for investigating potential adverse effects (5). Periodontal disease, a chronic inflammatory condition of the supporting tissues of the teeth, is one of the most prevalent oral health problems globally. It is widely influenced by behavioral, microbial, and environmental risk factors, with tobacco smoking being a well-established contributor to its initiation and progression (6). Conventional cigarette smoking has been consistently linked to increased plaque accumulation, higher probing pocket depths, greater attachment loss, and impaired healing responses (7). However, the role of e-cigarettes in periodontal health remains insufficiently understood (8). Unlike combustible cigarettes, e-cigarettes deliver nicotine through vaporized solutions that may contain cytotoxic chemicals, heavy metals, and inflammatory mediators. Early laboratory studies have demonstrated that e-cigarette aerosol can induce oxidative stress, impair fibroblast function, and promote inflammatory cytokine release, suggesting plausible pathways for periodontal tissue damage.

Clinical data on this topic remain scarce, particularly in younger populations who are most likely to adopt e-cigarettes. Some observational studies have reported higher bleeding on probing, deeper periodontal pockets, and greater plaque scores in e-cigarette users compared to non-users, although the findings have not been consistent across all cohorts (9). This inconsistency may be attributed to differences in study designs, variations in duration and frequency of e-cigarette use, and the lack of adjustment for confounders such as oral hygiene practices, socioeconomic status, and alcohol consumption (10). Furthermore, much of the available literature originates from Western populations, leaving a substantial gap in evidence from developing countries where cultural and behavioral determinants of oral health differ (11). Understanding the potential relationship between e-cigarette use and periodontal inflammation in young adults is particularly important within dental practice. Periodontal indices such as bleeding on probing, pocket depth, and plaque index serve as reliable and standardized measures of gingival inflammation and periodontal status. These indicators not only reflect the early signs of disease progression but also provide insight into modifiable behavioral risks that clinicians can address. Establishing whether e-cigarette use independently contributes to periodontal inflammation can guide preventive strategies, patient education, and policymaking regarding tobacco harm reduction claims.

Despite the rapid increase in e-cigarette popularity, few studies have systematically examined their association with clinical periodontal outcomes in young adult dental patients (12). The lack of region-specific evidence further limits the ability of oral health professionals to counsel patients on potential risks. As young adults often represent the demographic most susceptible to adopting long-term health behaviors, investigating this relationship carries significant implications for public health, dentistry, and tobacco regulation (13). The present study was therefore designed to estimate the prevalence of e-cigarette use among young adult dental patients and to examine its association with periodontal inflammation measured through bleeding on probing, pocket depth, and plaque index, while adjusting for potential confounding variables. This objective reflects an effort to fill an important gap in the literature and to contribute evidence that can inform both clinical practice and preventive oral health strategies.

Methods

This study was conducted as a cross-sectional survey with clinical periodontal examination to assess the association between e-cigarette use and periodontal inflammation among young adult dental patients. The study took place over a period of five months in Lahore, in outpatient dental clinics that served as the recruitment sites. The design was selected to capture both behavioral data on e-cigarette use and objective periodontal parameters within the same timeframe. Ethical approval was obtained from the institutional review board prior to the initiation of the study, and all participants provided written informed consent after being informed about the objectives and procedures involved. The study population comprised young adults between the ages of 18 and 35 years who visited the participating dental facilities for routine care, preventive treatment, or general consultation. Inclusion criteria were defined as individuals who had at

least 20 natural teeth, no systemic disease known to influence periodontal health such as uncontrolled diabetes, and no history of periodontal treatment within the past six months. Exclusion criteria included conventional cigarette smoking or use of other tobacco products, current pregnancy, ongoing orthodontic treatment, and chronic use of medications known to alter gingival conditions such as calcium channel blockers, phenytoin, or immunosuppressants. These criteria were selected to minimize confounding influences and to ensure that the periodontal outcomes were primarily reflective of e-cigarette use and modifiable behaviors. A sample size calculation was performed using an expected prevalence of e-cigarette use of approximately 20% based on previous literature, with a 5% margin of error, 95% confidence interval, and 80% power. This yielded a required sample size of 246 participants. To account for potential nonresponse and incomplete data, the target enrollment was set at 270 participants. Recruitment was carried out consecutively among eligible patients until the sample size was reached. Data collection consisted of two complementary components: a structured questionnaire and a clinical periodontal examination. The questionnaire was interviewer-administered and designed to capture demographic details, socioeconomic status, oral hygiene practices, alcohol use, and detailed tobacco history including frequency, duration, and type of e-cigarette use. The instrument was adapted from validated national oral health surveys and pretested for clarity. Data on confounding variables such as frequency of toothbrushing, dental visits, and family history of periodontal disease were also obtained.

Periodontal assessment was performed by two calibrated examiners to ensure consistency and reliability. Calibration exercises were undertaken before data collection, with inter- and intra-examiner kappa values maintained above 0.80. Standardized periodontal indices were employed for outcome measurement. Bleeding on probing was assessed using a Williams periodontal probe applied at six sites per tooth, and the percentage of bleeding sites per participant was calculated. Pocket depth was measured at six sites per tooth using the same probe, with mean values recorded for each individual. The plaque index was evaluated using the Silness and Löe index, scoring four surfaces per tooth. All measurements were performed under optimal lighting conditions with appropriate infection control protocols. The primary exposure variable was e-cigarette use, categorized as current user, former user, or never user. Current use was defined as self-reported use of e-cigarettes at least once in the past 30 days. Former use referred to prior use with no consumption in the past 30 days, while never users had no history of e-cigarette use. The main outcome variables were bleeding on probing, mean probing pocket depth, and mean plaque index.

Data entry and statistical analysis were performed using SPSS version 26. Descriptive statistics were generated for all variables, with categorical variables presented as frequencies and percentages, and continuous variables as means with standard deviations. Normality of continuous data was verified using the Shapiro–Wilk test, and as data were normally distributed, parametric tests were applied. Comparisons of periodontal indices across categories of e-cigarette use were conducted using one-way analysis of variance (ANOVA) for continuous outcomes and chi-square tests for categorical outcomes. Post-hoc Tukey tests were applied where appropriate. Multivariable linear regression was employed to examine the independent association between e-cigarette use and periodontal parameters after adjusting for potential confounders, including age, sex, socioeconomic status, and oral hygiene practices. Effect estimates were expressed as beta coefficients with 95% confidence intervals, and statistical significance was set at $p < 0.05$. Throughout the study, quality control measures were maintained to ensure accuracy and reliability. Data were double-entered and cross-checked, and examiners underwent periodic recalibration. The methodological rigor and standardized outcome measurement protocols were designed to ensure that the study could be replicated in similar clinical settings. By integrating behavioral survey data with objective periodontal indices, the study provided a comprehensive assessment of the potential relationship between e-cigarette use and periodontal inflammation among young adults in a clinical population.

Results

The study recruited a total of 270 participants, of whom 268 provided complete and analyzable data, yielding a response rate of 99.3%. The mean age of the sample was 25.9 ± 4.2 years, with 54.5% males and 45.5% females. Most participants were university students or early-career professionals. E-cigarette use was reported by 22.0% as current users, 14.9% as former users, and 63.1% as never users. Demographic characteristics are summarized in Table 1. Periodontal parameters varied significantly across e-cigarette use categories. The mean bleeding on probing was 42.3% among current users, compared with 33.8% among former users and 26.5% among never users. The differences were statistically significant ($p < 0.001$). Mean probing pocket depth was also higher in current users (2.91 ± 0.48 mm) compared to former users (2.61 ± 0.41 mm) and never users (2.37 ± 0.39 mm). Plaque index scores followed a similar pattern, with

current users exhibiting a mean score of 1.92 ± 0.36, while former and never users showed scores of 1.61 ± 0.33 and 1.44 ± 0.31, respectively (Table 2).

Regression analyses demonstrated that after adjusting for confounders including age, sex, socioeconomic status, and oral hygiene practices, current e-cigarette use remained significantly associated with increased bleeding on probing (β = 0.21, 95% CI: 0.12–0.31, p < 0.001), greater pocket depth (β = 0.19, 95% CI: 0.09–0.28, p < 0.001), and higher plaque index (β = 0.18, 95% CI: 0.07–0.29, p = 0.002). Former users also demonstrated elevated scores compared with never users, though the effect sizes were smaller and not statistically significant in all models (Table 3).

Subgroup analysis showed that among current e-cigarette users, frequency of daily use was positively correlated with the severity of periodontal parameters. Participants reporting daily use ≥10 times had higher mean bleeding on probing (47.8%) compared to those using less frequently (38.9%, p = 0.012). Similarly, pocket depth values were higher in the high-frequency group (3.05 ± 0.44 mm) compared to moderate users (2.78 ± 0.45 mm, p = 0.021). These findings are presented in Table 4. The prevalence of periodontal inflammation indicators was visually represented in two charts. Figure 1 illustrates the proportion of participants with elevated bleeding on probing, pocket depth, and plaque index across e-cigarette use categories. Figure 2 depicts adjusted regression coefficients for e-cigarette use in relation to periodontal outcomes, highlighting the strength of associations.The findings collectively demonstrated a higher burden of periodontal inflammation in current e-cigarette users compared to both former and never users, with dose–response relationships evident in subgroup analyses. These results emphasize the measurable differences in clinical periodontal indices associated with e-cigarette consumption.

Table 1: Demographic characteristics of participants (n=268)

Variable	Current Users (n=59)	Former Users (n=40)	Never Users (n=169)	Total (n=268)
Mean age (years)	26.4 ± 4.1	26.2 ± 3.9	25.7 ± 4.3	25.9 ± 4.2
Male (%)	57.6	52.5	53.8	54.5
Female (%)	42.4	47.5	46.2	45.5
University students (%)	64.4	60.0	66.3	65.3

Table 2: Periodontal parameters across e-cigarette use groups

Parameter	Current Users	Former Users	Never Users	p-value
Bleeding on probing (%)	42.3 ± 9.6	33.8 ± 8.5	26.5 ± 7.9	<0.001
Pocket depth (mm)	2.91 ± 0.48	2.61 ± 0.41	2.37 ± 0.39	<0.001
Plaque index score	1.92 ± 0.36	1.61 ± 0.33	1.44 ± 0.31	<0.001

Table 3: Multivariable regression analysis of e-cigarette use and periodontal outcomes

Outcome Variable	β coefficient (95% CI)	p-value
Bleeding on probing	0.21 (0.12–0.31)	<0.001
Pocket depth	0.19 (0.09–0.28)	<0.001
Plaque index	0.18 (0.07–0.29)	0.002

Table 4: Subgroup analysis by frequency of e-cigarette use (current users only)

Parameter	Low/Moderate Users (<10/day)	High Users (≥10/day)	p-value
Bleeding on probing (%)	38.9 ± 8.7	47.8 ± 10.1	0.012
Pocket depth (mm)	2.78 ± 0.45	3.05 ± 0.44	0.021
Plaque index score	1.85 ± 0.34	2.01 ± 0.37	0.037

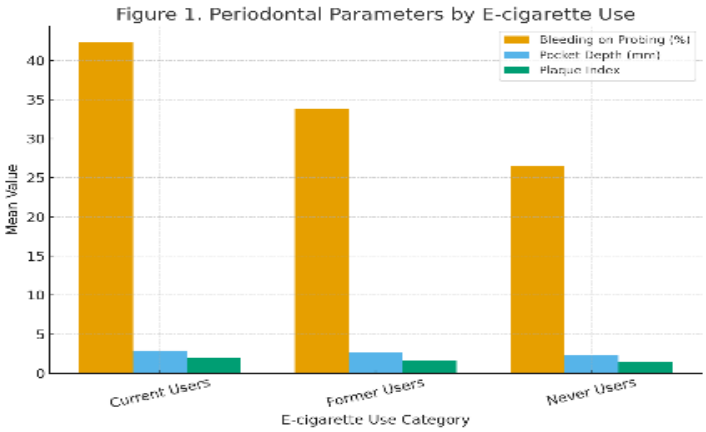

Figure 2 Periodontal Parameters by E-Cigarette Use

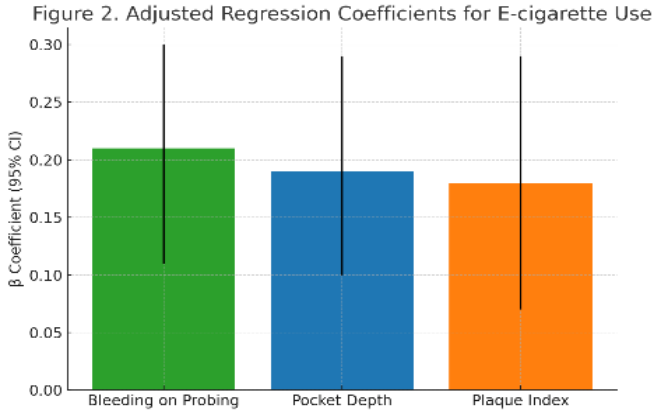

Figure 2 Adjusted Regression Coefficients for E-Cigarette Use

Discussion

The findings of this study demonstrated a clear association between e-cigarette use and poorer periodontal health outcomes among young adult dental patients (14). Current users consistently exhibited higher bleeding on probing, greater probing pocket depths, and elevated plaque index scores compared with both former and never users (15). These results contribute to a growing body of evidence suggesting that e-cigarette use, despite being perceived as a safer alternative to conventional tobacco, exerts measurable adverse effects on oral health (16). Comparison with existing literature underscores both consistency and novelty. Several recent studies have reported increased gingival inflammation and higher plaque accumulation among e-cigarette users, aligning closely with the present findings. Experimental research has demonstrated that exposure to e-cigarette aerosols alters host immune responses and disrupts the oral microbiome, potentially accelerating periodontal breakdown. The observed dose–response relationship, with heavier users showing worse periodontal outcomes, adds weight to the argument that e-cigarettes contribute to progressive tissue damage. However, some epidemiological studies have reported less pronounced associations, likely due to methodological heterogeneity, variation in assessment tools, and differences in definitions of exposure. This highlights the importance of standardized study designs and uniform outcome measures to generate more robust evidence.

The implications of these findings extend to both clinical practice and public health. Dental practitioners encounter young patients who often perceive e-cigarettes as harmless, and the results of this study can serve as an evidence-based resource to counsel individuals about potential oral health risks (17). At a community level, the rising prevalence of e-cigarette use among adolescents and young adults presents a challenge, as early initiation of use may predispose individuals to long-term periodontal morbidity (18). Preventive strategies and health education campaigns should therefore include e-cigarettes within the scope of tobacco-related oral health risks, rather than viewing them as a negligible alternative (19). The strengths of the study lie in its rigorous methodology, inclusion of calibrated examiners for periodontal measurements, and adjustment for key confounders such as oral hygiene practices and socioeconomic status. This strengthened the internal validity and reduced the likelihood that observed associations were solely attributable to external factors. The use of a clinical population provided real-world relevance and enhanced the practical applicability of the findings (20).

Nevertheless, several limitations must be acknowledged. The cross-sectional design precludes causal inference, as temporality between e-cigarette use and periodontal inflammation cannot be established (21). The reliance on self-reported data for exposure may have introduced reporting bias, particularly underestimation of use frequency. Additionally, while exclusion of conventional cigarette smokers minimized confounding, it also reduced the ability to compare risks directly between e-cigarettes and traditional tobacco. The study was conducted in a single urban setting, limiting generalizability to broader populations with different cultural, socioeconomic, and health backgrounds (22). Despite these constraints, the results highlight associations that are biologically plausible and supported by mechanistic research, reinforcing their credibility. Future research should focus on longitudinal cohort studies to establish causal pathways between e-cigarette use and periodontal deterioration. Incorporation of biomarkers of inflammation, salivary microbiome profiling, and quantification of aerosol exposure may provide deeper mechanistic insights. Additionally, comparative studies assessing dual users, exclusive e-cigarette users, and traditional smokers would help clarify the relative risks of different nicotine delivery systems. Expansion to multi-center populations across diverse age groups and socioeconomic strata would further strengthen external validity.

Conclusion

This study demonstrated that e-cigarette use among young adults was independently associated with higher levels of bleeding on probing, greater probing pocket depths, and increased plaque index scores, even after adjusting for confounders. The findings highlight the oral health risks posed by e-cigarettes and underscore the importance of incorporating their assessment into dental practice and public health prevention strategies. Continued research is warranted to establish causal mechanisms and long-term effects.

AUTHOR'S CONTRIBUTIONS

Author	Contribution
Fateen Khan*	Designed the study, performed data collection and analysis, and prepared the manuscript. Approved the final draft for submission.
Atif Kaleem	Contributed to study design, data acquisition, interpretation of findings, and performed critical review and editing of the manuscript. Approved the final draft for submission.

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