Is there a relationship between hyperlipidemia and periodontitis?

Hiperlipidemi ve periodontitis arasında bir ilişki var mı?

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SUMMARY

Aim: The aim of present study is to investigate any relationship between hyperlipidemia and periodontal disease.

Materials and Methods: In this cross sectional study, a total of 160 individuals were divided into two groups based on their metabolic status: hyperlipidemic group (n= 97) and normolipidemic group (n= 63). Plaque index, gingival index, bleeding on probing (BOP), probing depth (PD), clinical attachment level (CAL) and CPITN scores were measured. Triglyceride (TG), total cholesterol (TC), low density lipoprotein-cholesterol (LDL-C) and high density lipoprotein-cholesterol (HDL-C) levels had been determined during previously routine systemic examinations. Daily brushing habits, interdental cleaning, dietary habits, alcohol consumption and physical activity were also recorded.

Results: The mean BOP (%), PD, CAL, CPITN scores of the hyperlipidemic group were higher than the normolipidemic group ($P< 0.05$). TG showed positive association with TC, LDL-C, CAL, and negative association with HDL-C, CPITN ($P< 0.05$). Positive correlations were detected between TC and TG, LDL-C, HDL-C, BOP, PD, CAL, BMI ($P< 0.05$). LDL-C was positively correlated with PD, CAL ($P< 0.05$). Positive correlations were detected among all periodontal parameters as expected.

Conclusion: Our findings suggest that patients with hyperlipidemia manifested higher values of periodontal parameters compared to normalipidemic individuals and are more prone to periodontal disease.

Key words: HDL cholesterol, hyperlipidemia, LDL cholesterol, periodontal disease, triglyceride.

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ÖZET

Amaç: Bu çalışmanın amacı, hiperlipidemi ve periodontal hastalık arasındaki herhangi bir ilişki olup olmadığını araştırmaktır.

Gereç ve Yöntem: Bu kesitsel çalışmada toplam 160 kişi metabolik durumlarına göre hiperlipidemik grup (n = 97) ve normolipidemik grup (n = 63) olarak iki gruba ayrıldı. Plak indeksi, gingival indeksi, sondalamada kanama (SK), sondalama derinliği (SD), klinik ataşman seviyesi (KAS) ve CPITN skorları ölçüldü. Rutin yapılan sistemik incelemelerden trigliserid (TG), total kolestrol (TK), low density lipoprotein-cholesterol (LDL-C) ve high density lipoprotein-cholesterol (HDL-C) düzeyleri belirlendi. Günlük fırçalama alışkanlıkları, arayüz temizliği, beslenme alışkanlıkları, alkol tüketimi ve fiziksel aktivite de anket formuna kaydedildi.

Bulgular: Hiperlipidemik grubun ortalama SK (%), SD, KAS, CPITN skorları normolipidemik gruba göre daha yüksek bulundu ($p<0,05$). TG; TK, LDL-C, KAS ile pozitif ve HDL-C, CPITN ile negatif ilişki gösterdi ($p<0,05$). TK ve TG, LDL-C, HDL-C, SK, SD, KAS, BMI arasında pozitif korelasyonlar tespit edildi ($p<0,05$). LDL-C ile SD, KAS arasında pozitif korelasyon

saptandı (p<0,05). Tüm periodontal parametreler arasında pozitif korelasyonlar tespit edildi.

Sonuç: Bulgularımız, hiperlipidemili hastaların, normolipidemik hastalara kıyasla daha yüksek periodontal parametre değerlerine sahip olduğunu ve periodontal hastalığa daha yatkın olduklarını ortaya koymaktadır.

Anahtar Kelimeler: HDL kolesterol, hiperlipidemi, LDL kolesterol, periodontal hastalık, trigliserid.

INTRODUCTION

The periodontium, defined as the supporting tissues of the teeth, constitutes a developmental, biologic, and functional unit which undergoes certain changes under certain situations.[1] Periodontal disease, a common inflammatory and infectious disease, is initiated by specific microorganisms living in the microbial dental plaque accumulating on the root surface of the tooth.[2-4] It is assumed that such pathogenic microorganisms are directly involved in the destruction of periodontium.[2-4] Host-related factors including genetics, inflammatory immune response and environmental factors especially systemic health, diet, smoking etc. are all currently accepted as major predisposant factors, the initiation and progression of periodontal disease.[5] If the human body is viewed as a single unit, a local disturbance of the health balance cannot be assumed as a restricted entity limited in its impact region.[3,6,7] Hence, there are potentially two mechanisms describing the distant organ effects of periodontal inflammatory response oriented cells and mediators: 1) Direct migration and colonization of periodontal microorganisms in distant organs, bringing out an inflammatory reaction away from the point of invasion, 2) Systemic inflammation as a result of metastatic periodontal inflammation or activated soluble inflammatory pathways by blood-borne periodontal bacteria.[3,8-10] As a chronic inflammatory situation, periodontal disease has common action pathways like other systemic inflammatory diseases. To this end, strong evidence is building up supporting the possible associations between periodontitis and other inflammatory diseases one of which is cardiovascular disease (CVD).[3,8-10]

Hyperlipidemia develops due to the failure in the lipid metabolism characterized with the increase in plasma total cholesterol (TC), low density lipoprotein-cholesterol (LDL-C) and/or triglyceride (TG) levels and leads to atherosclerosis.[11] Initiation of an atherosclerotic plaque can represent a pathological basis of coronary heart disease together with CVD which is one of the frequent reasons of early death.[12-14] The existence of oral bacteria has been presented in the atheromatous plaques.[15-19] From the etiologic point of view, it has been stated that inflammation is a causative factor in the development of atherosclerotic plaque.[13,20-24] Although the exact relationship between serum lipid levels, CVD and periodontal disease cannot be determined so far, a number of studies suggested a probable association among them.[6,8,12,22,25-37] It has been propounded that both cardiovascular and periodontal diseases share the same risk factors such as smoking, aging, physical activity, diabetes, and male gender.[25,31,38-42] An acceptable prominence has been raised about the relation between periodontal diseases and cardiovascular disorders by means of inflammatory processes.[7,37] Direct interaction between lipids and macrophage cell membrane can alter the periodontal disease associated growth factor and proinflammatory cytokine expression.[31,43] Moreover, hyperlipidemia may be more essential compared to hyperglycemia in relation to the hyper responsive monocytic phenotype in periodontal diseases.[31,44-46] In this cross-sectional study, we aimed to investigate any interaction/association between hyperlipidemia and periodontal disease regarding the periodontal parameters together with age, gender, body mass index (BMI), dietary habit, physical activity, alcohol consumption and plasma lipid parameters.

MATERIALS AND METHODS

Study Population

A total of 240 subjects were examined among patients who attended to the Department of Periodontology, Marmara University or the Turkish Heart Foundation and had their plasma lipid values determined within the last 3 months. Out of 240, 160 subjects (57 male, 103 female, age range 35-65 years) eligible for this study were selected. Inclusion criteria were as follows: subjects having no periodontal treatment within previous 6 months, number of natural teeth ≥10, no history of cancer and systemic disease that affects lipid levels or periodontium, no history of medical treatment for hyperlipidemia, BMI< 30 kg/m2, no pregnancy, no history of systemic antibiotic treatment within previous 3 months, no smoking.

After being informed about the content and purpose of the study, patients signed informed consent forms. The study protocol was approved by the Ethical Commission of Preliminary Evaluation of Clinical Researches, Institute of Health Sciences, Marmara University with the number of 25.

Lipid Parameters and Patients' Habits

A specially designed questionnaire was used for individuals whose personal information, dietary habits, frequency of physical activity, medical status, resting blood pressure levels, plasma lipid levels {TG, TC, LDL-C, high density lipoprotein-cholesterol (HDL-C)}, number of missing teeth, frequency of tooth brushing and interdental cleaning were recorded. Plasma levels of TG, TC, LDL-C, and HDL-C had been determined previously at the laboratory as a part of individuals routine systemic examina-

tions. Plasma lipid levels were evaluated based on the criteria defined by National Cholesterol Education Program Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults (Adults Treatment Panel III) (National Cholesterol Education Program Expert Panel, 2001).[47] For each subject, height and weight were measured and BMI was calculated as kg/m^2. Subjects were also asked for alcohol consumption and categorized as regular, rare or never.[48] According to the amount of physical activity, subjects were classified as active, partially active or inactive.[49]

Periodontal Clinical Parameters

All periodontal clinical examinations were carried out by the same examiner (GTK). The plaque index (PI) as the measurement of the state of oral hygiene based on recording dental plaque accumulation,[50] gingival index (GI) as an assessment level of gingival health and inflammation[51] and bleeding on probing (BOP) as a sign of gingival inflammation were assessed on the buccal, lingual, mesial and distal sites of each tooth. Probing depth (PD) was measured as the distance from the gingival margin to bottom of the pocket with using 0.5 mm diameter periodontal probe (University of North Carolina 15, Hu-Friedy, Chicago, IL, USA) at mesiobuccal, midbuccal, distobuccal, distolingual, midlingual and mesiolingual sites of each tooth. Similarly, clinical attachment level (CAL) was measured as the distance between the cemento-enamel junction and bottom of the pocket. Additionally, the oral cavity was divided into sextants and each sextant was given a Community Periodontal Index of Treatment Needs (CPITN) score as described by Ainamo *et al.*[52] The CPITN scores of 0, 1, 2, 3, 4 were used to represent healthy periodontium, bleeding after probing, dental calculus detected by probing, 4-5 mm deep pockets and deep pockets ≥ 6 mm, respectively. While the CPITN scores of all sextants were measured, the highest value of sextants was recorded as the subject's CPITN score.[52]

Definition of Groups

First, all data obtained from 160 subjects were evaluated. Then, individuals were divided into groups based on their metabolic status. Subjects with plasma TG or TC levels > 200 mg/dl[47] and LDL-C levels > 130 mg/dl[47] were included in the hyperlipidemic group, while the normolipidemic group comprised of patients with plasma TG or TC levels below the aforementioned limits.[47] And then the groups were further evaluated for clinical periodontal parameters as well as to define the effects of the patient's habits on hyperlipidemia.

Statistical Analysis

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) for Windows 21.0 software (SPSS for Windows, Release 21.0, SPSS Inc. Chicago, IL, USA). Following descriptive statistical analyses of each group, comparisons of qualitative and quantitative data between the groups were performed using the Pearson chi-Square test and Mann Whitney-U test, respectively. Spearman correlation test was used to measure the degree of association between all parameters. Results are reported as 95% confidence interval and the p value was set at <0.05.

RESULTS

Demographic data, plasma lipid parameters and clinical periodontal parameters of the hyperlipidemic and normolipidemic group patients are elucidated in Table 1.

Table 1. Patients' Characteristics, Lipid and Periodontal Parameters.

	Total (n=160) Mean±SD	Hyperlipidemic group (n=97) Mean±SD	Normolipidemic group (n=63) Mean±SD	*P* Value*
Age	49.8 ±8.0	51.0 ± 8.1	47.7 ± 7.9	**0.016**
BMI (kg/m^2)	26.0 ±2.6	26.3 ± 2.4	25.0 ± 2.6	**0.002**
Number of missing teeth	4.9 ±4.4	5.7 ± 4.7	3.8 ± 3.8	**0.010**
Systolic blood pressure (mmHg)	120.0 ± 16.0	122.4 ± 12.1	121.2 ± 21.3	0.270
Diastolic blood pressure (mmHg)	80.0 ± 10.0	80.2 ± 7.0	78.4 ± 13.1	0.651
Lipid parameters TG (mg/dl)	149.0 ± 71.9	170.0 ± 78.9	116.8 ± 43.3	**0.000**
TC (mg/dl)	221.6 ± 46.3	250.7 ± 31.8	176.9 ± 24.1	**0.000**
LDL-C (mg/dl)	139.6 ± 42.2	165.3 ± 32.4	100.1 ± 18.3	**0.000**
HDL-C (mg/dl)	53.2 ± 13.7	53.0 ± 12.9	53.5 ± 15.0	0.829
Periodontal parameters PI	1.1 ± 0.5	1.2 ± 0.5	1.1 ± 0.4	0.627
GI	1.2 ± 0.5	1.3 ± 0.5	1.2 ± 0.4	0.191
BOP (%)	37.2 ± 24.4	41.0 ± 25.6	31.2 ± 21.4	**0.014**
PD (mm)	2.7 ± 0.5	2.8 ± 0.5	2.5 ± 0.3	**0.000**
CAL (mm)	2.9 ±0.7	3.1 ± 0.7	2.6 ± 0.4	**0.000**
CPITN	3.1 ± 0.8	3.3 ± 0.8	2.7 ± 0.7	**0.000**
CPITN 0		0.1 ± 0.1	0.3 ± 0.2	0.332
CPITN 1		0.1 ± 0.5	0.8 ± 1.3	**0.000**
CPITN 2		1.4 ± 1.8	2.7 ± 1.8	**0.000**
CPITN 3		2.8 ± 1.7	2.0 ± 1.8	**0.002**
CPITN 4		1.1 ± 1.4	0.2 ± 0.8	**0.000**

SD: standard deviation, BMI: body mass index, TG: triglyceride, TC: total cholesterol, LDL-C: low density lipoprotein-cholesterol, HDL-C: high density lipoprotein-cholesterol, PI: plaque index, GI: gingival index, BOP: bleeding on probing, PD: probing depth, CAL: clinical attachment level, CPITN: community periodontal index of treatment needs, * Mann-Whitney U test, p<0.05.

Age, BMI and number of missing teeth were significantly higher in the hyperlipidemic group compared to the normolipidemic group (P= 0.016, P= 0.002, P= 0.010, respectively). No significant difference was observed in the systolic and diastolic blood pressures between the groups (P= 0.270 and P= 0.651). HDL-C level was similar in both groups (P= 0.829). The clinical periodontal parameters PI and GI showed no difference between the two groups (P= 0.627, P= 0.191, respectively), whereas mean BOP (%), PD and CAL of the hyperlipidemic group were significantly higher than those of the normolipidemic group (P= 0.014, P= 0.000, P= 0.000, respectively). CPITN scores of the normolipidemic group were lower than the hyperlipidemic group (P= 0.000). CPITN 1 and CPITN 2 scores of the normolipidemic group were higher than those of the hyperlipidemic group (P= 0.000, P= 0.000, respectively),

on the contrary, CPITN 3 and CPITN 4 scores of the normolipidemic group were significantly lower than those of the hyperlipidemic group (P= 0.002, P= 0.000, respectively).

Table 2 represents habits of patients in the hyperlipidemic and normolipidemic groups. Daily brushing, interdental cleaning and dietary habits were all similar between the two groups (P= 0.285, P= 0.108 and P= 0.566, respectively). Statistically significant differences were observed between the groups regarding alcohol consumption and physical activity (P= 0.035, P= 0.000, respectively). Odds ratio of inactive subjects having hyperlipidemia was estimated as 3.8 compared to the active subjects. Hyperlipidemia in the patients that drink alcohol was 2.1 times more than the patients that never consume alcohol.

Table 2. Comparisons of the Patients' Habits Between the Groups

	Hyperlipidemic group n (%)	Normolipidemic group n (%)	*P* Value*	OddsRatio
Daily brushing habits				
Never	3 (3)	0 (0)		
Once a day	42 (43)	22 (35)	0.285	-
Twice a day	48 (50)	39 (62)		
Three times a day	4 (4)	2 (3)		
Interdental cleaning				
Yes	11 (11)	13 (21)	0.108	-
No	86 (89)	50 (79)		
Dietary habits				
Well-balanced	64 (66)	45 (71)		
Plant based	24 (25)	11 (18)	0.566	-
Animal orgin	8 (8)	5 (8)		
Starchy	1 (1)	2 (3)		
Alcohol consumption				
Never	67 (69)	52 (82)	**0.035**	**2.1**
Rare	24 (25)	8 (13)		
Regular	6 (6)	3 (5)		
Physical activitiy				
Active	7 (7)	8 (13)	**0.000**	**3.8**
Partially active	17 (18)	27 (43)		
Inactive	73 (75)	28 (44)		

* Pearson chi-square test, , p<0.05

Table 3 displays the correlation coefficients between the patient's characteristics, plasma lipid levels and clinical periodontal parameters. Age was positively correlated with number of missing teeth (ρ= 0.405, P= 0.000), systolic blood pressure (ρ= 0.166, P= 0.036) and CAL (ρ= 0.179, P= 0.024).

Table 3. Correlations of the Patient's Characteristics, Plazma Lipid Levels and Periodontal Parameters

	BMI (kg/m²)	Number of missing teeth	Systolic blood pressure (mmHg)	Diastolic blood pressure (mmHg)	Daily brushing habit	TG (mg/dl)	TC (mg/dl)	LDL-C (mg/dl)	HDL-C (mg/dl)	PI	GI	BOP (%)	PD (mm)	CAL (mm)	CPITN
Age	0.155	0.405**	0.166*	0.014	-0.102	0.104	0.109	0.040	0.083	0.058	0.051	0.014	0.065	0.179*	-0.006
BMI (kg/m²)	-	0.128	0.254**	0.133	-0.214**	0.235**	0.162*	0.183*	-0.141	0.044	0.010	0.076	0.150	0.222*	-0.006
Number of missing teeth		-	0.250**	0.278**	-0.447**	0.079	0.084	0.057	-0.070	0.298**	0.283**	0.226*	0.332**	0.379**	-0.123
Systolic blood pressure (mmHg)			-	0.609**	-0.161*	0.171*	0.043	0.058	-0.033	0.060	0.064	0.076	0.167*	0.166*	-0.048
Diastolic blood pressure (mmHg)				-	-0.162*	0.213**	0.080	0.079	-0.089	0.150*	0.168*	0.154	0.227**	0.233**	-0.071
Daily brushing habit					-	-0.138	-0.014	0.026	0.058	-0.297**	-0.410**	-0.362**	-0.426**	-0.463**	0.111
Lipid parameters TG (mg/dl)						-	0.225**	0.188*	-0.402**	0.045	0.057	0.072	0.156	0.195*	-0.185*
TC (mg/dl)							-	0.928**	0.180*	0.017	0.096	0.160*	0.207**	0.208**	0.022
LDL-C (mg/dl)								-	0.042	-0.026	0.057	0.144	0.205**	0.274**	0.064
HDL-C (mg/dl)									-	0.056	0.056	0.016	0.127	0.060	0.061
Periodontal parameters PI										-	0.824**	0.759**	0.691**	0.636**	-0.081
GI											-	0.921**	0.715**	0.676**	-0.131
BOP (%)												-	0.688**	0.695**	-0.069
PD (mm)													-	0.915**	-0.005
CAL (mm)														-	-0.055
CPITN															-

BMI: body mass index, TG: triglyceride, TC: total cholesterol, LDL-C: low density lipoprotein-cholesterol, HDL-C: high density lipoprotein-cholesterol, PI: plaque index, GI: gingival index, BOP: bleeding on probing, PD: probing depth, CAL: clinical attachment level, CPITN: community periodontal index of treatment needs, *p<0.05, **p<0.01.

Positive associations were observed between the BMI and systolic blood pressure (ρ= 0.254, P= 0.001), TG (ρ= 0.235, P= 0.003), TC (ρ= 0.162, P= 0.040), LDL-C (ρ= 0.183, P= 0.021) and CAL (ρ= 0.222, P= 0.005). Number of missing teeth showed positive correlation with both systolic (ρ= 0.250, P= 0.000) and diastolic (ρ= 0.278, P= 0.000) blood pressure together with all clinical parameters; PI (ρ= 0.298, P= 0.000), GI (ρ= 0.283, P= 0.000), BOP (ρ= 0.226, P= 0.002), PD (ρ= 0.332, P= 0.001), CAL (ρ= 0.379, P= 0.000). Systolic blood pressure was positively associated with diastolic blood pressure (ρ= 0.609, P= 0.000), TG (ρ= 0.171, P= 0.003), PD (ρ= 0.167, P= 0.035), CAL (ρ= 0.166, P= 0.036). Diastolic blood pressure showed positive correlations with TG (ρ= 0.213, P= 0.007), PI (ρ= 0.157, P= 0.047), GI (ρ= 0.168, P= 0.033), PD (ρ= 0.227, P= 0.004), CAL (ρ= 0.233, P= 0.003). Negative associations were observed between daily brushing habit and BMI (ρ= -0.214, P= 0.000), number of missing teeth (ρ= -0.447, P= 0.000), systolic (ρ= -0.161, P= 0.036) and diastolic (ρ= -0.162, P= 0.040) blood pressure together with all clinical parameters (PI (ρ= -0.397, P= 0.036), GI (ρ= -0.410, P= 0.000), BOP (ρ= -0.362, P= 0.000), PD (ρ= -0.425, P= 0.000), CAL (ρ= -0.453, P= 0.000) as expected. TG showed positive association with TC (ρ= 0.273, P= 0.000), LDL-C (ρ= 0.188, P= 0.017) and CAL (ρ= 0.185, P= 0.019), whereas negative association with HDL-C (ρ= -0.487, P= 0.000) and CPITN (ρ= -0.187, P= 0.022). Positive correlations were detected between TC and TG (ρ= 0.273, P= 0.000), LDL-C (ρ= 0.939, P= 0.000), HDL-C (ρ= 0.180, P= 0.022), BOP (ρ= 0.160, P= 0.044), PD (ρ= 0.327, P= 0.000), CAL (ρ= 0.338, P= 0.000), BMI (ρ= 0.162, P= 0.040). LDL-C was positively correlated with PD (ρ= 0.255, P= 0.001) and CAL (ρ= 0.274, P= 0.000). Positive correlations were detected among all periodontal parameters as expected; between PI and GI (ρ= 0.874, P= 0.000), BOP (ρ= 0.759, P= 0.002), PD (ρ= 0.651, P= 0.001), CAL (ρ= 0.628, P= 0.000); between GI and BOP (ρ= 0.921, P= 0.000), PD (ρ= 0.715, P= 0.000), CAL (ρ= 0.676, P= 0.000); between BOP and PD (ρ= 0.688, P= 0.000), CAL (ρ= 0.655, P= 0.000); between PD and CAL (ρ= 0.915, P= 0.000).

DISCUSSION

The precise underlying mechanisms explaining the link between hyperlipidemia and periodontal disease have not yet been defined clearly. A number of hypotheses and models were proposed to address the possible interaction between these. The literature demonstrating the relationship is based on 2 different models. First model describes the interaction by offering a set point serum lipid level which is within a physiological range and is highly influenced by individual factors including diet, inherited physiology, metabolism, presence of systemic disease and periodontal condition.[10] In case of crossed upper lipid level which can be described as a threshold level of physiological set point serum lipid level, it can cause severe impairments in tissue response with a synergistic

manner by affecting the cytokine profiles, inhibition of enzyme activities, overstated proinflammatory monocytic responses and inhibited macrophage growth factor production.[10,31,43-46] Second model puts forward a cyclic relationship. The cycle may begin with the elevation of serum lipid levels or with the presence of periodontitis, both of which may lead to further elevation of serum proinflammatory cytokine levels causing an exaggerated tissue response that lasts with more severe periodontitis, metabolic disturbances and systemic diseases.[8-10,26,43,53,54] It is noteworthy that both hyperlipidemia and periodontitis are risk factors for CVD which is the number one cause of death worldwide.[7,55] Thus, there is still a great necessity for addressing the association between periodontitis and hyperlipidemia. Therefore, this cross sectional study was planned to investigate any relation between periodontal clinical parameters and plasma lipid levels together with age, gender, BMI, dietary habits, physical activity and alcohol consumption, in a total of 160 individuals.

The comparisons of periodontal clinical parameters between normolipidemic individuals and hyperlipidemic patients showed that PD, BOP, CAL and CPITN in the hyperlipidemic group were significantly higher compared with normolipidemic group. This result demonstrates that patients with hyperlipidemia may have a pronounced tissue response and show a high rate periodontal disease susceptibility than those who are normolipidemic,[10,22,26,27,29,31,56] although PI and GI of the groups were similar. Hence, the similarity in the oral hygiene regimens of the groups by means of brushing/interdental cleaning is of importance in creation a homogeneous population necessary for true assessment of any relationship between periodontal disease and hyperlipidemia. If higher PI score had been detected in the hyperlipidemic group this might cause more inflammation acting as a confounder and might represent a limitation in considering the tissue response. Sangwan *et al*.[37] reported similar periodontal clinical findings and concluded that patients with hyperlipidemia are more prone to periodontal disease and, also underlined the importance of revealed PI result to enlighten the exact relation between hyperlipidemia and periodontitis. Interestingly, in the present study CPITN 1 and CPITN 2 scores which reflect the bleeding of gingival tissues and the amount of dental calculus were significantly higher in the normolipidemic group compared to the hyperlipidemic group; on the contrary, CPITN 3 and CPITN 4 which reflect probing depths were significantly higher in the hyperlipidemic group. These findings may also favor an affirmative relationship between serum lipids and periodontal tissue response or vice-versa and are in line with aforementioned studies.[10,22,26,27,29,31,56]

In the present study, age, number of missing teeth and BMI were significantly higher in the hyperlipidemic group compared to the normolipidemic group. The finding of revealed number of missing teeth was consistent with the assumption stating association between periodontal disease progression and serum lipid levels. However, it should be kept in mind that our patients might not have lost their teeth only because of periodontal disease. In contrast with our study, Fentoglu *et al*.[31] declared no differences between the hyperlipidemic and the systemically healthy groups with regard to number of missing teeth data. It has been shown that BMI was significantly associated with hyperlipidemia.[31,57,58] Assessing the metabolic control by evaluating the factors such as BMI, diet, physical activity, alcohol consumption which are important for lipid metabolism is very crucial to eliminate these possible confounders for defining the association between hyperlipidemia and periodontitis.

Comparisons of patients' habits between the groups demonstrated that physical activity in the hyperlipidemic group was significantly lower and alcohol consumption was significantly higher than the normolipidemic group. Hyperlipidemia may occur from a high-fat diet which leads to functional abnormalities in polymorphonuclear leukocytes (PMNL).[31,59] It has been suggested that dietary lipids and endotoxins can stimulate PMNL which play a major role in the pathogenesis of periodontitis.[31,60,61] Recently published studies also concluded that obesity and hyperlipidemia can alter the host response leading to increase periodontal breakdown[62] and a cholesterol-enriched diet could lead to alveolar bone loss together with increasing periodontal inflammation and serum pro-oxidants levels.[63] It is widely known that lifestyle adjustments such as increased level of physical activity, decreased level of alcohol consumption, acceptable dietary habit and stress administration are significant issues not only in the prevention of hyperlipidemia but also in the treatment of CVD.[64,65] Although BMI result of our study which represents an objective parameter compare to the diet is in line with the literature,[31,37,62,66] dietary habits of patients were similar. The physical activity and alcohol consumption results of the present study are in conformity with the studies suggesting a possible interaction between hyperlipidemia and periodontal disease.[48,49,65,67]

A probable association between hyperlipidemia and periodontitis were investigated by assessing the biochemical parameters together with periodontal parameters in a number of studies.[22,31,36,37,47,62,67-69] Sangwan *et al*.[37] reported significant positive associations between PD and TC, CAL and LDL-C as well as between GI and TG. Similarly, our findings suggest a positive correlation between PD and TC, CAL and LDL-C parameters, however, no significant correlation was present between GI and TG levels. Fentoglu *et al*.[31] reported significant negative correlations between HDL-C and CAL parameters while

confirming significant positive correlations between TG and BOP/PD parameters. On the contrary; the present study demonstrates no significant correlations between these parameters. Johansson *et al*.[67] and Wakai *et al*.[69] found that low level of HDL-C is associated with lower number of teeth loss and higher CPITN score. Results of our study proposes no significant correlations between HDL-C and number of missing teeth together with HDL-C and CPITN scores. Katz *et al*.[12] reported a strong association between CPITN 4 and TC also between CPITN 4 and LDL-C parameters, and proposed that the severity of periodontal disease is related to patients' TC level. But, no association was demonstrated with regard to TG level similar with the other studies.[66,69] Similar to the findings, present study demonstrates higher CPITN 3 and 4 scores in the hyperlipidemic group. However, we found significant negative correlation between TG and CPITN parameters. This difference can be explained with discrepancies in the disease profile and severity of the participants included to the studies. On the other hand, Cavagni *et al*.[62] evaluated the role of obesity/hyperlipidemia on alveolar bone loss in rats and reported that the animals with obesity/hyperlipidemia together with alveolar bone loss showed statistically significantly higher TG and TC levels than those without periodontal breakdown. Interestingly our BMI results strongly support these evidences with detected positive correlations with TG, TC, LDL-C and CAL parameters. Also, Morita *et al*.[36] detected a noteworthy relation between TG and periodontal parameters. In another study, researchers suggested a positive relationship between CAL and TC, LDL-C, and TG parameters, whereas PD was found to be related with TG but not with TC in hyperlipidemic female patients.[68] Our study demonstrates significant positive associations between TG and CAL, also TC and BOP, PD and CAL parameters. Moreover, LDL-C was found to be positively correlated with PD and CAL. Findings of this study may support the evidences that suggest a strong association between hyperlipidemia and periodontal disease.[22,27-31,35,36,56,58]

There are also studies demonstrating that periodontal disease is highly associated with coronary heart disease,[40] even with acute myocardial infarction.[70] Keeping in mind that the role of hyperlipidemia together with the inflammation in the formation of atherosclerosis cannot be hypothetically rejected.[7,16,37] Periodontal disease with multifactorial chronic inflammatory properties can be related to CVD as a contributing factor.[7,22,25,28,41]

However, there are some limitations of our study. Two way cause-effect relationships and specific interactions cannot be well established by cross sectional study design. Longitudinal studies with larger number of participants are necessary to confirm the accurate cause-effect relationship. Within the limits of this study, it can be concluded that a probable association is present between hyperlipidemia and periodontal disease. Such results may guide both dentists and physicians to develop novel preventive and therapeutic protocols for both periodontal disease and CVD.

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