Full Paper

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Dose-Response Association of Smoking with Periodontitis Severity Among Adult Males

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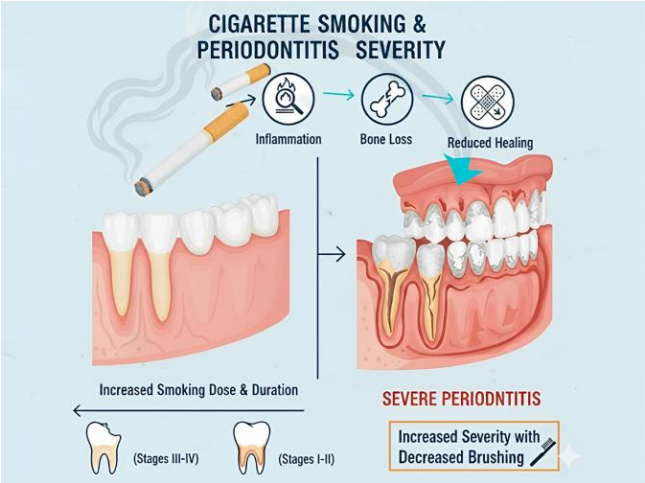

Abstract: Cigarette smoking is a major modifiable risk factor for periodontitis, and its dose–response effect on disease severity warrants focused investigation to guide public health interventions. This cross-sectional study examined the prevalence and dose–response relationship between cigarette smoking and periodontitis severity in 210 male smokers in Benghazi, Libya. Data were collected through clinical examination and a structured questionnaire and analyzed using SPSS version 23. Periodontitis was highly prevalent (87.6%), with 95.65% of cases classified as Grade C. Inferential analysis revealed a signific association between smoking dose and overall disease status ($p = 0.005$). A strong positive dose–response correlation was observed, whereby periodontitis severity (Stages I–IV) increased with both mean age and mean smoking duration. Additionally, 90.9% of Stage IV patients reported never brushing. These findings highlight the dose-dependent and compounding detrimental effects of smoking on periodontal health.

Keywords: periodontitis, cigarette smoking, dose–response relationship, periodontal disease severity, smoking duration, oral hygiene behavior

Received: 2025.10.11
Accepted: 2025.12.27
Published: 2025.12.30
DOI: 10.58332/scirad2025v4i4a05

Introduction

Periodontal disease represents a spectrum of conditions ranging from gingivitis, a reversible inflammation of the gingival tissues, to periodontitis, a destructive inflammatory disease affecting the periodontal ligament, cementum, and alveolar bone. If untreated, gingivitis can progress to periodontitis, resulting in irreversible tissue loss and, ultimately, tooth loss [1-3]. Globally, periodontitis is the 11th most common disease, with a prevalence estimated to range between 20% and 50%. While it may occur in children and adolescents, it is more frequently observed in adults and remains the leading cause of tooth loss in this population. Several systemic and environmental factors, including diabetes mellitus and smoking, influence host immune responses and increase susceptibility to periodontal destruction [4-6].

Smoking is recognized as one of the most significant risk factors for the onset and progression of periodontal disease [5]. Evidence shows that smokers face a two- to six-fold higher risk of developing chronic periodontitis compared with nonsmokers, with nearly 40% of periodontitis patients identified as smokers. This association is dose-dependent, as higher cigarette consumption correlates with increased risk and greater disease severity. Mechanistically, smoking disrupts host inflammatory responses, alters the subgingival microbiota, and impairs tissue healing, thereby undermining periodontal homeostasis. Clinical studies further indicate that smoking negatively affects treatment outcomes in both periodontal and implant therapy. Consequently, both smoking status and intensity should be carefully considered in research and treatment planning [7-9].

Despite extensive global evidence, data from Libya remain scarce. Differences in smoking patterns, oral hygiene behaviors, access to preventive dental care, and socioeconomic factors may influence the presentation of periodontal disease across populations, making population-specific investigation necessary. In particular, it remains unclear how smoking intensity and duration relate to periodontal disease severity when assessed using the current staging and grading system in this population. Accordingly, we hypothesized that higher smoking intensity and longer smoking duration are associated with increased severity of periodontitis. Given the high prevalence of smoking and periodontitis in

the region, local investigations are necessary to clarify the dose–response relationship and to guide preventive and therapeutic strategies. Therefore, the primary objective of the current study was to determine the prevalence and severity of chronic periodontitis among smokers in Benghazi, Libya. The secondary objective was to evaluate the dose–response relationship between smoking intensity and duration and periodontal disease severity.

Materials and Methods

This cross-sectional clinical study employed a convenience sampling strategy and included 210 male patients who attended the LIMU Dental Clinic in Benghazi between May 2021 and December 2022. Ethical approval was obtained from the Faculty of Dentistry Research Ethics Committee (DEN-2024-00156), and written informed consent was obtained from all participants in Arabic. A post hoc power assessment indicated that the achieved sample size was sufficient (>80%) to detect statistically significant associations between smoking exposure and periodontitis severity. Eligible participants were cigarette smokers aged 18 years or older who presented for consultation. Patients with chronic systemic diseases known to affect periodontal status (including diabetes mellitus and autoimmune disorders), psychiatric conditions, alcohol or drug use, orthodontic appliances, or those who refused to participate were excluded. Information was gathered through a structured questionnaire and a clinical examination. The questionnaire covered age, education, oral hygiene practices, and smoking history, including duration and intensity. Smokers were grouped into low-intensity (<10 cigarettes/day) and high-intensity (≥10 cigarettes/day) categories. Clinical assessment was performed by three calibrated examiners using a UNC-15 probe at six sites per tooth, excluding third molars. The main periodontal parameters measured were pocket depth (PD) and clinical attachment loss (CAL). Periodontal disease was staged and graded according to the 2018 classification proposed by Tonetti et al [10]. Data analysis was carried out using SPSS version 23. Descriptive results were presented as frequencies and charts. For inferential analysis, the chi-square test was used for categorical variables, and the independent-samples t test was used for continuous variables. Statistical significance was set at $p < 0.05$.

Results

The study included 210 male smokers.

1. Sample demographics and periodontal disease prevalence

About half of the participants were young adults (18–34 years). Regarding education, most had completed graduate-level studies (52.4%), followed by undergraduates (42.4%),

while only 5.2% held a postgraduate degree. Oral hygiene habits varied: one-third of the participants (32.9%) reported not brushing their teeth, nearly half (48.1%) brushed once daily, and 19.0% brushed twice daily. Most participants were heavy smokers (91.4%), while 8.6% were light smokers. Periodontal disease was widespread, with 87.6% of the sample diagnosed with periodontitis and 12.4% presenting with gingivitis. Among those with periodontitis, almost all (95.7%) were classified as Grade C, reflecting rapid disease progression.

Table 1. Characteristics of the sample of male smokers

Characteristic	**Category**	**N**	**%**
Total Sample	Male Smokers	210	100.0
Age	Young Adults (18–34 years)	≈105	≈50.0
	Other Age Groups (Implicit)	≈105	≈50.0
Education Level	Graduate-level studies	110	52.4
	Undergraduate studies	89	42.4
	Postgraduate degree	11	5.2
Brushing Frequency	Not brushing	69	32.9
	Once daily	101	48.1
	Twice daily	40	19.0
Smoking Intensity	High-intensity smokers	192	91.4
	Light smokers	18	8.6
Periodontal Status	Periodontitis	184	87.6
	Gingivitis	26	12.4
Periodontitis Grade	(Subgroup N=184)		
Among those with Periodontitis	Grade C (Rapid Progression)	176	95.7†
	Grades B	8	4.3†

2. Association between smoking dose and disease status

Chi-square analysis showed a significant association between smoking dose and overall periodontal disease status ($p = 0.005$). Periodontitis was observed in 89.6% of heavy smokers compared with 66.7% of light smokers, whereas gingivitis was relatively more common among light smokers. In contrast, smoking dose was not associated with the distribution of periodontitis stage ($p = 0.636$), age group ($p = 0.325$), or education level ($p = 0.952$).

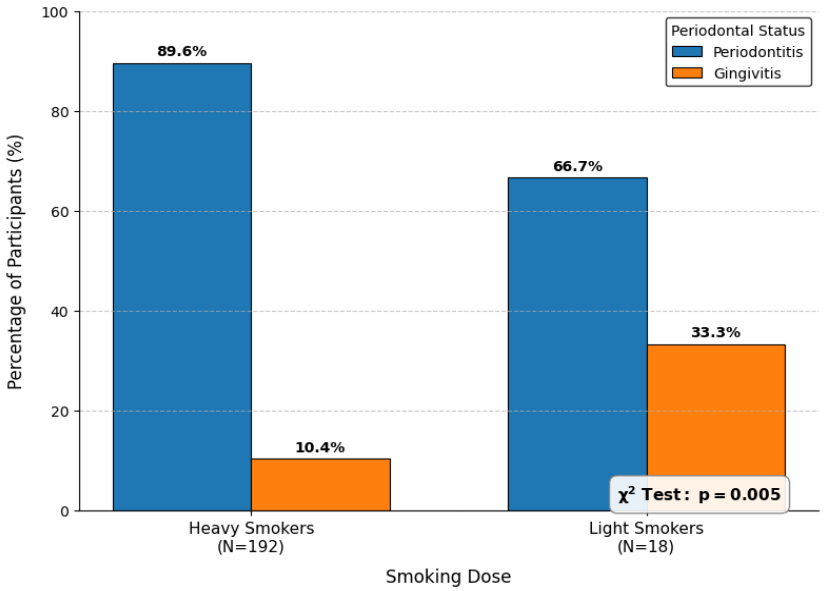

Figure 1. Association between smoking intensity and Periodontitis prevalence

Table 2. Association between smoking intensity and selected demographic and clinical characteristics

Characteristic	p-value	Significance
Overall Periodontal Disease Status	0.005	Significant
Periodontitis Stage	0.636	Not Significant
Age Group	0.325	Not Significant
Education Level	0.952	Not Significant

3. Dose–response relationship: age and duration of smoking

Both patient age and smoking duration showed a clear dose–response pattern with periodontitis severity. Mean age increased steadily across disease stages, from 23.9 years in Stage I to 61.6 years in Stage IV. A similar trend was observed for smoking duration, which rose from a mean of 5.5 years in Stage I to 33.6 years in Stage IV.

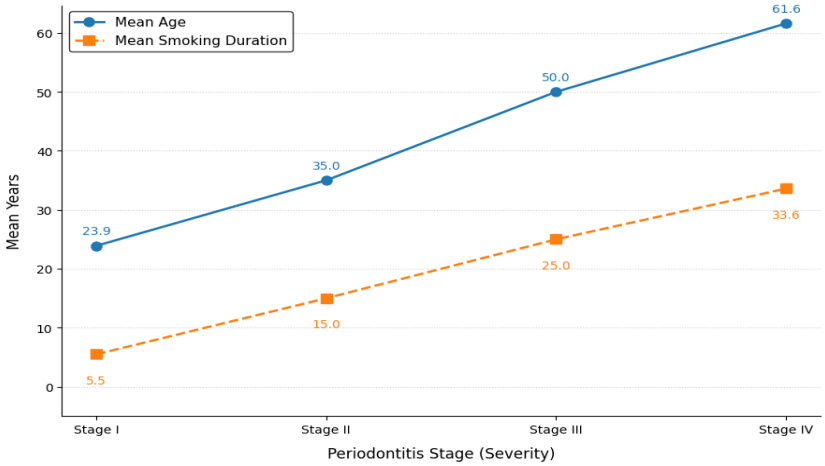

Figure 2. Relationship between periodontitis severity and mean values for age and smoking duration

4. Periodontitis severity and oral hygiene practice

A clear inverse relationship was observed between oral hygiene frequency and disease severity. Among patients with mild periodontitis (Stage I), 28.6% brushed twice daiy. In contrast, oral hygiene was largely absent in severe cases: 90.9% of Stage IV patients never brushed their teeth, and none reported brushing twice daily. This trend suggests that inadequate mechanical biofilm control significantly accelerates disease progression.

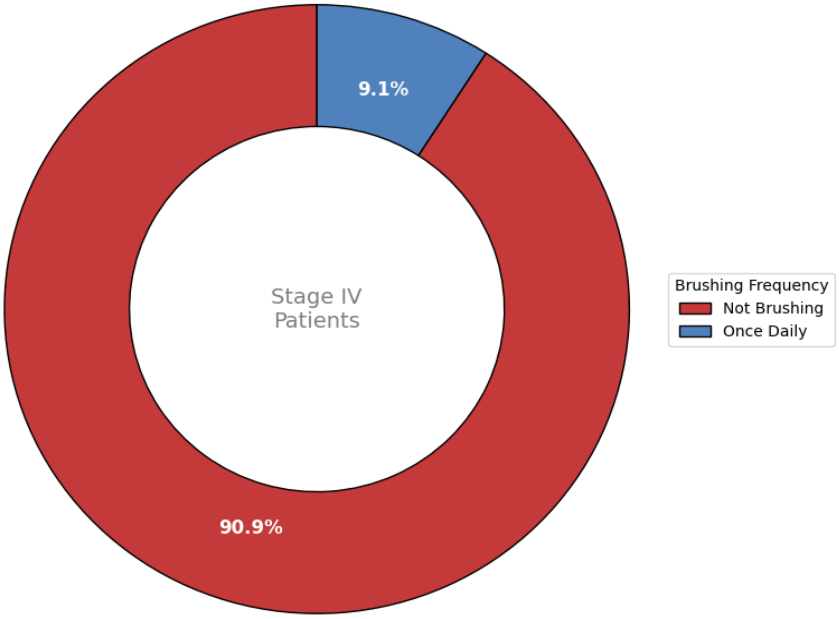

Figure 3. Brushing frequency of patients with severe (Stage IV) Periodontitis

In contrast, education level showed no clear association with disease severity; Stage IV cases were almost equally distributed between graduate (45.5%) and undergraduate (45.5%) participants.

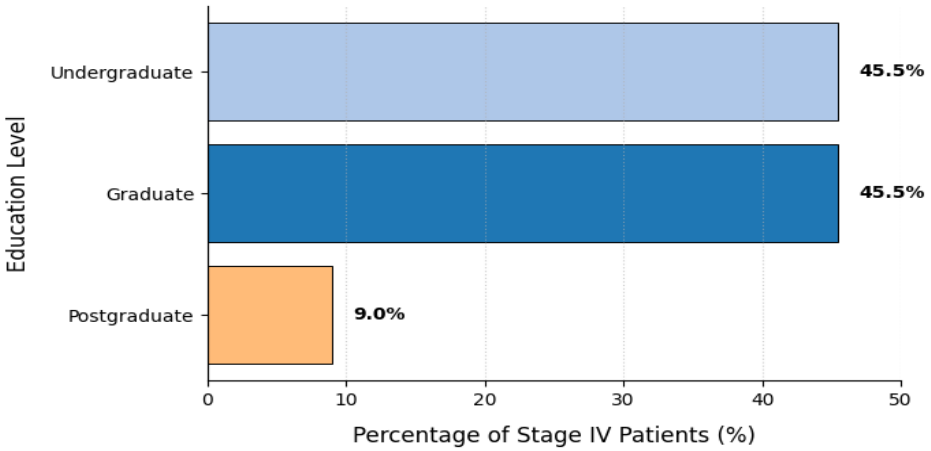

Figure 4. Distribution of education level among patients with Stage IV Periodontitis

Discussion

This cross-sectional study aimed to determine the prevalence and severity of chronic periodontitis among smokers and to evaluate the dose–response relationship between smoking intensity and periodontal disease in a Libyan population. The primary finding—that 87.6% of participants were diagnosed with periodontitis, with 95.65% classified as Grade C—underscores the substantial detrimental impact of tobacco use in this cohort. This is consistent with the systematic review by Alwithanani, which analyzed 15 studies and reported that smoking increases the incidence of periodontitis by 85% [11], and with the retrospective study of 2,069 patient records by Chatzopoulos et al. which linked smoking to rapid progression (Grade C) [12]. However, the remarkably high proportion of Grade C cases in our study suggests that, in this specific demographic of male smokers, the cumulative inflammatory burden overwhelms host reparative mechanisms, accelerating tissue destruction far beyond the expected age-related rate.

Inferential analysis revealed a statistically significant association between smoking dose and disease status ($p = 0.005$), with periodontitis being more prevalent among heavy smokers (89.6%). These results are consistent with Beklen et al., who in a five-year cross-sectional study from 2015–2020 including 7,028 smokers demonstrated that smoking intensity is a critical determinant of disease severity [13]. The most important finding is the clear positive dose-response relationship linking cumulative smoking exposure to disease severity. The mean smoking duration increased from 5.5 years in Stage I patients to 33.6 years in Stage IV patients. This cumulative effect is supported by a retrospective study of 258 patients by Ravida et al., which reported that teeth of heavy smokers had a 4.4-fold higher risk of tooth loss compared to never-smokers [14]. Given that our Stage IV patients had an average smoking duration of over three decades, they are on a direct trajectory for significant tooth loss unless immediate intervention is initiated. The high proportion of heavy smokers classified as Grade C can be explained by established biological mechanisms. Nicotine-induced vasoconstriction reduces nutrient and oxygen supply to the periodontium, while simultaneous suppression of neutrophil function and antibody production facilitates bacterial invasion. This compromised immune response directly promotes tissue destruction and bone loss, contributing to the rapid progression observed in our cohort [11].

Severity was also strongly associated with basic preventive habits: 90.9% of patients with Stage IV disease reported that they did not brush, and none reported brushing twice daily. This pattern aligns with the findings of Goswami et al., who observed that individuals with periodontal pockets generally had more dental plaque and visited the dentist less frequently [15]. In our population, this lack of mechanical biofilm control likely acts as a

"double-hit" alongside the chemical insult from tobacco, further compounding the risk of severe attachment loss.

Our study found no statistically significant association between smoking dose and education level ($p = 0.952$), contrasting with findings from the Hamburg City Health Study, in which Walther et al. reported that education level (low vs. high) was significantly associated with periodontitis (OR: 1.33, 95% CI: 1.18–1.47) [16]. This discrepancy is likely explained by the mediation pathway identified by Baumeister et al., who found that smoking mediates 35% of the educational effect on periodontitis [17]. These findings suggest that the extreme biological risk conferred by heavy smoking intensity in our sample likely outweighed the subtle protective benefits typically associated with higher education.

Despite the clear clinical significance of the dose-response correlation, several limitations should be noted. As a cross-sectional study, this research shows associations but cannot establish direct causality. Additionally, the sample was limited to 210 male smokers from a single clinical center, which may restrict the generalizability of the prevalence findings. Nevertheless, the results carry important clinical and public health implications: the data indicate that young adult males (18–34 years, the most prevalent group) who are heavy smokers face a documented risk for severe Grade C periodontitis. Clinically, the fact that 90.9% of Stage IV patients never brush provides a simple, high-yield flag for screening. Therefore, public health strategies should focus on young adult males for targeted anti-tobacco campaigns, and therapy for Grade C heavy smokers should include immediate, personalized smoking cessation counseling to mitigate the confirmed risk of rapid disease progression.

Conclusions

The current study confirms a severe burden of Grade C periodontitis among male smokers, associated with a clear dose–response relationship involving both smoking duration and intensity. These findings highlight smoking as a critical, modifiable risk factor, whereby cumulative exposure—compounded by poor oral hygiene—is linked to accelerated periodontal tissue destruction. Accordingly, clinical management should prioritize smoking cessation counseling alongside oral hygiene instruction to limit rapid disease progression. Future longitudinal studies in broader populations, including females, are recommended to further validate these trends and clarify causal pathways.

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