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Chapter

Oral Health and Cardiovascular Disorders

Ioana Mozos and Dana Stoian

Abstract

Several studies reported the cross talk between oral health and cardiovascular disorders. The aim of the present chapter is to review the main mechanisms linking oral and cardiovascular disorders, the main pathologies which could be linked, and possibilities for prophylactic and therapeutic interventions. Periodontitis was associated with cardiovascular risk, and the links between the two entities are represented by bacteria and their toxins released into the blood, causing endothelial dysfunction and providing a proatherogenic and prothrombotic effect and an inflammatory and immune reaction. The mentioned mechanisms explain the reported associations of periodontitis with stroke, coronary heart disease, and peripheral vascular disease. Periodontitis was also associated with diabetes mellitus and impaired lipid metabolism. Not all studies confirmed the association between periodontitis and coronary artery disease or stroke. Tooth loss, the most important consequence of periodontitis, has been also associated with cardiovascular disease. Dental and pulpal caries were also found to be independent risk factors for atherosclerosis, while restorations were inversely related to an atherosclerotic burden. Sucrose is involved in both cariogenesis and atherosclerosis. Fluorides prevent aortic calcifications and enamel demineralization and inhibit bacterial metabolism but are cardiotoxic. Heightening awareness of good dental hygiene can improve cardiovascular health.

Keywords: periodontitis, periodontal bacteria, dental caries, tooth loss, sucrose, fluorides, cardiovascular risk, inflammation, dyslipidemia, abdominal aorta aneurysm

1. Introduction

Cardiovascular disorders are the main mortality causes worldwide. The most common substrate is atherosclerosis, with several risk factors, a latent evolution, and possible sudden, unexpected fatal outcomes. Oral diseases, the most common chronic diseases, are important public health problems considering their prevalence, their impact on health and quality of life, and therapy expenses [1].

Several links have been reported between cardiovascular and oral disorders. The present chapter aims to review and emphasize the main mechanisms linking oral and cardiovascular disorders, the main pathologies which could be linked, and possibilities for prophylactic and therapeutic interventions.

2. Periodontitis (PD)

Periodontitis, the chronic inflammatory disease irreversibly affecting the supporting structures of the teeth, occurs due to periodontopathogen bacteria and subgingival plaque [2, 3]. Periodontitis was associated with an impaired cardiovascular health, endothelial dysfunction, and atherosclerosis [2, 4]. Several epidemiological studies, review articles, and meta-analysis confirmed a positive association between periodontitis and cardiovascular disorders [5–8].

2.1 Periodontal bacteria

Different species of periodontal bacteria cause periodontitis, including *Porphyromonas gingivalis*, *Aggregatibacter actinomycetemcomitans*, and *Prevotella intermedia* [9]. A synergistic, physiologically compatible, and dysbiotic microbial community, including keystone pathogens such as *Porphyromonas gingivalis*, impairs and manipulates the defense mechanisms of the host (delaying recruitment or destroying neutrophils, degradation of antibodies and complement) and increases the virulence of the entire microbial community [10]. Bacteremia is caused by chewing, tooth brushing, dental flossing, or invasive dental maneuvers, such as tooth extraction or periodontal treatment [11, 12]. The intensity of bacteremia depends on the severity of periodontitis [8]. The oral cavity and periodontal pockets represent reservoirs of gram-negative and anaerobic bacteria, able to interact with the cardiovascular tissue [11]. *Porphyromonas gingivalis* and *Prevotella intermedia* generate antibodies, which can also cause tissue injury [13]. Antibodies against *Porphyromonas gingivalis* cross-react with heat shock proteins expressed by endothelial cells, contributing to detrimental cardiovascular consequences [14]. Molecular mimicry between human and bacterial heat shock proteins enables also atherogenesis [3]. Periodontal pathogens and their noxious products are released into the systemic circulation through the ulcerated sulcular epithelium of the gingiva, and they can induce insulin resistance, systemic inflammation, are involved in all stages of atherogenesis, and explain, probably, the perio-systemic link through the released inflammatory mediators [15, 16]. Dissemination through the blood of alive periodontal pathogens is possible also through immune cells [3].

Porphyromonas gingivalis can invade aortic endothelial cells, due to their fimbriae, and fimbrillin peptides can induce the expression of interleukin 8 and monocyte chemotactic protein [17]. *Porphyromonas gingivalis* multiply inside the endothelial cells and activate Toll-like receptor 2, resulting in release of pro-inflammatory cytokines [8]. *Porphyromonas gingivalis*-infected endothelial cells have also a higher expression of adhesion molecules, which exert a proatherogenic effect [17]. Bacteria and their virulence factors directly stimulate white blood cells, fibroblasts, mast, and dendritic and endothelial cells, causing an inflammatory reaction and expression of metalloproteinases [14, 18]. Oral bacteria such as *Porphyromonas gingivalis*, *Aggregatibacter actinomycetemcomitans*, and *Prevotella intermedia* and oral bacteria DNA and RNA have also been identified in atheroma, and they are able to activate monocytes, which transform into macrophages and foam cells [8, 14, 18, 19]. Plaque rupture is caused by endothelial cell apoptosis and extracellular matrix degradation due to periodontal pathogens [8].

Toxins of periodontal pathogens, such as proteases (gingipain), adhesins, and lectins, regulate the bacterial biofilm; can also impair the immune response of the host, by degradation of interleukins; and enable atherosclerotic plaque formation by increasing proliferation of vascular smooth muscle cells and platelet aggregation [3].

Probiotics might represent a solution, preventing dental caries and reducing episodes of streptococcal pharyngeal infection, pocket depth, and plaque index [14]. Several cardiovascular benefits have been also described for probiotics, such as lowering blood pressure and circulating lipids [20].

2.2 Inflammatory reaction linking periodontitis and cardiovascular disorders

Periodontitis is a source of inflammatory mediators, such as TNF alpha and interleukin 1 and 6 [2]. Inflammatory markers may be produced locally in the oral cavity and released into the bloodstream or are the result of bacteremia [14].

Atherosclerosis is a high inflammatory state, and inflammatory mediators can cause endothelial dysfunction, a proatherogenic and prothrombotic effect, and are involved in the development and evolution of the atherosclerotic plaque [18, 21]. The same inflammatory markers are involved in both atherosclerosis and periodontitis [21]. Periodontitis impairs endothelial function and is also associated with oxidative stress [13].

2.3 Periodontitis, cardiovascular risk, and disorders

Periodontitis was associated with several cardiovascular risk factors, especially hypertension, diabetes mellitus, dyslipidemia, and smoking [21]. Smoking is a risk factor for both cardiovascular disorders and oral health. It is known to impair periodontal tissue perfusion, inflammatory reaction, fibroblast function, and tissue healing, causing also endothelial dysfunction [2]. Several cardiovascular disorders were associated with periodontitis, such as stroke, coronary heart disease, peripheral vascular disease, arrhythmias, and aorta aneurysm [11, 13, 22].

A link between periodontitis and abdominal aorta aneurysm has been demonstrated [11, 23]. Periodontal pathogens or their by-products may be involved in systemic and local mechanisms associated with the development and evolution of abdominal aorta aneurysm (AAA), suggesting an infective theory of AAA pathogenesis. [23–26]. There is, probably, a translocation of periodontal pathogens from subgingival microbiota to the bloodstream and then to the aortic wall, where they might contribute to the weakening of the aortic wall or secondary colonize AAAs. [9, 23, 27]. Suzuki et al. reported deeper pocket depth and more severe bleeding on probing in abdominal aorta aneurysm patients compared to the non-AAA patients [9] (**Table 1**).

Periodontopathic bacteria were detected in aortic walls of patients with AAA [28]. *Porphyromonas gingivalis* worsened AAA development through toll-like receptor signaling and matrix metalloproteinases (MMPs) [28]. Pharmacological inactivation of MMPs prevented the development of AAA [29]. Several other periodontal pathogens were also involved in the pathogenesis of AAA, such as *Treponema denticola* and *Campylobacter rectus* [11].

The impaired blood flow through vessels affected by atherosclerosis may affect also the gums and explain the association of coronary heart disease or peripheral arterial disease with periodontitis [30]. A poor periodontal state with increased inflammatory markers (C-reactive protein and TNF alpha) was reported in a study including 25 patients with peripheral arterial disease [22]. Kure et al. described a mutual inflammatory pathway in patients with both periodontitis and peripheral arterial disease, including local and systemic mechanisms [22]. The association of oral health-myocardial infarction was explained by common factors, such as low socioeconomic status, smoking,

Study participants	Assessed variables	Results	Conclusions	Reference
142 patients with tachycardia (TA) and 25 patients with AAA	• Periodontitis • *P. gingivalis*, *A. actinomy*, *Prevotella intermedia* in saliva and subgingival plaque (PCR) • Serum antibody titers against the bacteria (ELISA)	• Fewer remaining teeth and deeper pocket depth in AAA patients than in TA patients; comparable periodontal bacteria and antibody titers between the two groups	• Periodontitis has a more important influence on aneurysm progression than on arrhythmia	Suzuki et al. [25]
12 patients with AAA and 24 sex- and age-matched non-AAA patients	• Periodontal pathogens: *P. gingivalis*, *A. actinomy*, and *Prevotella intermedia* in oral samples using PCR • Probing pocket depth (PD), bleeding on probing (BOP), number of teeth, community periodontal index (CPI)	• AAA patients had deeper PD, more severe BOP, average CPI, and less number of teeth; periodontal bacteria were not different between the two groups	• AAA patients have bad oral and periodontal conditions	Suzuki et al. [9]
70 patients with PAD or AAA	• Periodontal pathogens (*A. actinomy*, *P. gingivalis*, *Campylobacter rectus*, and *Tannerella forsythia*) in vascular, blood, and subgingival samples (quantitative and nested PCR)	• All periodontal pathogens were found in subgingival sample • Bacterial DNA was detected in a few patients in vascular and blood samples	• There is probably a migration of periodontal pathogens from subgingival microbiota to the bloodstream and to atheromatous plaques	Figuero et al. [27]
32 AA patients	• 7 periodontal bacteria (PCR) in aneurysmal walls, mural thrombi, occlusive atherosclerotic aorta, and control arterial tissue	• Bacteria were found in the aneurysmal walls and occlusive aorta	• Bacteria may play a role in development or weakening of the aneurysmal wall in AAA	Kurihara et al. [11]

Note: P. gingivalis = Porphyromonas gingivalis, A. actinomy = Aggregatibacter actinomycetemcomitans, PCR = polymerase chain reaction assays, PAD = peripheral arterial disease.

Table 1.
Periodontitis and abdominal aorta aneurysm (AAA).

diabetes mellitus, insulin resistance, nutrition, and aging. Persons who care for dental health pay also special attention to lifestyle.

Periodontitis was also associated with myocardial hypertrophy [12]. Ventricular remodeling after myocardial infarction and pressure overload myocardial hypertrophy were aggravated by *Aggregatibacter actinomycetemcomitans* [12, 31]. Periodontal pathogens increase the level of MMPs, especially MMP-2, which are responsible for gingival extracellular matrix destruction [12]. MMPs are also released into the blood and are responsible for occurrence of myocardial inflammation, pressure overload myocardial hypertrophy, myocardial interstitial, and perivascular fibrosis, causing systolic and diastolic dysfunction [12].

Significant associations were also reported between periodontitis and cardiac arrhythmia. Periodontitis, as a chronic inflammatory disorder, was an independent predictor of arrhythmic events and major adverse cardiac events in patients with atrial fibrillation (AF) according to a study including 227 patients with AF [13]. The link periodontitis-atrial fibrillation is explained by the inflammatory infiltration of atrial cardiomyocytes causing hypertrophy, oxidative stress, and the cardiac tissue damage induced by antibodies generated in response to *Porphyromonas gingivalis* and *Prevotella intermedia* [13, 32]. The control of periodontitis may improve inflammation and may prevent embolic events and recurrence of arrhythmia [13]. Chen et al. also reported an increased risk of atrial fibrillation or flutter in patients with periodontitis, according to a study including the nationwide database of the Taiwanese population (393,745 patients with periodontitis and 393,745 non-PD individuals) [33]. However, the association PD-atrial fibrillation or flutter was not significant in patients with hyperthyroidism, a disorder with a significant role in triggering those arrhythmias [33]. Other arrhythmias, such as atrial tachycardia, atrial and ventricular premature contractions, and ventricular tachycardia, were also more common in patients with periodontitis [13]. Periodontitis may influence tachyarrhythmia progression [34]. *Porphyromonas gingivalis* and *Prevotella intermedia* were especially detected in saliva from tachyarrhythmia patients (compared to bradyarrhythmia subjects), and they may be involved in myocardial remodeling [34].

2.4 Periodontitis and dyslipidemia

Several researchers considered the potential relationship between periodontitis and lipid metabolism [35]. According to a meta-analysis including 19 studies, with nonsmoking subjects, with chronic periodontitis, not taking any lipid lowering drugs, periodontitis was significantly associated with low HDL and high LDL and triglyceride levels [35]. The link between periodontitis and low HDL could be periodontal infection and inflammation [36]. Certain bacteria can also increase VLDL and small dense LDL levels and induce selective proteolysis of apoprotein B-100, supporting the role of lipoproteins in linking periodontitis and atherosclerosis [3].

Not all studies confirmed the link between lipid metabolism disorders and periodontal health. Sridhar et al. reported no association between periodontal health, assessed using the gingival index, oral hygiene index, periodontal disease index scores and attachment loss, and serum lipids (total cholesterol, LDL, HDL, and triglycerides) in patients with or without coronary heart disease [37] (**Table 1**). Another study, including 1297 nondiabetic subjects, who had never smoked and were under 50 years, a subpopulation of the Health 2000 Health Examination Survey, revealed a significant association of high serum triglycerides and low HDL with periodontal infection only among obese patients [38]. TNF alpha may increase triglycerides by impairing lipoprotein lipase activity [18].

Proprotein convertase subtilisin/kexin type 9 (PCSK9) plays a critical role in regulation of circulating LDL cholesterol concentrations and seems to be

upregulated in patients with periodontitis, according to a study including 40 periodontitis patients with *Porphyromonas gingivalis* antibodies [39] (**Table 2**). In Japanese male subjects, the concentrations of serum proprotein convertase subtilisin/kexin type 9 (PCSK9) correlated with periodontal parameters according to a study including 108 male subjects [40] (**Table 2**).

A bidirectional relationship periodontitis-dyslipidemia was suggested, considering that periodontal inflammation impairs lipid metabolism and dyslipidemia increases the susceptibility for periodontitis due to the associated inflammatory reaction [3].

2.5 Periodontitis and hypertension

Periodontitis was associated with poor blood pressure control, especially in elderly patients; a good periodontal health enabled improvement of systolic blood pressure through antihypertensive therapy [41, 42]. Severity of periodontitis has also been associated with increased systolic blood pressure [43]. The number of periodontal pockets was significantly related to hypertension in a study including

Study participants	Results	Conclusions	Reference
108 male subjects with and without periodontal disease	The concentrations of PCSK9 (proprotein convertase subtilisin/kexin type 9) were increased in subjects with periodontal disease (determined as a probing depth of ≥4 mm in at least one site) compared with healthy subjects	PCSK9 could be a biomarker for diagnosing chronic periodontitis and may evaluate the risk for periodontitis to cause atherosclerotic vascular disease	Tabeta et al. [40]
40 periodontitis patients and 30 control subjects	PCSK9 concentrations in periodontitis patients were significantly higher than in control subjects. No correlations were found between PCSK9 concentrations and lipid profiles	Periodontal infection upregulates PCSK9 production	Miyazawa et al. [39]
120 subjects, with 30 subjects in each group: healthy group (A), chronic periodontitis group (B), coronary heart disease (CHD + periodontitis group) (C), and CHD – periodontitis group (D)	No significant difference with respect to the lipid profile levels (total cholesterol, HDL, LDL, triglycerides) was noticed between the four groups	Periodontal disease did not cause any change in the lipid profile in systemically healthy or in CHD patients	Sridhar et al. [37]
1297 dentate, nondiabetic subjects, nonsmokers, aged under 50 years	No consistent association was found between serum lipid levels (HDL, LDL, and triglycerides) and periodontal infection among normoweight subjects but an association of high serum triglycerides and low HDL with periodontal infection among obese subjects	Lipid levels were associated with periodontal infection only in obese subjects with a high serum triglyceride level and/or a low HDL-cholesterol level	Saxlin et al. [38]

Table 2.
Studies linking lipid metabolism and periodontitis.

3352 patients with self-reported history of hypertension and myocardial infarction [44]. Intensive periodontal treatment, including the use of a locally delivered antimicrobial, reduced systemic inflammatory markers and systolic blood pressure and improved lipid profiles and cardiovascular risk in 40 patients with severe periodontitis, in a 6-month trial [43].

2.6 Periodontitis and diabetes mellitus

There is a risk factor reciprocity and symbiotic relationship between diabetes mellitus and periodontitis. Diabetes causes glycation of proteins; increases collagenase activity; impairs the function of neutrophils, lymphocytes, monocytes, and inflammatory response; causes periodontal vascular changes due to micro- and macroangiopathy and bone loss; and delays wound healing [2]. Periodontitis is a source of inflammatory mediators, released into the bloodstream and increasing insulin resistance [2]. Several common pathological pathways have been also described for diabetes mellitus and periodontitis, such as immune mechanisms, genetic component, as well as an improper response to environmental factors [2].

2.7 Periodontitis and aging

The population of periodontal bacteria increases with age [45]. Age is also a nonmodifiable cardiovascular risk factor. Several authors reported an increased arterial stiffness in patients with periodontitis [46–48]. Arterial stiffness indicates the impaired elastic vessel wall properties, is related to atherosclerosis and arteriosclerosis, and is considered a predictor of cardiovascular events [49].

2.8 Tooth loss

In adults, the most important causes of tooth loss are dental caries and, in patients older than 40 years, periodontitis. In patients with periodontitis, chronic inflammation is responsible for the destruction of the periodontal ligament and the resorption of the alveolar bone, enabling tooth loss [3]. Tooth loss, a marker of poor oral health, influences nutrient intake and food choices, with reduced intake of vegetables and dietary fibers, as well as socializing, and psychosocial risk factors, including social isolation, which are associated with a worse prognosis in cardiovascular disorders [50]. A healthy diet, rich in fruits and vegetables, is a cornerstone of cardiovascular disease prevention [4, 51]. Tooth loss is also associated with age, which is a cardiovascular risk factor. Observational studies linked tooth loss with coronary heart disease, heart failure, stroke, peripheral vascular disease, and cardiovascular mortality [30, 52]. The link tooth loss-cardiovascular disorders is explained by oral bacteria, especially *Streptococcus sanguis* and *Actinobacillus actinomycetemcomitans*, which contribute to a systemic inflammation with higher levels of C-reactive protein, endothelial dysfunction, atherosclerosis progression, and plaque instability [50]. On the other hand, a positive relationship was reported between tooth loss and all-cause mortality in persons who lost more than 10 teeth, but not for circulatory mortality, according to a meta-analysis including 18 prospective studies [50]. It must be mentioned that tooth extractions are not always disease related, because they may provide space for a full denture [30].

2.9 Periodontal interventions and cardiovascular outcomes

Periodontal interventions reduced cardiovascular risk, systemic inflammation, dyslipidemia, blood pressure, and endothelial dysfunction and may prevent

embolic events and recurrence of arrhythmia [13, 43, 53]. Plaque removal in patients with stable coronary artery disease and periodontitis leads to lower levels of CRP, IL-6, and IL-8 [54]. Dental scaling (no more than twice per year) was associated with a lower risk of atrial fibrillation or flutter, probably due to its protective effect on PD [33]. Despite the association between periodontitis and atherosclerotic cardiovascular disease, periodontal interventions do not improve cardiovascular outcomes [30, 54]. Poor oral health can be considered as a risk marker for cardiovascular disorders, a biomarker of the severity of atherosclerosis [30].

3. Dental caries and lesions of endodontic origin

Dental caries and chronic apical periodontitis are different stages of the same inflammatory condition, and the focal infection theory has gained again attention [18, 21].

Streptococcus mutans, the bacteria commonly associated with dental caries, was identified also in the atherosclerotic plaque, suggesting a proatherogenic potential of dental caries, and may also cause bacterial endocarditis [21, 55]. It takes less than 1 minute after an oral intervention for the oral bacteria to reach the heart or the peripheral capillaries [21]. Normally, microorganisms are eliminated within minutes, but in patients with valvular heart disease, bacteremia may cause infective endocarditis [18].

A positive association between apical periodontitis and cardiovascular disease was also demonstrated [56]. Apical periodontitis, the inflammatory injury around the apex of a tooth due to gram-negative bacteria, may also cause systemic effects due to cytokines (interleukin 1 beta, interleukins 2, 6, 8, and 17, TNF alpha), reactive oxygen species, and matrix metalloproteinase, similar to chronic periodontitis [18, 21]. Interleukin 1 (IL-1) level, the predominant form of interleukin found in endodontic injuries, is involved in the formation, growth, and destabilization of the atherosclerotic plaque [18]. Interleukin 6 (IL-6) was associated with formation and activation of osteoclasts and also with unstable angina, left ventricular dysfunction, diabetes mellitus and its complications, hypertension, and obesity [18]. Interleukin 8 is associated with irreversible pulpitis and osteolysis in apical abscesses but also with angiogenesis and plaque formation [18]. TNF alpha was related to osteoclast activation and bone resorption, production of Il-6 and C-reactive protein, expression of cell adhesion molecules, smooth muscle cell proliferation, and lipid metabolism [18]. Interleukin 17 regulates matrix metalloproteinases, responsible for tissue destruction, and is involved in expression of genes encoding pro-inflammatory cytokines, endothelial damage, and cell apoptosis [18].

Periapical disease was associated with hypertension and stroke [57, 58]. Comparing aspects of periapical lesion formation in hypertensive and normotensive conditions using hypertensive and wild-type control mice, no differences were noticed in periapical lesion size and cytokines expressions, but hypertensive rats showed an elevated number of osteoclasts, responsible for bone destruction [59]. The link between bone destruction and hypertension is angiotensin II, able to upregulate RANKL expression in osteoblasts [59].

4. Sucrose

Sucrose enables cariogenesis in the presence of *Streptococcus mutans*. Dale et al. demonstrated an increased risk of congenital heart defects (patent ductus arteriosus, valvular pulmonary stenosis, ventricular septal defect, atrial septal defect)

in offsprings of women after intake of sucrose-sweetened soft beverages during pregnancy [60].

Sucrose can also influence cardiovascular risk factors, especially overweight and obesity, diabetes mellitus, and blood lipids. The cardiovascular risk associated with a high sucrose intake is due to fructose-induced increase in blood triglycerides by stimulation of de novo lipogenesis and impairment of postprandial lipoprotein clearance [61]. The literature search did not provide a strong association between sucrose intake and LDL or HDL cholesterol level [61]. Only one study reported increase of LDL cholesterol and apoprotein B due to fructose consumption [62]. Daily fructose intake increasing blood triglycerides is of 50–60 g daily or above [61].

Intake of sweetened beverages, important contributors to free sugar intake and source of hidden calories, was associated with hypertension and impaired fasting glycemia in a study including 1158 young healthy participants [63]. Development of hypertension due to sucrose intake was related to slight insulin resistance with impaired nitric oxide synthase action, elevated lipoperoxidation, and decreased nonenzymatic antioxidant capacity and sirtuin 3 [64].

5. Fluorides

Fluorides enable synthesis of calcium fluoroapatite, which promotes remineralization of the enamel subjected to cariogenic factors and inhibits bacterial metabolism [2]. On the other hand, it has been demonstrated that fluoride induces damage to cardiomyocytes, due to Ca^{2+} metabolic disorder, and an abnormal expression of cardiac troponin T and I [65]. Fluoride can enter the cells; in excessive amounts it can cause serious damage to the cytoskeleton, nuclear condensation, myocardial fiber breakage, calcium overload, and mitochondrial dissolution, which impairs ATP production [65, 66]. The mentioned changes could explain myocardial ischemia, myocardial infarction, and heart failure associated with high fluoride intake, involving increased oxidative stress, apoptosis, and necrosis [67]. Fluoride in drinking water is nephrotoxic according to a study performed in rats with experimental chronic kidney disease, increasing the incipient aortic calcifications [68].

6. Biomarkers linking cardiovascular and oral disorders

Several serum biomarkers related especially to the peripheral inflammatory and immune response and oxidative stress link chronic periodontitis to atherosclerotic cardiovascular disease [13, 40]. The gingival index was associated with fibrinogen and white blood cell counts in periodontal patients and controls, adjusted for age, smoking, and socioeconomic status [69]. C-reactive protein (CRP) is a marker of both low-grade inflammations associated with periodontitis and apical lesions of endodontic origin and a risk indicator of cardiovascular events [13, 21, 70]. Apical lesions of endodontic origin were associated with the most promising biomarker of subclinical atherosclerosis: high-sensitivity C-reactive protein [70, 71].

Besides CRP, elevated cytokines were also associated with atrial fibrillation in patients with periodontitis [13]. IgA antibodies to periodontal pathogens were also revealed in patients with periodontitis [13].

Brain natriuretic peptides, released from ventricular cardiomyocytes in response to pressure and volume overload, were also increased in patients with periodontitis, related to severity of the disorder [3]. Ischemia-modified albumin, a marker of myocardial ischemia and end product of oxidative stress, was increased in

patients with chronic periodontitis compared to periodontally healthy controls and decreased after nonsurgical periodontal therapy [72].

Matrix metalloproteinases, markers of plaque vulnerability, and subclinical atherosclerosis were also associated with periodontitis [12, 73].

7. Conclusions

It is important to recognize the importance of oral health, especially of chronic oral infections, for cardiovascular health and quality of life, considering that oral disorders are diagnosed easier and earlier than cardiovascular diseases. Several links were found between oral and cardiovascular disorders, including common risk factors, microbiological, clinical, inflammatory, and molecular markers. Oral bacteria, such as *Streptococcus mutans*, *Porphyromonas gingivalis*, *Aggregatibacter actinomycetemcomitans*, and *Prevotella intermedia*, may represent links between oral and cardiovascular disorders.

Both dentists and cardiologists, as well as other medical health-care providers, must extend their roles, considering the cross talk between oral and cardiovascular disorders. Markers of oral health enable screening of several cardiovascular disorders.

Conflict of interest

There is no conflict of interest.

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