



## Original Article



## The Association Between High Cholesterol Levels and Severity of Periodontitis

Rashid Javaid<sup>1</sup>, Sana Mukhtar<sup>2</sup>, Ambreen Nawaz<sup>3</sup>, Anila Errum<sup>4</sup>, Bakhtawar Arslan<sup>5</sup> and Anum Fatima<sup>6</sup><sup>1</sup>Department of Oral Biology, De' Montmorency College of Dentistry, Lahore, Pakistan<sup>2</sup>Department of Periodontology, Foundation University College, Lahore, Pakistan<sup>3</sup>Department of General Pathology and Microbiology, Azra Naheed Dental College, Lahore, Pakistan<sup>4</sup>Department of Pharmacology, Azra Naheed Dental College, Lahore, Pakistan<sup>5</sup>Department of Prosthodontics, Liaquat Institute of Medical and Health Sciences, Thatta, Pakistan<sup>6</sup>Department of Dentistry Surgeon, Islamabad Medical and Dental College, Islamabad, Pakistan

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Department of Oral Biology, De' Montmorency College of Dentistry, Lahore, Pakistan  
rashidjavaid282@gmail.comReceived Date: 27<sup>th</sup> September, 2024Acceptance Date: 24<sup>th</sup> November, 2024Published Date: 30<sup>th</sup> November, 2024

## ABSTRACT

Periodontitis is a common inflammatory condition affecting tooth-supporting structures, leading to tooth loss and is linked to systemic diseases, including cardiovascular disease.

**Objectives:** To examine the association between high cholesterol levels and periodontitis severity in a sample from Lahore, Pakistan. **Methods:** A cross-sectional study was conducted at De' Montmorency College of Dentistry, Lahore, over six months. A total of 154 participants aged  $\geq 40$  years with periodontitis symptoms and without any systemic diseases were included. Participants were grouped based on the severity of periodontal disease status into no periodontitis group, mild disease group, moderate disease group, and severe periodontitis. Blood samples were collected and analyzed for lipid profile parameters. Multivariable regression analyses were performed, adjusting for age, gender, BMI, smoking, alcohol use, and exercise, to evaluate associations between lipid levels and periodontitis severity. **Results:** Severe periodontitis was found in 58 participants (37.7%). Multivariable regression indicated an inversely associated link between high-density lipoprotein cholesterol in blood and disease severity ( $p < 0.05$ ). Lower total cholesterol and higher triglyceride levels were associated with severe periodontitis ( $p < 0.05$ ). Logistic regression showed that participants with severe periodontitis had significantly higher values of the odds ratio of decreased high-density lipoprotein cholesterol (OR 1.34, 95% CI 1.05–1.72), total cholesterol (OR 1.26, 95% CI 1.02–1.55), and triglyceride levels (OR 1.48, 95% CI 1.12–1.96). **Conclusions:** It was concluded that severe periodontitis is greatly linked with lower high-density lipoprotein cholesterol and elevated triglyceride and total cholesterol levels, suggesting that periodontal health may influence lipid profile and increase cardiovascular disease risk.

## INTRODUCTION

Periodontitis is a localized inflammatory condition which may affect the structures that support the tooth, resulting in tooth loss by affecting the gingiva, bone, and periodontal ligament that support the teeth [1]. About 45–50% of adults have mild types of periodontitis, and that number rises to over 60% in those over 65 [2]. Severe periodontitis affects 11.2% of people worldwide and is reported to be the 6th most frequent disease in humans globally [3]. The prevalence of periodontitis in Pakistan has been estimated to vary across different provinces, with 37% reported in Punjab, 40% in Sindh, 20% in Khyber Pakhtunkhwa, and 3%

in Baluchistan, based on a 95% confidence interval [4]. Research suggests that bacteria isolated from the subgingival swab of a periodontitis patient may enter the bloodstream and stimulate host cells, leading to the production of inflammatory mediators in distant body parts [5]. Periodontitis raises the chance of developing other systemic disorders [6, 7], including cardiovascular diseases (CVD) [8, 9]. CVD accounts for approximately one-third of all deaths worldwide, with around 17.8 million fatalities annually [10]. Since atherosclerosis is a major factor in CVD pathophysiology, high-density lipoprotein



cholesterol (HDL-C) has been reported to be associated inversely with CVD development [11]. Its activity in increasing cholesterol outflow, endothelium restoration, angiogenesis, and preventing oxidative alteration of LDLs, inflammation of the vessels, and thrombosis has been linked to its potent anti-atherosclerotic actions [12]. Epidemiological studies on humans [13] and animals [14] indicate that elevated lipid levels contribute to periodontitis, though the exact mechanism linking periodontitis to atherosclerosis is unknown. Few studies from published literature have examined the correlation between lipid profiles and periodontitis after controlling for variables including health-related behaviours and demographic factors that may skew the results. Comprehensive investigations are necessary since there is a close link between HDL-C with periodontitis and variables such as BMI, alcohol consumption, and smoking habits [15]. Furthermore, many population studies have divided participants based on the condition that periodontitis exists or not, often ignoring disease severity, making it difficult to determine the full impact [16].

This study aims to assess if there is any association between elevated cholesterol levels with the severity of periodontitis in a sample population from the dental clinic at de' Montmorency College of Dentistry, Lahore, Pakistan.

## METHODS

The research took place at De' Montmorency College of Dentistry, Lahore, over six months starting from October 2023 to March 2024, after approval from the institutional review board (Ref # 8105/DCD). Participants in this study were selected from the outpatient department for routine dental check-ups. A simple random sampling technique was used to recruit participants. The inclusion criteria required participants to be 40 years or older, with at least 10 remaining natural teeth and no systemic diseases (diabetes, cardiovascular disease, cancer, nephrosis, or hepatopathy). Additionally, participants must not have undergone systemic antibiotic treatment or periodontal treatment within the last three months. Exclusion criteria included individuals not following the inclusion criteria and/or unable or unwilling to complete the necessary examinations and provide blood samples. The number of samples was considered using the equation for comparing means among three groups, considering the expected differences in cholesterol levels between these groups. An expected mean difference of 0.5 mmol/L was estimated to ensure the accuracy of the sample size calculation. The sample size calculation aimed to detect a significant association with a significance value at  $\leq 0.05$  and 80% power. Based on this calculation, 42 participants per group were required. Accounting for a 20% dropout rate, the final sample size was increased to 51 participants per group,

making a total sample size of 154. Periodontal examinations were conducted by experienced periodontists at de' Montmorency College of Dentistry, Lahore. The examinations involved assessing probing depth (PD) and clinical attachment loss (CAL) at multiple sites per tooth. The severity of periodontitis was categorized into no periodontitis, mild, moderate, and severe disease. The criteria for periodontitis severity were based on the American Academy of Periodontology (AAP) and Centers for Disease Control (CDC) guidelines [17] (Table 1).

**Table 1:** Criteria for Severity of Periodontitis

Periodontitis Severity	CAL	PD	Criteria
Severe Periodontitis	$\geq 6$ mm at $\geq 1$ Interproximal Site	$\geq 5$ Mm at the Same Site with CAL $\geq 6$ Mm Or Distinct Site(S)	Must Meet Both CAL and PD Criteria
Moderate Periodontitis	$\geq 4$ mm at $\geq 1$ Interproximal Site	$\geq 5$ Mm at the Same Site Or Distinct Site(S)	Must Meet Either CAL Or PD Criteria
Mild Periodontitis	$\geq 3$ mm at $\geq 1$ Interproximal Site	$\geq 4$ Mm at the Same Spot With CAL $\geq 3$ Mm Or Distinct Site(S)	Must Meet Both CAL and PD Criteria
No Periodontitis	No Sites Meeting the Criteria for Mild, Moderate, Or Severe Periodontitis	-	Absence of Any of the Above Criteria

All the participants were informed about the study and written consent was taken. After collecting blood samples from eight-hour-fasted participants, biochemical analyses were performed. The serum lipid profile parameters included total cholesterol (TC), HDL-C, Low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG). To account for potential confounding variables, additional covariates were evaluated alongside periodontal and biochemical tests. Participants completed questionnaires to provide information on age, gender, weight, height, alcohol consumption, exercise frequency, and smoking behaviour. BMI was calculated as weight (kg)/height (m<sup>2</sup>). Alcohol consumption was categorized as never, rarely, frequently, or every day, exercise regularity as never, 1 to 3 times a week, 4 to 6 times a week, once per day, and more than once per day, and smoking habits as current smoker, former smoker, and non-smoker. Former smokers were those who had quit smoking for at least six months. Data were analyzed statistically with SPSS-25.0. The categorical type of data was presented as percentages, while continuous variables were expressed as means  $\pm$  standard error. ANOVA was done for the continuous type of variables, while, chi-square was used to analyze categorical variables for the comparison of various factors across groups. The multivariate analysis between different parameters of lipid profile and periodontitis severity was determined using multiple linear regression models adjusted for gender, age, BMI, alcohol consumption,

exercise frequency, and smoking behaviours. Logistic regression tests were conducted to investigate the relationship between abnormal lipid profile parameters and periodontitis severity. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were applied for the quantification of the strength of these correlations.

## RESULTS

The analysis of the ABO and Rh blood typing of the 1049 participants revealed that B-type was most common, observed in 358 (34.1%) of the participants, followed by blood group O, which was present in 295 (28.1%) of the women. Blood group A accounted for 279 (26.6%) of the sample, while the least common was blood group AB, found in 117 (11.2%) of the participants. Regarding the Rh factor, a significant majority of 972 (92.7%) were Rh-positive, with only 77 (7.3%) being Rh-negative (Figure 1).

**Table 2:** Demographic Features and Covariates of Patients

Characteristic	No Periodontitis (n=20)	Mild/Moderate (n=76)	Severe. (n=58)	Overall. (n=154)	p-Value
Male Participants	8 (40.0%)	38 (50.0%)	29 (50.0%)	75 (48.7%)	0.344
Age (Years)	67.2 ± 4.1	68.9 ± 5.0	69.1 ± 5.2	68.5 ± 4.8	0.260
BMI (kg/m <sup>2</sup> )	23.9 ± 3.1	24.5 ± 2.9	24.3 ± 3.2	24.3 ± 3.1	0.694
<b>Exercise Frequency</b>					
- Never	4 (20.0%)	24 (31.6%)	16 (27.6%)	44 (28.6%)	<0.001*
- 1-3 Times Per Week	1 (5.0%)	3 (3.9%)	3 (5.2%)	7 (4.5%)	
- 4-6 Times Per Week	1 (5.0%)	1 (1.3%)	0 (0.0%)	2 (1.3%)	
- Once Per Day	10 (50.0%)	38 (50.0%)	31 (53.4%)	79 (51.3%)	
- >1 Time Per Day	4 (20.0%)	10 (13.2%)	8 (13.8%)	22 (14.3%)	
<b>Alcohol Use</b>					
- Never	14 (70.0%)	52 (68.4%)	39 (67.2%)	105 (68.2%)	0.177
- Seldom	3 (15.0%)	5 (6.6%)	4 (6.9%)	12 (7.8%)	
- Often	0 (0.0%)	3 (3.9%)	3 (5.2%)	6 (3.9%)	
- Every day	3 (15.0%)	16 (21.1%)	12 (20.7%)	31 (20.1%)	
<b>Smoking Habits</b>					
- Current Smoker	2 (10.0%)	10 (13.2%)	8 (13.8%)	20 (13.0%)	0.287
- Former Smoker	1 (5.0%)	4 (5.3%)	3 (5.2%)	8 (5.2%)	
- Nonsmoker	17 (85.0%)	62 (81.6%)	47 (81.0%)	126 (81.8%)	

The unadjusted correlations between blood lipid markers and periodontitis severity are displayed. In individuals without the disease, mild or moderate disease condition, and severe disease, the mean value of HDL-C levels was 1.45 ± 0.35 mmol/L, 1.42 ± 0.340 mmol/L, and 1.38 ± 0.32 mmol/L, respectively. Significantly decreased HDL-C values were seen in participants with severe periodontitis (p<0.05). Additionally, compared to individuals with minimal or mild-to-moderate periodontitis, those with severe periodontitis had significantly higher levels of triglycerides (TG) and total cholesterol (TC) (p<0.05). There were no discernible variations in LDL-C values between the groups (Table 3).

**Table 3:** Serum Lipid Parameters by Periodontitis Severity

Lipid Parameter	No Periodontitis (n=20)	Mild/Moderate (n=76)	Severe (n=58)	p-Value
HDL-C (mmol/L)	1.45 ± 0.35	1.42 ± 0.340	1.38 ± 0.32	0.042*
Low-HDL-C (%)	4 (20.0%)	16 (21.1%)	13 (22.4%)	0.434
TC (mmol/L)	5.15 ± 1.30	5.45 ± 1.05	5.55 ± 1.03	0.038*
High-TC (%)	11 (55.0%)	37 (48.7%)	25 (43.1%)	0.297
TG (mmol/L)	1.59 ± 1.05	1.67 ± 0.90	1.69 ± 0.92	0.049*
High-TG (%)	7 (35.0%)	18 (31.0%)	22 (28.9%)	0.195

Higher total cholesterol and triglyceride levels were associated with increased severity of periodontitis, while HDL-C levels were inversely correlated. Specifically, each step, in periodontitis severity was linked to a significant rise in the value of total cholesterol (p<0.05) and triglyceride levels (p<0.05), and a reduction in the levels of HDL-C (p<0.05). LDL-C levels did not show any significant correlation. The multivariable linear regression analysis revealed the adjusted means and 95% confidence intervals for the lipid parameters stratified by periodontitis severity (Table 4).

**Table 4:** Multiple Linear Regression Analysis of HDL-C, TC, and TG Levels

Variable	HDL-C (p-Value)	TC (p-Value)	TG (p-Value)
Periodontitis	0.040*	0.034*	0.048*
Age	0.213	0.015*	0.022*
Gender	<0.01*	<0.01*	0.03*
BMI	<0.01*	0.197	0.162
Alcohol usage	<0.01*	0.072	0.054
Exercise Regularity	0.459	0.947	0.634
Smoking Behaviors	0.124	0.121	0.145

To examine the odds ratios between clinically aberrant

HDL-C, TC, and TG levels and the severity of periodontitis, a multivariate logistic regression model was built. Participants having severe periodontitis have substantially more chances to have aberrant TG levels (adjusted OR 1.48, 95% CI 1.12–1.96,  $p < 0.05$ ) and abnormal HDL-C levels (adjusted OR 1.34, 95% CI 1.05–1.72,  $p < 0.05$ ) after controlling for all other variables. A statistically significant result was also observed in the relationship between aberrant TC levels and severe periodontitis (adjusted OR 1.26, 95% CI 1.02–1.55;  $p < 0.05$ ) (Table 5).

**Table 5:** Regression Analysis of Clinically Abnormal Lipid Profile Levels and Severity of Periodontitis

Lipid Parameter	Model 1 (OR, 95% CI)	Model 2 (OR, 95% CI)	p-Value
HDL-C	1.34 (1.05–1.72)	1.30 (1.03–1.68)	0.043*
Total Cholesterol	1.26 (1.02–1.55)	1.22 (1.01–1.52)	0.048*
Triglycerides	1.48 (1.12–1.96)	1.42 (1.08–1.90)	0.037*

Age, gender and BMI have been adjusted in model 1; BMI, alcohol consumption, age, exercise frequency, gender and smoking habits have been adjusted in the results shown for model 2; results are considered significant at  $\leq 0.05$

## DISCUSSION

This study characterizes one of the first comprehensive investigations into the link between the severity level of periodontitis and various parameters of lipid profiles, specifically HDL-C, total cholesterol, and triglycerides, in a population-based study. Previous research has consistently linked aging with adverse lipid profiles, suggesting that changes in lipoprotein cholesterol absorption, synthesis, and metabolism occur through complex mechanisms as individuals age [18]. These changes predispose older adults to dyslipidemia, thereby increasing their susceptibility to cardiovascular disease (CVD) [19]. The findings of current research also indicated that severe periodontitis was linked significantly with the levels of various parameters of lipid profile. This verifies the clinical importance of monitoring lipid profiles in patients with periodontitis. Routine monitoring of lipid profiles in these patients may allow for timely management to alleviate the risk of systemic complications associated with both dyslipidemia and periodontitis. Some of the published studies have identified lower HDL-C levels among individuals with periodontitis [20] while some others have shown links between periodontitis and higher HDL-C levels [21]. These inconsistencies could be due to variations in research design, sampling technique and size, or the demographic features of the study population [22]. Moreover, the link between periodontitis and lipid profile parameters may be influenced by confounding factors such as gender, age, and genetic predispositions [21]. Several studies report a bidirectional relationship between periodontitis and lipid profile. The presence of

periodontitis may inversely influence serum lipid profile, contributing to dyslipidemia [23]. Conversely, low HDL-C levels may increase periodontitis and vice versa [24]. The protective effects of hyperlipidemia treatment of periodontal health further support this bidirectional relationship [25]. Using full-mouth periodontal examinations (FMPE), the "gold standard" for assessing periodontal health, is one of our study's strengths [26]. However, the resource-intensive nature of FMPEs and their potential to cause fatigue for both participants and clinicians should be considered when designing such studies. Despite these challenges, FMPEs offer high accuracy and thoroughness, enhancing the validity of findings related to the link between periodontitis and lipid profiles [27]. We acknowledge some limitations to our study. Being cross-sectional, it limits the ability to establish a causal relationship between periodontitis severity and abnormal lipid levels. Additionally, as the study was carried out on a specific population, the findings might not be generalized to other population groups. Future large-scale, longitudinal studies with a detailed examination of confounding factors are needed to explore the underlying mechanisms of the association between periodontal disease and lipid profile more deeply.

## CONCLUSIONS

It was concluded that the results of this research show a significant relationship between severe periodontitis with dyslipidemia. This justifies the clinical inferences for managing lipid profiles in patients with periodontitis and highlights the need for more research to investigate possible therapeutic interventions.

## Authors Contribution

Conceptualization: RJ

Methodology: RJ, SM, AN, AE, BA

Formal analysis: SM, AF

Writing review and editing: RJ, AE, AF

All authors have read and agreed to the published version of the manuscript

## Conflicts of Interest

All the authors declare no conflict of interest.

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