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Original Article

# Loss of Teeth and Coronary Heart Disease Mortality in Older Patients

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SUMMARY

*Objective:* Most of the existing studies examined the relationship between periodontitis and coronary heart disease (CHD) with a broad age range. This study aims to examine whether periodontitis is associated with increased CHD mortality in older patients.
*Methods:* 1385 patients who underwent digital radiographic examination, and aged 75 and above, were included in this retrospective cohort study. We used Cox proportional hazards regression and competing risk hazard models to compute hazard ratio (HR) and 95% confidence interval (CI) regarding CHD mortality.
*Results:* Significantly associations were found between loss of teeth and CHD mortality. The HR (95% CI) was 1.04 (1.01, 1.07) after adjusting for relevant confounding variables. Results from the stratification analysis indicated that female, aged 80 and above, body mass index (BMI) < 25, non-smokers and non-drinkers may face increased risks.
*Conclusion:* Loss of teeth increased the risk of CHD mortality in the older patients, particularly in female, aged 80 and above, BMI < 25, non-smokers and non-drinkers.



## 1. Introduction

Throughout the world, a demographic revolution steps forward. The proportion of older people is growing faster than of any other age group. Approximately, 600 million people are aged 60 years and over, and this number will double by 2025.[1] Generally, adverse health-related outcomes usually occur later in life, but the biology leading to these events begins much earlier. It is important, consequently, to identify early signs of accelerated ageing that occurs unnecessarily early in the life course.[2]

Periodontal disease (PD) is defined as the bacterial and inflammatory destruction of gingiva and teeth-supporting structures including bone and periodontium, including gingivitis and periodontitis.[3] The prevalence of PD is high, with gingivitis or periodontitis affecting up to 90% of the population worldwide.[4] The chronic periodontal infection may persist over many years, if PD is not diagnosed and treated. There is progression in the breakdown of tissues, and teeth may become mobile and eventually exfoliate.[5]

PD has been linked to cardiovascular disease (CVD) by a number of reports. An increased risk was observed for myocardial infarction among patients with PD by a case-control study in Swedish.[6] A cohort study conducted in Netherlands showed that PD was independently associated CVD.[5] Similar studies in Sweden found that tooth loss was related to myocardial infarction, heart failure and total CVD outcomes.[7] There was also meta-analysis showed that PD increased the risk of coronary heart disease (CHD).[8] However, almost all the existing studies analyzed subjects with a broad age range. Little is known regarding whether those associations remain true in old subjects after controlling for the potential confounding effects of lifestyle factors and other comorbid diseases.

With a retrospective cohort study design, the hypothesis of the current study is that alveolar bone loss and loss of teeth, as indicators of PD, are independent risk factors for CHD mortality in the older patients.

## 2. Methods

A cohort of 1385 patients who aged ≥ 75 years and were examined with panoramic radiographs was set up. All the subjects were followed from January 1, 2010 to December 31, 2019. As has been elaborated in our previous research, the dental examination for these patients was followed by a standardized protocol. The third molars were excluded due to their complicated shapes when the number of remaining teeth in the oral cavity was enumerated. Dentures, partial, and complete implant bridge, in either jaw, were not included in the scope of residual teeth. Measurements of alveolar bone loss were made from the cementoenamel junction to the tooth apex (total root length) and from the marginal bone crest to the tooth apex (total bone height). The proportion of remaining bone

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height of the teeth was calculated from total root length and total bone height. Participants were subsequently allocated to four groups based on the quartile of the above proportion: healthy (≥ 51% remaining bone), mild periodontitis (43% to 51% remaining bone), moderate periodontitis (26%–43% remaining bone), and severe periodontitis (< 26% remaining bone).[9] Smoking status were defined as nonsmoker, previous smoker, and current smoker. Drinking status were defined as never drink, drink sometimes and drink every day. CHD was defined as code I25, hypertension was defined as I10 and diabetes was defined as E10–E14 (International Classification of Diseases, Revision 10).

### *2.1. Statistical analysis*

Inter-group difference was compared using Chi-square test or Fisher's exact test for categorical variables and t test for continuous variables. We performed Cox proportional hazards model to examine periodontitis associated CHD mortality. We employed competing risk hazard models to identify risk factors for the cumulative incidence of specific events in the presence of competing risks. CHD mortality was set as the primary event of interest, and death from another cause was treated as the competing event in the competing risk hazard models. Statistical analysis was conducted using R (R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.).

This study was approved by the Ethics Committee of the Shanghai Ninth People's Hospital (SH9H-2019-T36-2).

## 3. Results

The baseline characteristics of the subjects are shown in Table 1. Totally, 64 (4.62%) subjects died from CHD at the end of the study period. The mean age of these patients was 83.07 ± 4.84. Among them, 40.62% were male subjects and 59.38% were female subjects. The loss of teeth and proportion of remaining bone height for these patients was 16.36 ± 8.74 and 0.34 ± 0.22 respectively. Subjects died from CHD were more likely to suffer from hypertension and diabetes.

As shown in Table 2, mortality for CHD was not associated with alveolar bone loss. The hazard ratio (HR) [95% confidence interval (CI)] for patients with severe alveolar bone loss was 1.36 (0.68, 2.75) after adjusting for relevant confounding factors. Significant associations were only found between loss of teeth and CHD mortality. The adjusted HR (95% CI) was 1.04 (1.01,1.07). Analysis based on competing risk models also showed that alveolar bone loss was not linked to CHD. The adjusted HR (95% CI) for loss of teeth was 1.03 (1.01,1.06).

We conducted stratified analysis to examine potential effect modifiers for CHD mortality in the case of PD exposure. As is shown in Figure 1, we found that female, body mass index (BMI) < 25 and aged 80 and above subgroups were more susceptible to tooth loss associated CHD mortality. Moreover, loss of teeth were also more likely to increase the risk of death from CHD in nonsmokers and nondrinkers.

## 4. Discussion

In a retrospective cohort study, we examined associations between PD and CHD mortality and summarized our findings as below: (1) tooth loss is associated with CHD mortality in individuals including and above 75 years of age. (2) the associations differed due to sex, age, BMI and history of smoking and drinking (3) Female, aged 80 and above, BMI < 25, non-smoker and non-drinker may face in-

**Table 1**
Baseline characteristics in the total sample.

| | Survivors | CHD mortality | p |
|---|---|---|---|
| Participants | 971 (70.11%) | 64 (4.62%) | / |
| The proportion of remaining bone height | 0.39 (0.18) | 0.34 (0.22) | 0.086 |
| Loss of teeth | 13.41 (8.19) | 16.36 (8.74) | 0.009 |
| Age | 80.22 (3.62) | 83.07 (4.84) | < 0.001 |
| Sex | | | 0.438 |
| Male | 451 (46.45%) | 26 (40.62%) | |
| Female | 520 (53.55%) | 38 (59.38%) | |
| BMI (kg/m$^2$) | | | 0.950 |
| < 25 | 793 (81.67%) | 53 (82.81%) | |
| ≥ 25 | 178 (18.33%) | 11 (17.19%) | |
| Education levels (year) | | | 0.522 |
| ≤ 6 | 382 (39.63%) | 26 (40.63%) | |
| 7–12 | 309 (32.05%) | 22 (34.38%) | |
| > 12 | 73 (7.57%) | 7 (10.94%) | |
| Smoking condition | | | 0.765 |
| Never | 826 (87.78%) | 54 (88.52%) | |
| Quit | 91 (9.67%) | 6 (9.84%) | |
| Everyday | 24 (2.55%) | 1 (1.64%) | |
| Drinking condition | | | 0.392 |
| Never | 771 (81.93%) | 53 (86.89%) | |
| Sometimes | 155 (16.47%) | 7 (11.48%) | |
| Everyday | 15 (1.59%) | 1 (1.64%) | |
| Hypertension | | | 0.631 |
| Without | 198 (20.39%) | 11 (17.19%) | |
| With | 773 (79.61%) | 53 (82.81%) | |
| Diabetes | | | 0.008 |
| Without | 896 (92.28%) | 52 (81.25%) | |
| With | 75 (7.72%) | 12 (18.75%) | |

BMI: body mass index; CHD: coronary heart disease.

**Table 2**
HR and 95% CI for association between PD and CHD mortality.

| | Crude HR (95% CI) | Adjusted HR (95% CI)* | p for trend |
|---|---|---|---|
| Alveolar bone loss | | | 0.155 |
| Healthy (≥ 0.51) | 1.00 | 1.00 | |
| Mild (0.43–0.51) | 0.93 (0.44,1.95) | 0.84 (0.39,1.80) | |
| Moderate (0.26–0.43) | 1.28 (0.64,2.56) | 1.25 (0.61,2.54) | |
| Severe (< 0.26) | 1.52 (0.77,2.99) | 1.36 (0.68,2.75) | |
| Loss of teeth | 1.05 (1.02,1.08) | 1.04 (1.01,1.07) | |
| Competing risk models | Fine-Gray test | P | Subdistribution HR (95% CI)* |
| Severity of alveolar bone loss | 1.38 | 0.709 | 1.12 (0.88,1.42) |
| Loss of teeth | 44.98 | 0.022 | 1.03 (1.01,1.06) |

* Sex, age, BMI, smoking, drinking, education levels, hypertension and diabetes were adjusted.
BMI: body mass index; CHD: coronary heart disease; CI: confidence interval; HR: hazard ratio; PD: periodontal disease.

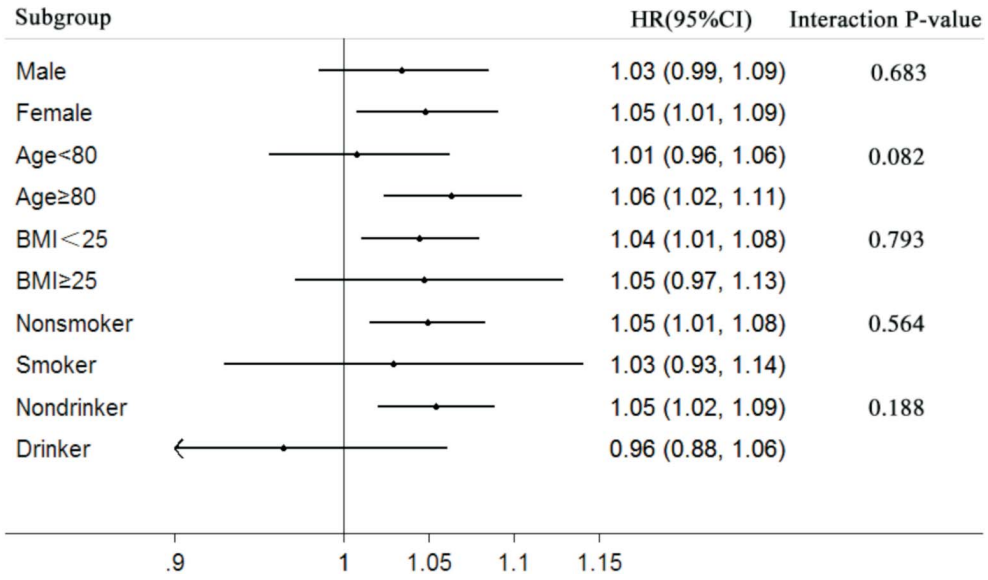


**Figure 1.** Stratified analysis for association between tooth loss and CHD mortality. BMI: body mass index; CHD: coronary heart disease; CI: confidence interval; HR: hazard ratio.

creased risks of tooth loss associated CHD mortality.

Most of the existing studies examined the PD associated CHD with a broad age range. Limited information is available specifically for the old patients. With a relatively large sample size, we provided evidence of association between tooth loss and CVD in the 75 and above population. Additionally, there is no need to consider the effects of age on changes that may potentially confound factors related to systemic condition when we limit the study population to a narrow age range. As a result, findings of our study are more likely to reveal a much higher level of scientific evidence.[10]

A variety of researches have reported the associations between PD and CHD.[11–13] Bahekar et al. have found in their study that PD significantly increased the incidence of CHD with a relative risk (RR) of 1.14 (1.074–1.213).[14] Humphrey et al. reported that both PD and tooth loss were associated with CHD and the RR was found to be 1.24 (1.01–1.51) and 1.34 (1.10–1.63, 95% CI) respectively.[15] In consistent with previous studies, we also found that tooth loss significantly increased the risk of CHD mortality in the older patients. However, we did not observe substantial evidence for the association between alveolar bone loss and CHD. We believe this can partly be explained by the fact that tooth loss is viewed as a severe outcome of PD and has been shown to be an early indicator of accelerated ageing.[2] Our findings were also supported by studies which demonstrated that elevated markers of systemic bacterial exposure such as periodontal bacterial burden and periodontitis specific serology had a greater risk of inducing CHD.[16]

The biological model of the association between PD, tooth loss and risk of CVD takes into account several potential mechanisms. Translocation of bacteria from the oral to systemic compartment may initiate localized inflammatory and immune responses at extraoral sites.[17] Immunologically competent cells stimulated by bacterial lipopolysaccharides secrete excessive amounts of pro-inflammatory mediators (IL-1, IL-6, TNF-$\alpha$, PGE2), which stimulate the liver to produce acute phase proteins (CRP), intensify platelet aggregation processes and increase plasma viscosity.[18] Additionally, old patients with fewer teeth and especially those who are edentate may have impaired masticatory function which limits their dietary choices and affects their nutritional status. This could further increase their susceptibility of developing CVD.[19,20]

This study was subject to certain limitations. The evaluation of PD in our study was based on the alveolar bone loss. We didn't conduct clinical examination. As a result, indexes such as probing depth and bleeding on probing, which may be better indicators of PD, was not considered in our study. In addition, some baseline comorbidities such as history of coronary artery disease, myocardial infarction, ischemic stroke and prescribed medications such as antiplatelet, beta-blockers and statins were not considered. There is the possibility that the inclusion of these variables may further diminish the association we found. Last, the retrospective data collection may bring bias to our study. Results found in the current study still need to be further validated in the future researches.

In conclusion, tooth loss is significantly associated with CHD

mortality in older patients. The pronounced association among female, aged 80 and above, BMI < 25, non-smokers and non-drinkers deserves attention. These results underline the importance for the collaboration between geriatrist cardiologist and dentist to improve oral health education and to early identify patients at risk of CHD in the older population.

## Conflicts of interest

None.

## Acknowledgement

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## Impact statement

Little is known regarding the association between periodontitis and coronary heart disease in the older patients. Loss of teeth were found to be significantly associated with coronary heart disease mortality in a ≥ 75-year age group cohort. There is the necessity to underlines the importance of considering tooth loss in prevention of coronary heart disease, particularly in the older patients.

## Author contributions

Yong Zhang: Conceptualization and project administration; Binxin Cai: Conceptualization and project administration; Jinyang Wu: Data curation and Formal analysis; Chengshuai Yang: Supervision and validation; Xiaofeng Xu: Writing-original draft; Yifeng Qian: Conceptualization and resources; Shilei Zhang: Conceptualization and resources.

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