Infectious Dental Diseases in Patients with Coronary Artery Disease: An Orthopantomographic Case–Control Study

Kyosti Oikarinen, *DDS, PhD;* ***Mohammad Zubaid,*** *MB, ChB, FRCPC;* ***Lukman Thalib,*** *PhD;* ***Kari Soikkonen,*** *DDS, PhD;* ***Wafa Rashed,*** *MD, FRCP (UK);* ***Tryggve Lie,*** *DDS, PhD*

Contact Author

Dr. Oikarinen
Email: *kyosti.oikarinen@oulu.fi*

ABSTRACT

Purpose: To investigate a potential association between coronary artery disease (CAD) and a variety of radiographically detectable infectious dental diseases, a hospital-based prospective case–control study was conducted in Kuwait.

Materials and Methods: Eighty-eight consecutive patients with a first attack of unstable angina pectoris or acute myocardial infarction were enrolled as cases and were matched on the basis of age, sex and nationality with control patients who were known not to have CAD. The severity and extent of periodontal bone loss and other radiographic signs of infection in both cases and controls were analyzed with orthopantomograms.

Results: More cases than controls had teeth needing extraction ($p = 0.043$), periapical lesions ($p = 0.028$), molars with furcation lesions ($p < 0.001$), teeth with marginal bone loss ≥ 6 mm ($p = 0.001$) and teeth with angular (vertical) bone loss ($p < 0.001$). Analysis of the total dental index showed that the median scores were higher for cases than controls for both radiographically diagnosed periodontitis ($p < 0.001$) and periapical lesions ($p = 0.008$).

Conclusions: In summary, there was a significant association between radiographically diagnosed periodontal diseases and CAD. These results should not be regarded as indicating a causal relationship, especially given that the diagnosis of periodontitis was based only on a radiographic examination. The true impact of oral infections on CAD should be examined in a large prospective clinical and interventional study.

For citation purposes, the electronic version is the definitive version of this article: www.cda-adc.ca/jcda/vol-75/issue-1/35.html

Coronary artery disease (CAD) is a major cause of morbidity and mortality in Kuwait and worldwide.[1] As early as the 1980s, studies suggested an association between CAD and oral infections,[2] and this issue has recently attracted renewed interest within the cardiac and dental research communities.[3–11] Several researchers have proposed a causal relationship,[10,12–14] whereas others have been more cautious.[5,10]

Söder and Yakob[8] showed that women with high levels of dental plaque and severe gingival inflammation were at risk for atherosclerosis. Ylöstalo and colleagues[9] documented associations between a variety of dental conditions (self-reported gingivitis, dental caries and

Table 1 Details and definition of the total dental index used in this study

Type of finding	Score
Caries	
No carious lesions	0
1–3 carious lesions	1
4–7 carious lesions	2
≥ 8 carious lesions	3
Periodontitis	
None	0
Gingival pockets 4–5 mm deep	1
Gingival pockets ≥ 6 mm deep	2
Periapical lesions	
None	0
1	1
2	2
≥ 3	3
Pericoronitis	
Absent	0
Present	1

Source: Mattila and others[2] (reproduced with permission from the BMJ Publishing Group).

tooth loss) and angina pectoris. However, they suggested that the associations might have been due to confounding factors. In a recent study with a large sample size and a long follow-up period, people with 9 or more missing teeth had a greater risk of cardiovascular disease than those with fewer than 5 teeth missing.[11]

Patients with severe cardiac disease visit the dentist and clean their teeth less frequently than patients without such problems.[15] Heart disease and oral infections such as periodontitis are influenced by a variety of health behaviours, so interpretation of the connection between a single risk factor (e.g., diabetes, smoking) and outcomes is challenging.

Acute myocardial infarction[1] and infectious dental diseases[16] are common in Kuwait. This study was undertaken to investigate whether CAD was related to the type and severity of radiographically detectable dental infections in patients with a first episode of CDA.

Material and Methods

Eighty-eight consecutive patients with a first episode of symptoms of unstable angina or acute myocardial infarction who were admitted to Mubarak Al-Kabeer Hospital, the largest hospital in Kuwait, were recruited for the study. The patients were selected on the basis of confirmed diagnosis of myocardial infarction, with or without ST-segment elevation. All diagnoses were made by experienced cardiology specialists. Patients with cardiogenic shock, those who received ventilation and those whose physical condition prevented them from answering a questionnaire and undergoing dental radiography were excluded.

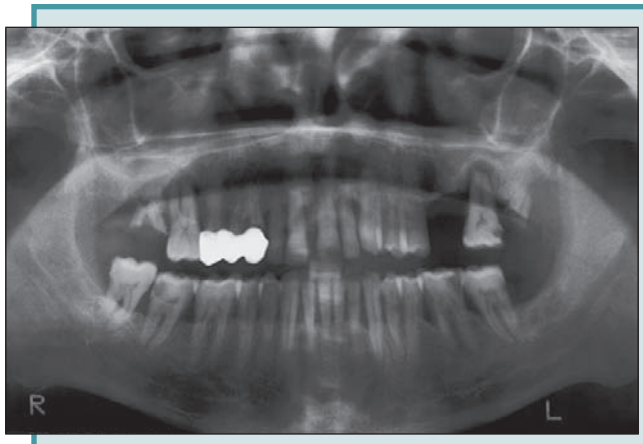

Figure 1: Orthopantomogram of a 47-year-old patient with acute myocardial infarction. The patient has several dental foci. The upper molars have lost all bony support because of extensive periodontitis. Advanced horizontal periodontitis can be observed in all of the mandibular teeth.

The cases were matched by age, sex and nationality with 88 visitors to the hospital (excluding first-degree relatives of the cases) who had no history of any heart disease. Cases were matched according to nationality because residents of Kuwait come from several countries.

Ethical approval was obtained from the Research Committee of the faculty of dentistry, Kuwait University. Participation was voluntary, and written consent was obtained from all participants.

All participants were interviewed and examined by a cardiologist, and a structured data sheet was completed for each person. The items recorded included conventional cardiac risk factors, professional status and household income. Blood samples were collected and analyzed for white blood cell count, serum glucose, serum cholesterol and other biochemical variables.

Dental Assessment

Dental infections were diagnosed on the basis of examination of panoramic radiographs of the jaws obtained with PM 2002 Proline radiographic equipment (Planmeca, Helsinki, Finland). All radiographs were obtained by the same radiographic technician and were analyzed by the same expert radiologist (K.S.), who was blinded to the participants' study status.

The total number of teeth, the number of molars and the number of teeth with fillings and root fillings were recorded. Secondary caries was defined as loss of enamel and dentin; tertiary caries was defined as a lesion extending into the pulp. Teeth were recorded as needing

Table 2 Demographic and medical characteristics of cases and controls

Characteristic	No. (%) of participants[a]		*p* value
	Cases (*n* = 88)	Controls (*n* = 88)	
Age (median and IQR)	48.8 (10.0)	47.0 (11.6)	0.27
Sex			> 0.99
Male	82 (93.2)	82 (93.2)	
Female	6 (6.8)	6 (6.8)	
Marital status			> 0.99
Married	85 (96.6)	82 (93.2)	
Single	2 (2.3)	6 (6.8)	
Not stated	1 (1.1)		
Occupation			0.15
Professional	27 (30.7)	23 (26.1)	
Other	59 (67.0)	65 (73.9)	
Not stated	2 (2.3)		
Mean household income[b]			0.44
Current smoker	50 (56.8)	38 (43.2)	0.46
High blood pressure	14 (15.9)	10 (11.4)	0.38
Diabetes[c]	18 (20.5)	8 (9.1)	0.034
Body mass index (kg/m^2), mean (SD)	26.3 (3.7)	26.4 (4.8)	0.88
Triglycerides (mmol/L), mean (SD)	1.66 (1.46)	1.50 (1.04)	0.40
Serum glucose (mmol/L), mean (SD)	6.7 (3.1)	5.7 (1.0)	0.004
White blood cells (× 10^9/L), mean (SD)	9.60 (3.50)	7.10 (2.55)	< 0.001
Cholesterol (mmol/L), mean (SD)	5.20 (1.06)	4.90 (1.05)	0.049

SD = standard deviation.
[a]Except where indicated otherwise.
[b]Mean values for household income for each group are not available.
[c]According to self-reporting by patients; no objective data (e.g., blood glucose levels).

extraction if the caries had destroyed the crown or if periodontitis had extended to involve most of the supporting bone. A periapical lesion was defined as osteolysis larger than 3 mm in diameter surrounding the apex of the root. The molars were examined for furcation lesions, indicated by radiolucency between the roots. Mild periodontitis was diagnosed if bone loss on either the distal or mesial side was between 4 and 5 mm (measured from the cementoenamel junction). Severe periodontitis was diagnosed if bone loss on either the distal or mesial side was 6 mm or more. Vertical (angular) bone loss appeared as triangular loss of bone on either the distal or mesial side of the tooth. As in some earlier studies, a total dental index was used to illustrate the burden of infection (**Table 1**).[2]

A radiograph obtained from a 47-year-old patient with acute myocardial infarction and several dental foci of infection is shown in **Fig. 1** as an example.

Statistical Analysis

Various dental- and cardiac-related health outcome measures were compared between cases and controls using appropriate nonparametric methods. Categorical outcome variables were compared using the χ^2 test, and interval or scale variables were compared using the Mann–Whitney *U* test. All analyses were carried out using SPSS version 11 (SPSS Inc., Chicago, Ill.); $p < 0.05$ was defined as indicating statistical significance.

Results

The 2 groups were well matched for age, sex, marital status, professional status and household income (**Table 2**). Diabetes was significantly more common among cases than controls (20.5% vs. 9.1%, $p = 0.034$), and serum levels of cholesterol and glucose and the white blood cell count were all significantly higher among the cases. Cases and controls had almost the same mean total number

Table 3 Pathological findings in panoramic tomograms, expressed as median proportion (and interquartile range [IQR]) of teeth

Feature	Median proportion of teeth with features (IQR)		*p* value
	Cases	Controls	
Teeth with fillings	0.0 (0.13)	0.06 (0.17)	0.10
Teeth with root fillings	0.0 (0)	0.0 (0)	0.12
Teeth with secondary caries	0.0 (0.08)	0.04 (0.09)	0.55
Teeth with tertiary caries	0.0 (0.04)	0.0 (0.05)	0.65
Teeth to be extracted	0.04 (0.15)	0.03 (0.07)	0.043
Periapical lesions	0.0 (0.06)	0.0 (0.02)	0.028
Molars with furcation lesions	0.17 (0.83)	0.0 (0.14)	< 0.001
Teeth with bone loss of 4–5 mm	0.23 (0.3)	0.17 (0.36)	0.84
Teeth with bone loss ≥ 6 mm	0.05 (0.75)	0.0 (0.08)	0.001
Teeth with angular (vertical) bone loss	0.0 (0.12)	0.0 (0)	< 0.001

IQR = interquartile range.

Table 4 Total dental index scores[a]

Characteristic	Median index (IQR)		*p* value
	Cases (*n* = 88)	Controls (*n* = 88)	
Caries	1 (1)	1 (1)	0.67
Periodontitis	2 (1)	1 (1)	< 0.001
Periapical lesions	0 (1)	0 (0)	0.008
Pericoronitis	0 (0)	0 (0)	0.75

IQR = interquartile range.
[a]*See Table 1 for the scoring scheme.*

of teeth (25.0 vs. 26.0) and the same mean number of molar teeth (7.3 vs. 7.9).

There were no significant differences between cases and controls in terms of numbers of teeth with fillings, root fillings, secondary caries or tertiary caries (**Table 3**). However, teeth needing extraction, periapical lesions, molars with furcation lesions, teeth with severe periodontitis and teeth with angular bone loss were all significantly greater for cases than for controls (**Table 3**).

Components of the total dental index were compared in terms of median values (and interquartile ranges [IQRs]) between cases and controls. Scores for periodontitis and periapical lesions, but not those for caries or pericoronitis, were higher among cases than controls (**Table 4**).

Discussion

We found greater evidence of radiographically detectable dental infections and poor dental health among patients with CAD than among controls. The following indicators of poor dental health occurred more frequently among the cases than among the controls: periapical lesions, molars with furcation lesions, teeth with bone loss of 6 mm or more and teeth with angular (vertical) bone loss. In addition, patients with CAD had higher total dental index values for periodontitis and periapical lesions but not for caries or pericoronitis.

Only patients with a confirmed diagnosis of CAD (i.e., myocardial infarction) were included as cases in this study, and all cases of CAD were diagnosed and treated by experienced cardiologists. Conversely, the diagnosis of periodontitis was based solely on bone loss as seen in radiographs; analyses of bleeding and probing depth of the gingival pockets would have been needed to confirm the diagnosis, but the authors did not examine the patients clinically. As such, the data must be interpreted with caution. Nonetheless, given that the aim of the study was to investigate differences in the burden of infection between cases and controls, this limitation was not deemed severe. Indeed, panoramic radiography without clinical probing was previously used to estimate marginal bone loss as a sign of periodontitis in women with CAD.[17]

To illustrate the individual burden of infection, we used percentage (rather than number) of teeth, which better reflects actual exposure. The results showed that dental infections were more frequent among patients

experiencing their first episode of CAD than among controls. In particular, periodontal infections seemed significantly more frequent and more severe among cases than among controls, in agreement with many earlier studies.[6–8,17–19] For example, Meurman and colleagues[20] showed that gingivitis but not periodontitis was related to severe heart disease.

These results do not reveal a causal relation between these 2 conditions. Indeed, given the multifactorial background of each disease, causality would be difficult to confirm. This may explain the variation in conclusions reported in the literature.[11] In particular, confounding factors might be overestimated, which would lead to an underestimation of risks.[7] As expected, the patients in this study had greater elevation of cholesterol levels and hypertension than did the controls; this is because cholesterol and hypertension are intermediate variables, and their elevation would lead to case status (i.e., presence of CAD). The study aim was to show differences between cases and controls and then use them in explaining differences in dental findings.

The cases and controls did not differ in terms of total number of teeth. This contradicts the findings of some previous studies.[11,15,21] For example, Paunio and coworkers[21] noticed more missing teeth among patients with ischemic heart disease than among controls, and Meurman and colleagues[20] showed that patients with severe heart disease who were referred for open-heart surgery had fewer teeth than controls. Tu and coworkers[11] reported recently that individuals with severe tooth loss had 35% greater likelihood of death from heart disease than those with 4 or fewer missing teeth; similarly, Lai[22] found an association between tooth loss and heart disease. These findings might have been due to common behavioural background factors, as shown by Ylöstalo and colleagues.[9] Alternatively, they might be due to a more direct causal relation, since missing teeth have been regarded as a sign of sustained oral infection.

Further evidence is needed to confirm a relation between infectious oral diseases and CAD. In particular, there is a need for longitudinal epidemiologic, clinical and interventional studies.[7,23] Even without data from such studies, and although the literature is far from unanimous, it is recommended that dental infection be listed as a possible contributing factor to acute myocardial infection, along with smoking, overweight, high lipid concentration and high blood pressure. Periodontal infection may occur without major signs or symptoms, even if a large area is affected.[24] So far, however, dental infection has not been mentioned in any books dealing with coronary risk factors.

The evidence gathered from controls in this study indicates that dental caries and periodontitis are frequent among people living in Kuwait, as was previously documented by Behbehani and Scheutz.[16] Cardiac problems are also relatively common.[1] The results of this study should be taken into consideration when planning strategies to prevent cardiac disease. Dental consultations and elimination of dental infection should be part of the comprehensive treatment of all patients with cardiac problems.

In conclusion, the results of this study confirmed those of previous reports by showing a correlation between dental and oral infections and CAD. True causality could not be proven in this study, and a prospective interventional study is needed for this purpose. Nonetheless, dental infection should be considered a contributing factor to CAD.

THE AUTHORS

Dr. Oikarinen *is a professor and head of oral and maxillofacial surgery at the Institute of Dentistry, University of Oulu, and dentist-in-chief, department of oral and maxillofacial surgery, Oulu University Hospital, Oulu, Finland.*

Dr. Zubaid *is a professor in the department of medicine, faculty of medicine, Kuwait University and head of the division of cardiology, Mubarak Al-Kabeer Hospital, Kuwait City, Kuwait.*

Dr. Thalib *is an associate professor in the department of community medicine, faculty of medicine, Kuwait University, Kuwait City, Kuwait.*

Dr. Soikkonen *is an assistant professor at Helsinki University, Helsinki, Finland.*

Dr. Rashed *is a consultant in the division of cardiology, Mubarak Al-Kabeer Hospital, Kuwait City, Kuwait.*

Dr. Lie *is a professor and head of the department of surgical sciences, faculty of dentistry, Kuwait University, Kuwait City, Kuwait.*

Acknowledgements: *This study was supported by the Kuwait University Research Administration Grant No. DS 02/01.*

Correspondence to: *Professor Kyosti Oikarinen, Institute of Dentistry, P. O. Box 5281, FIN-90014 University of Oulu, Finland.*

The authors have no declared financial interests.

This article has been peer reviewed.

References

1. Zubaid M, Rashed WA, Husain M, Mohammad BA, Ridha M, Basharuthulla M, and others. A registry of acute myocardial infarction in Kuwait: patient characteristics and practice patterns. *Can J Cardiol* 2004; 20(8):783–7.

2. Mattila KJ, Nieminen MS, Valtonen VV, Rasi VP, Kesäniemi YA, Syrjälä SL, and others. Association between dental health and acute myocardial infarction. *BMJ* 1989; 298(6676):779–81.

3. Danesh J, Collins R, Peto R. Chronic infections and coronary heart disease: is there a link? *Lancet* 1997; 350(9075):431–6.

4. Mattila KJ, Valtonen VV, Nieminen MS, Asikainen S. Role of infection as a risk factor for atherosclerosis, myocardial infarction, and stroke. *Clin Infect Dis* 1998; 26(3):719–34.

5. Hujoel PP, Drangsholt M, Spiekerman C, DeRouen TA. Periodontal disease and coronary heart disease risk. *JAMA* 2000; 284(11):1406–10.

6. Geerts SO, Legrand V, Charpentier J, Albert A, Rompen EH. Further evidence of the association between periodontal conditions and coronary artery disease. *J Periodontol* 2004; 75(9):1274–80.

7. Meurman JH, Sanz M, Janket SJ. Oral health, atherosclerosis, and cardiovascular disease. *Crit Rev Oral Biol Med* 2004; 15(6):403–13.

8. Söder B, Yakob M. Risk for the development of atherosclerosis in women with a high level of dental plaque and severe gingival inflammation. *Int J Dent Hyg* 2007; 5(3):133–8.

9. Ylöstalo PV, Järvelin MR, Laitinen J, Knuuttila ML. Gingivitis, dental caries and tooth loss: risk factors for cardiovascular diseases or indicators of elevated health risks. *J Clin Periodontol* 2006; 33(2):92–101.

10. Tenenbaum H, Matthews D, Sándor G, McCulloch C. Oral health–systemic health: what is the true connection? Interviews by Sean McNamara. *J Can Dent Assoc* 2007; 73(3):211–6.

11. Tu YK, Galobardes B, Smith GD, McCarron P, Jeffreys M, Gilthorpe MS. Associations between tooth loss and mortality patterns in the Glasgow Alumni Cohort. *Heart* 2007; 93(9):1098–103.

12. DeStefano F, Anda RF, Kahn HS, Williamson DF, Russell CM. Dental disease and risk of coronary heart disease and mortality. *BMJ* 1993; 306(6879):688–91.

13. Beck JD, Pankow J, Tyroler HA, Offenbacher S. Dental infections and atherosclerosis. *Am Heart J* 1999; 138(5 Pt 2):528–33.

14. Seymour RA, Steele JG. Is there a link between periodontal disease and coronary heart disease? *Br Dent J* 1998; 184(1):33–8.

15. Meurman JH, Qvarnström M, Janket SJ, Nuutinen P. Oral health and health behavior in patients referred for open-heart surgery. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2003; 95(3):300–7.

16. Behbehani JM, Scheutz F. Oral health in Kuwait. *Int Dent J* 2004; 54(6 Suppl 1):401–8.

17. Buhlin K, Gustafsson A, Ahnve S, Janszky I, Tabrizi F, Klinge B. Oral health in women with coronary heart disease. *J Periodontol* 2005; 76(4):544–50.

18. Joshipura KJ, Rimm EB, Douglass CW, Trichopoulos D, Ascherio A, Willett WC. Poor oral health and coronary heart disease. *J Dent Res* 1996; 75(9):1631–6.

19. Joshipura KJ, Douglass CW, Willett WC. Possible explanations for the tooth loss and cardiovascular disease relationship. *Ann Periodontol* 1998; 3(1):175–83.

20. Meurman JH, Janket SJ, Qvarnström M, Nuutinen P. Dental infections and serum inflammatory markers in patients with and without severe heart disease. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2003; 96(6):695–700.

21. Paunio K, Impivaara O, Tiekso J, Mäki J. Missing teeth and ischaemic heart disease in men aged 45-64 years. *Eur Heart J* 1993; 14:54–6.

22. Lai JY. Association between tooth loss and risk for heart disease [News & Updates]. *J Can Dent Assoc* 2006; 72(10):201.

23. Scannapieco FA, Bush RB, Paju S. Associations between periodontal disease and risk for atherosclerosis, cardiovascular disease, and stroke. A systematic review. *Ann Periodontol* 2003; 8(1):38–53.

24. Hujoel PP, White BA, Garcia RI, Listgarten MA. The dentogingival epithelial surface area revisited. *J Periodont Res* 2001; 36(1):48–55.