The Association of Tooth Scaling and Decreased Cardiovascular Disease: A Nationwide Population-based Study

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ABSTRACT

OBJECTIVE: Poor oral hygiene has been associated with an increased risk for cardiovascular disease. However, the association between preventive dentistry and cardiovascular risk reduction has remained undetermined. The aim of this study is to investigate the association between tooth scaling and the risk of cardiovascular events by using a nationwide, population-based study and a prospective cohort design.

METHODS: Our analyses were conducted using information from a random sample of 1 million persons enrolled in the nationally representative Taiwan National Health Insurance Research Database. Exposed individuals consisted of all subjects who were aged ≥50 years and who received at least 1 tooth scaling in 2000. The comparison group of non-exposed persons consisted of persons who did not undergo tooth scaling and were matched to exposed individuals using propensity score matching by the time of enrollment, age, gender, history of coronary artery disease, diabetes, hypertension, and hyperlipidemia.

RESULTS: During an average follow-up period of 7 years, 10,887 subjects who had ever received tooth scaling (exposed group) and 10,989 age-, gender-, and comorbidity-matched subjects who had not received tooth scaling (non-exposed group) were enrolled. The exposed group had a lower incidence of acute myocardial infarction (1.6% vs 2.2%, P < .001), stroke (8.9% vs 10%, P = .03), and total cardiovascular events (10% vs 11.6%, P < .001) when compared with the non-exposed group. After multivariate analysis, tooth scaling was an independent factor associated with less risk of developing future myocardial infarction (hazard ratio [HR], 0.69; 95% confidence interval [CI], 0.57-0.85), stroke (HR, 0.85; 95% CI, 0.78-0.93), and total cardiovascular events (HR, 0.84; 95% CI, 0.77-0.91). Furthermore, when compared with the non-exposed group, increasing frequency of tooth scaling correlated with a higher risk reduction of acute myocardial infarction, stroke, and total cardiovascular events (P for trend < .001).

CONCLUSION: Tooth scaling was associated with a decreased risk for future cardiovascular events.

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KEYWORDS: Cardiovascular disease risk; National Health Insurance; Tooth scaling

Cardiovascular disease has become the leading cause of mortality worldwide, accounting for approximately 30% of all deaths. Atherosclerosis is considered not just a cholesterol storage disorder but a sustained, dynamic, and inflammatory process in vasculature. Because inflammation plays an important role in the atherosclerosis process, there is continued interest in the implication of chronic infections and inflammatory diseases in atherosclerosis and cardiovascular disease.

There have been reports that poor oral hygiene, specifically periodontal disease, is associated with an increased...
risk for cardiovascular disease, probably by adding to the inflammatory burden of individuals. Proinflammatory mediators, such as C-reactive protein (CRP), interleukin-6, fibrinogen, von Willebrand factor, and serum amyloid A, have been shown to be elevated in patients with periodontal disease. The meta-analyses demonstrated poor oral hygiene with periodontal disease had an overall increased risk of 24% to 35% for coronary heart disease and a higher risk for stroke ranging from 1.2% to 3.0%, suggesting that poor oral hygiene with periodontal disease is one risk factor contributing to the formation of cardiovascular disease. In addition, tooth brushing was reported to reduce cardiovascular disease risk, further supporting the importance of oral hygiene in cardiovascular risk management.

Subgingival scaling in individuals with widespread periodontitis reduced serum inflammatory markers. In the Periodontitis and Vascular Events study, any preventive or periodontal care significantly reduced the percentage of people with elevated high-sensitivity CRP (values > 3 mg/L). However, there is limited information on whether tooth scaling, meaning a more generalized tooth cleaning with removal of dental plaque and calculus, could reduce cardiovascular disease risk. The Taiwan National Health Insurance (NHI) program allows beneficiaries to receive tooth scaling, unrelated to the presence of severe periodontitis, or not. Therefore, we conducted a nationwide population-based study using the Taiwan National Health Research Insurance database to investigate the impact of tooth scaling on the risks for cardiovascular disease and stroke with a prospective cohort study design.

**MATERIALS AND METHODS**

**Database**

The Taiwan NHI program, which has operated since 1995, enrolls nearly all the inhabitants of Taiwan (21,869,478 beneficiaries of 22,520,776 inhabitants at the end of 2002). The NHI Research Database at the National Health Research Institute in Miaoli, Taiwan, is in charge of the complete NHI claims database and released a dataset for research purposes. This cohort dataset comprises 1,000,000 randomly sampled beneficiaries still enrolled in the NHI program during 2000 and collected all subjects who were aged 50 years or more in 2000 and who had received full-mouth tooth scaling or localized tooth scaling (exposed group) from January 1 to December 31, 2000. We used the NHI Bureau coding for treatment procedures to identify dental scaling (91004c for full-mouth scaling and 91003c for localized scaling).

We excluded patients who had acute myocardial infarction (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] code 410.xx) or ischemic stroke (ICD-9-CM codes 433.xx, 434.xx, 436, and 437.1) diagnosed before 2000 to increase the likelihood of identifying only new cases of acute myocardial infarction and stroke.

The non-exposed group was matched to the exposed group using a propensity score, which has been widely used in control selection in large sample size databases. A 1:1 propensity-score matching was performed with receiving or not receiving tooth scaling as the dependent variable. The following variables were included to balance known risk factors across groups: the time when subjects were enrolled, age, gender, history of coronary artery disease, diabetes, hypertension, and hyperlipidemia. The non-exposed group comprises subjects who had never received any tooth scaling at enrollment or any time after, so there are no cross-over subjects in our study.

Study end points were defined by ICD-9-CM codes for acute myocardial infarction or ischemic stroke appearing any 1 time during hospitalization or 2 times in the ambulatory care center. Similar identifications for cases have been proven valid, and the sensitivity and specificity of identification for events using ICD-9-CM in the National Health Research Insurance database compared with direct chart review were 100% and 95%, respectively. More details have been described in previous studies. Other covariates, including age and preexisting (in the year before treatment) hypertension (401.xx-405.xx), diabetes mellitus (250.xx), hyperlipidemia (272.xx), and coronary artery disease (411.xx-414.xx) were identified via ICD-9-CM coding. All patients were followed up to the study end point or December 31, 2007.
Table 1  Demographic Data of Study Population

<table>
<thead>
<tr>
<th></th>
<th>Tooth Scaling</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes (n = 10,887)</td>
<td>No (n = 10,989)</td>
<td>P Value</td>
</tr>
<tr>
<td>Age, y</td>
<td>61.09 ± 8.64</td>
<td>61.24 ± 8.8</td>
<td>.19</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>5406 (49.7)</td>
<td>5423 (49.4)</td>
<td>.65</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>3492 (32.1)</td>
<td>3597 (32.7)</td>
<td>.30</td>
</tr>
<tr>
<td>DM, n (%)†</td>
<td>1734 (15.9)</td>
<td>1810 (16.5)</td>
<td>.28</td>
</tr>
<tr>
<td>Dyslipidemia, n (%)‡</td>
<td>1607 (14.6)</td>
<td>1712 (15.6)</td>
<td>.19</td>
</tr>
<tr>
<td>CAD, n (%)§</td>
<td>1627 (14.9)</td>
<td>1712 (15.6)</td>
<td>.19</td>
</tr>
<tr>
<td>Chronic renal disease, n (%)</td>
<td></td>
<td>759 (7.0)</td>
<td>695 (6.3)</td>
</tr>
<tr>
<td>Arrhythmia, n (%)¶</td>
<td>8.64</td>
<td>61.24</td>
<td>.19</td>
</tr>
</tbody>
</table>

DM = diabetes mellitus; CAD = coronary artery disease.

All chronic conditions were defined by administrative claims using ICD-9-CM codes:

‡Dyslipidemia = ICD-9-CM code: 272.xx.

Statistical Analysis

We used Microsoft SQL Server 2005 (Microsoft Corp, Redmond, Wash) for data management and computing and SPSS software (v. 15.0, SPSS Inc, Chicago, Ill) for statistical analysis. All data were expressed as the frequency (percentage) or mean ± standard deviation. The parametric continuous data between the exposed and non-exposed groups were compared by unpaired Student’s t-test. The categorical data between the 2 groups were compared with chi-square test and Yates’ correction or Fisher exact test as appropriate. Survival analysis was assessed using Kaplan-Meier analysis, with the significance based on the log-rank test. The survival time was calculated from the date of enrollment to the date of diagnosis of acute myocardial infarction or stroke. Multiple regression analysis was carried out using Cox proportional hazard regression analysis to evaluate whether tooth scaling was an independent factor in determining the occurrence of acute myocardial infarction, stroke, or total cardiovascular events. Subsequent subgroup analysis was performed to investigate the effects of tooth scaling among other risk factors for cardiovascular event, such as age, gender, history of diabetes mellitus, hyperlipidemia, hypertension, and coronary heart disease. Statistical significance was inferred at a 2-sided P value of <.05.

RESULTS

We obtained a sample size of 21,876 subjects, including 10,887 subjects who had received full-mouth or localized tooth scaling at least once during the study period (exposed group) and propensity score matched with another 10,989 subjects without tooth scaling (non-exposed group). There were no significant differences in age, gender, history of hypertension, diabetes, dyslipidemia, and coronary artery diseases between these 2 groups (Table 1).

During an average follow-up period of 7 years, 408 (1.8%) of the 21,876 subjects who had ever received tooth scaling therapy had acute myocardial infarction and 2062 subjects (9.4%) had an episode of stroke (Table 2). By comparison, the non-exposed group had a significantly higher incidence of acute myocardial infarction (239/10,989 subjects, 2.17%) and stroke (1099 patients, 10.00%), indicating that tooth scaling was associated with a reduced risk of cardiovascular event development. During the follow-up period, the patients with full-mouth or localized tooth scaling had significantly higher acute myocardial infarction-free survival (Figure 1A), higher stroke-free survival (Figure 1B), and higher total cardiovascular event-free survival (Figure 1C) than subjects in the non-exposed group. The results of log-rank test and Kaplan-Meier survival analyses of acute, stroke, and total cardiovascular events are shown in Figure 1A-C, respectively. In addition, the association between tooth scaling and malignancy occurrence was analyzed, and there was no difference in cancer incidence between the exposed and non-exposed groups (10.48% vs 10.21%; P = .52).

Cox proportional hazard regression model analysis showed that tooth scaling was independently associated with less risk of developing future myocardial infarction.

Table 2  Association Between Tooth Scaling and Cardiovascular Events

<table>
<thead>
<tr>
<th>Events</th>
<th>Crude HR (95% CI)</th>
<th>Adjusted HR (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tooth Scaling (-)</td>
<td>Tooth Scaling (+)</td>
</tr>
<tr>
<td>AMI</td>
<td>Total</td>
<td>1 (referent)</td>
</tr>
<tr>
<td></td>
<td>408</td>
<td>239 (2.2%)</td>
</tr>
<tr>
<td></td>
<td>Stroke</td>
<td>2062</td>
</tr>
<tr>
<td></td>
<td>Total cardiovascular events</td>
<td>2366</td>
</tr>
</tbody>
</table>

HR = hazard ratio; AMI = acute myocardial infarction.

*Adjusted for age, gender, history of hypertension, diabetes mellitus, hyperlipidemia, dysrhythmia, and chronic kidney disease.
†P < .05.
hazard ratio [HR], 0.69; 95% confidence interval [CI], 0.57-0.85), stroke (HR, 0.85; 95% CI, 0.78-0.93), and composite events (HR, 0.84; 95% CI, 0.77-0.91) after adjusting for age, gender, hypertension, diabetes mellitus, hyperlipidemia, chronic renal failure, and history of coronary artery disease (Table 2).

Furthermore, the HR of experiencing a myocardial infarction during the 7-year follow-up period was 0.61 times less in patients receiving tooth scaling more than once every 2 years (95% CI, 0.46-0.81) and 0.80 (95% CI, 0.63-1.00) times less in the less frequent tooth scaling group than in the group without tooth scaling during the follow-up period. As for stroke, a greater risk reduction was observed in patients who received tooth scaling at a frequency of more than once every 2 years (HR, 0.81; 95% CI, 0.73-0.92 vs HR, 0.92; 95% CI, 0.83-1.02 for tooth scaling at a frequency of less than once every 2 years) (Figure 2). This association between frequency of tooth scaling and reduced risk also remained for total cardiovascular events (HR, 0.90; 95% CI, 0.82-0.99 vs HR, 0.79; 95% CI, 0.71-0.88 for frequent and occasional tooth scaling, respectively). The decreased risk of acute myocardial infarction, stroke, and total cardiovascular complications decreased gradually in association with increasing tooth scaling frequency (P for trend <.001), indicating tooth scaling was associated with a reduced risk in developing cardiovascular events. The subgroup analyses further demonstrated that the association existed independently with other established cardiovascular risk factors (Figure 3).

**DISCUSSION**

Our study showed that patients who received tooth scaling had a significantly lower incidence of acute myocardial infarction and stroke when compared with the non-exposed group. Further analysis showed that the frequency of tooth scaling was strongly associated with the risk reduction of cardiovascular events, further suggesting a negative association between tooth scaling and cardiovascular disease risk.

There is considerable attention on oral hygiene and its role in the cause of cardiovascular disease. Poor oral hygiene is the major cause of periodontal disease, which is an infectious disease of the periodontium caused by a group of predominantly anaerobic Gram-negative bacteria present on the tooth surface. Periodontal disease has been reported to be associated with an increased risk for cardiovascular disease, peripheral vascular disease, and stroke. In their analysis of different observational study designs, Bahekar et al demonstrated a higher risk of developing cardiovascular disease in patients with periodontal disease in prospective cohort studies (relative risk, 1.14; 95% CI, 1.07-1.21), cross-sectional studies (odds ratio [OR], 1.59; 95% CI, 1.33-1.91), and case-control studies (OR, 2.22; 95% CI, 1.59-3.12). A study of 9962 adults who participated in the First National Health and Nutrition Examination Survey found that the relative risk for incident non-hemorrhagic stroke was 1.24 (95% CI, 0.74-2.08) for gingivitis, 2.11 (95% CI, 1.30-3.42) for periodontitis, and 1.41 (95% CI,
Data from the Normative Aging Study and Dental Longitudinal Study of the US Department of Veterans Affairs (follow-up period of 25-30 years) also demonstrated that periodontal disease was a significant independent risk factor for peripheral vascular disease (OR, 2.27; 95% CI, 1.3-3.9). This association was even more significant with increasing severity of periodontal disease, indicating the close relationship between periodontal disease and cardiovascular risk.

There are many proposed mechanisms to explain the relationship between periodontal disease and cardiovascular disease. First, periodontal disease represents a chronic infection that leads to chronic inflammation, increasing circulating cytokines such as CRP, interleukin-1, interleukin-6, tumor necrosis factor-α, fibrinogen, von Willebrand factor, and serum amyloid A, which would in turn increase atherosclerosis. Periodontitis also is associated with increased concentrations of plasma lipids, such as total and low-density lipoprotein cholesterol and triglycerides, perhaps by increased systemic inflammatory burden. Periodontal infection may lead to endothelial dysfunction, inflammation, and atherosclerosis. Furthermore, the atherosclerotic process impairs endothelial functions and induces functional and structural changes in vascular smooth muscle in patients with periodontitis. Periodontal pathogens, such as Porphyromonas gingivalis, Fusobacterium nucleatum, and Actinobacillus actinomycetemcomitans, have been identified in atherosclerotic plaques. The Atherosclerosis Risk in Communities Study reported that patients with poor oral hygiene and severe generalized periodontitis have higher carotid intima-media wall thickness, furthermore highlighting the relationship between periodontal disease and increased risk of cardiovascular disease.

Dental calculus (plaque) consists of bacterial content that may irritate and inflame gingiva, leading to periodontitis. Periodontal treatment, defined as subgingival scaling and root planning, was associated with decreased levels of inflammatory cytokines. Periodontal treatment decreases serum inflammatory markers, such as CRP and periodontal interleukin-6. In addition to decreasing inflammatory markers, periodontal treatment may decrease the surrogate end point of cardiovascular disease, including lipoprotein-associated phospholipase A2, endothelial dysfunction, and intima-media thickness. To our knowledge, the current study is the first to investigate the association between tooth scaling and future cardiovascular events by using a large nationwide population-based study. Our study finding that the risk of acute myocardial infarction, stroke, and total cardiovascular complications decreased gradually in association with increasing tooth-scaling frequency further extends the clinical observation that periodontal treatment may provide a protective benefit in decreasing the development of cardiovascular disease. The self-reported frequency of tooth brushing was associated with decreased cardiovascular disease events (HR, 1.7; 95% CI, 1.3-2.3) and CRP levels in a study of 11,869 individuals in the Scotland Health Survey, which is in concordance with our study, indicating that oral hygiene may provide an additional benefit in preventing cardiovascular events.

Study Strengths and Limitations
The strength of our study is the use of a population-based dataset, which enrolls a large sample size and enables us to compare
prospectively trace the differences between 2 groups. However, there are still some limitations in our study. First, the diagnoses of acute myocardial infarction and stroke are identified using the ICD-9 codes from the database. Although diagnoses rely largely on administrative claims data reported by physicians or hospitals, and may be less accurate than diagnoses made according to standardized criteria, previous studies using ICD-9 coding in the same database have shown high sensitivity (100%) and specificity (95%) in identifying cardiovascular events.12-14 Second, a common

![Figure 3](https://example.com/figure3.png)

**Figure 3** HRs of tooth scaling for events of acute myocardial infarction (A), stroke (B), and total cardiovascular events (C) in subgroup analysis; by proportional hazards regression analysis, adjusted for age, gender, history of hypertension, diabetes mellitus, hyperlipidemia, dysrhythmia, and chronic kidney disease. AMI = acute myocardial infarction; CI = confidence interval; HR = hazard ratio.
bias in studies using databases is the immortal time bias. However, our study enrolled subjects in the exposed group if their first tooth scaling was performed in 2000, and the enrolled index date is the first day they receive tooth scaling. Therefore, there is no immortal time bias in our study. Third, some important cardiovascular disease risk factors, such as smoking, body mass index, alcohol consumption, dietary factor, and family history are not available and may result in compromised findings and an inadequate adjustment of confounding factors. Smoking, in particular, is of major concern. However, oral hygiene studies conducted in Taiwan have shown that approximately 10% to 20% of the study population are smokers, suggesting smokers are less likely to seek preventive dental care. Fourth, the NHI provides tooth scaling for all beneficiaries once per year. It is not mandatory and may be unrelated to clinical severity of periodontitis. Because of the limitation of the database, the prevalence of periodontitis cannot be identified in both groups. Therefore, the possibility of selection bias cannot be excluded. Finally, more than 98% of the residents in Taiwan are of Chinese ethnicity. The ability to generalize the results to other racial/ethnic groups is unclear. Further study is needed to confirm our findings and their relevance in relation to other ethnic groups.

CONCLUSIONS
The present study suggests that tooth scaling is associated with a decreased risk for acute myocardial infarction, stroke, and total cardiovascular events, with the greatest risk reduction observed in patients who received tooth scaling at higher frequencies. It supports the growing evidence of poor oral hygiene as a risk factor for cardiovascular disease. Our findings support tooth scaling in addition to daily tooth brushing to improve oral hygiene and reduce the risk of cardiovascular disease.

References


