Journal of Dental Sciences (2021) 16, 268–274

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jds.com

Original Article

Association between Periodontal Health and Stroke: Results from the 2013–2015 Korea National Health and Nutrition Examination Survey (KNHANES)

Min-Jeong Cho [a,b], Young-Seok Kim [a], Eun Young Park [c], Eun-Kyong Kim [a*]

[a] *Department of Dental Hygiene, College of Science & Technology, Kyungpook National University, Sangju, South Korea*
[b] *Department of Preventive Dentistry, School of Dentistry, Kyungpook National University, Daegu, South Korea*
[c] *Department of Dentistry, Yeungnam University College of Medicine, Daegu, South Korea*

Received 17 February 2020; Final revision received 8 May 2020
Available online 29 May 2020

KEYWORDS
Oral hygiene;
Periodontitis;
Stroke

Abstract *Background/purpose:* As the population ages, the prevalence of stroke increases, and as such there has been increasing interest in the risk factors associated with stroke. Although an association between periodontitis and stroke has been suggested, there has been no study of this association among the Korean population. Therefore, we investigated the association between periodontal health and stroke among Korean adults.
Materials and methods: A total of 9497 adults aged ≥40 years representing the Korean population were included in this cross-sectional study from the Korea National Health and Nutrition Examination Survey (KNHANES) VI (2013–2015). Periodontitis was diagnosed by dentists based on the Community Periodontal Index (CPI). Also, participants filled out a questionnaire regarding their experience of doctor-diagnosed stroke. Hypertension, diabetes, body mass index (BMI), and oral hygiene behavior covariates were adjusted in logistic regression analysis.
Results: The mean age of the study population was 55.71 ± 0.17 years and 52.7% of them were female. Also, 248 people had a history of having a stroke. Results of the logistic regression analysis after adjusting for age and sex showed a significant relationship between oral health behavior, periodontal health, and stroke even after adjusting for age, sex, education, household income, national health insurance, employment status, alcohol, smoking, diabetes, hypertension, BMI, and oral health behaviors (odds ratio [OR], 1.71; 95% confidence interval [CI] = 1.03–2.85).

* Corresponding author. Department of Dental Hygiene, College of Science & Technology, Kyungpook National University, 2559, Gyeongsangde-ro, Sangju, Gyeongsangbuk-do, South Korea.
E-mail address: jinha01@naver.com (E.-K. Kim).

https://doi.org/10.1016/j.jds.2020.05.006

Conclusion: Our findings suggest that periodontitis is associated with stroke in Korean adults.

Introduction

According to the World Health Organization (WHO), stroke is defined as a disease that persists for 24 h or longer following the acute onset of focal neurological impairment or disturbance of consciousness caused by a cerebrovascular accident, such as vascular blockage or rupture.[1] Stroke is a major cause of death worldwide, including Korea, and even if it does not lead to death, it is still a disease that can cause various physical and mental impairments.[2] In Korea, according to 2010 Statistics Korea data, approximately 53.2 people per 100,000 population die from stroke annually, making it the second most common cause of death after cancer and the leading cause of death among diseases related to a single organ.[3] Moreover, according to the Korea National Health and Nutrition Examination Survey (KNHANES) data reported in 2005, 15.9 people per 1000 population of adults 19 years and older (16.44 males and 15.37 females) were afflicted with stroke, and that number was predicted to increase by 3-fold by 2030.[3] Consequently, the prevalence of stroke is increasing not only in Korea, but also in a few other countries undergoing a shift to an aging society, and as such, interest in the risk factors associated with stroke has been heightened.

According to a 2012 study by Jung et al.,[4] hypertension (63.5%) was the most common risk factor among stroke patients in the Korean Stroke Registry between 2002 and 2010, with smoking (33.0%), diabetes (30.1%), prior stroke (19.7%), cardio-embolism (19.4%), and dyslipidemia (19.3%) also among the risk factors. In addition, recent studies have reported periodontal disease as an independent risk factor for stroke.[5] In patients with periodontal disease, irreversible destruction of the periodontal tissues occurs from chronic inflammation caused by bacterial infection.[6] The chronically inflamed state of the periodontal tissues increases the systemic inflammatory response, which has been reported to exacerbate atherosclerosis by facilitating the deposition of cholesterol on the blood vessel walls.[7] In other words, chronic inflammation in the periodontal tissues can cause a stroke by increasing the blood concentration of substances related to the immune response and facilitating the atherosclerotic process in the cerebral blood vessels.[8]

Epidemiological studies have suggested an association between periodontal disease and stroke. According to a 2009 cohort study in Korea by Choe et al.,[9] follow-up of 867,256 patients for 14 years found the occurrence of stroke in 28,258 cases, and in both males and females tooth loss was reported as an independent risk factor for stroke. Moreover, a cross-sectional study that measured the periodontal pocket depth for assessment of the current state of periodontal tissue inflammation also reported periodontitis as a risk factor for stroke.[9] Also, a 2008 case–control study by Sim et al.[10] conducted oral examinations in 265 stroke patients from 3 months to 1 year after the onset of stroke for assessment of their clinical attachment level (CAL). The results showed that severe periodontitis (CAL $\geq$ 6 mm) was independently associated with non-fatal stroke. A 2010 case–control study by Pradeep et al.[11] also reported that oral examination performed within 5 days from the onset of acute ischemic stroke indicated a significant association between periodontitis and stroke.

However, these precedent studies were limited to a few subjects who did not represent the general population of the country, resulting in a high probability of bias during the subject selection process. A 2006 study by Lee et al.[12] used the United States National Health and Nutrition Examination Survey (US NHANES) to investigate the correlation between periodontitis and cumulative stroke in groups that represented the entire U.S. population. However, no studies to date have included groups that represent the entire Korean population. Therefore, the present study aimed to assess the association between periodontitis and history of stroke among Koreans by using data from KNHANES, a nationally representative survey of Korea, to adjust for major risk factors for stroke and oral hygiene behavior, such as tooth brushing.

Materials and methods

Study participants

The present study analyzed KNHANES data, collected from 2013 to 2015. KNHANES was conducted by the Ministry of Health and Welfare, Korea. KNHANES is a nationally representative, stratified, complex, and multistage sample survey. The data were obtained publicly through the proper raw data request procedure of the Korea Center for Disease Control and Prevention. Among a total of 19,856 people who underwent an oral examination, 11,219 adults 40 years or older were selected as candidates for the study. Due to missing information, 1722 people were excluded, and a total of 9497 people were finally selected as the subjects of the study. The KNHANES was approved by the institutional review board of the Korea Centers for Disease Control and Prevention (IRB No = 2013-07CON-03-4C, 2013-12EXP-03-5C, 2015-01-02-6C).

Periodontal assessment

A dentist trained on the KNHANES protocol examined the community periodontal index (CPI) to assess

periodontitis.[13] The tooth numbers examined were 17, 16, 11, 26, 27, 37, 36, 31, 46, and 47. The scores were marked as "0" for healthy periodontal tissue, "1" for periodontal tissue with bleeding on probing, "2" for periodontal tissue with supra-gingival or subgingival calculus formation, "3" for periodontal tissue with shallow periodontal pockets with a probing pocket depth (PPD) of 4.0—5.5 mm, and "4" for periodontal tissue with deep periodontal pockets with a PPD of ≥6 mm. The highest CPI score among each sextant of the mouth was selected as a representative value of each participant. The Kappa values of periodontal assessment among trained dentists were 0.703, 0.778, and 0.799 in 2013, 2014, and 2015, respectively.

Stroke assessment

Those who answered "yes" to the question "have you suffered from a stroke that was diagnosed by a doctor?" were classified as the "stroke" group. Those who answered "no" to the question were classified as the "no stroke" group. Those who answered "don't know" were excluded from the study.

Covariates

The subjects were divided into 2 age groups (40—59 years and ≥60 years) and 4 educational level groups (below primary school graduation, secondary school graduate, high school graduate, and college graduate or higher). They were divided into 4 groups by household income (lower, lower middle, upper middle, and upper) and into 3 groups by type of insurance (region, occupation, and medical care assistance). Subjects were asked if they had a prior history of smoking or drinking alcohol or if they currently smoked or drank alcohol. Those who answered "yes with doctor's diagnosis" to the question "are you currently suffering from hypertension?" or "are you currently suffering from diabetes?" were classified as the "hypertension" or "diabetes" groups, respectively. The subjective oral health status was assessed on a 5-point Likert scale, with "very good," "good," and "normal" grouped into the "good" category and "poor" and "very poor" grouped into the "poor" category. Average daily tooth brushing frequency was investigated as the oral health behavior-related variable, with responses divided into 0, 1—2, and ≥3. Moreover, the use of auxiliary oral hygiene devices besides tooth brushes, such as dental floss, interdental brush, oral rinse (mouthwash), electric toothbrush, and water pick, was investigated for each subject, with results categorized as "none used (0)," "1 used (1)," or "2 or more used (2)." To determine oral health status, subjects were asked if they had experienced a toothache and if they had dental treatment in the past year, giving either a "yes" or "no" answer to each question. Chewing level was graded on a 5-point Likert scale and answers were divided into "poor," "fair," and "good." The number of remaining teeth, except wisdom teeth, was divided into 2 groups of either 0—19 or ≥20 teeth.[14]

Statistical analysis

A complex sample design analysis was done in order to represent the sample results. Sampling weights were applied to consider the unequal selection probabilities of sample design and non-respondents. A chi-square test of general linear model was used to compare the differences in general characteristics, oral health status, and oral health behavior between the 2 groups based on the presence of stroke. In Model I, the logistic regression analysis was performed to analyze the effects of oral health behavior and the status on stroke. Meanwhile, Model II was adjusted for age and sex, while Model III was adjusted for age, sex, education, household income, national health insurance, employment status, alcohol use, smoking, diabetes, hypertension, BMI, and oral health behavior. Statistical Package for the Social Sciences (SPSS) 23.0 (SPSS Inc, Chicago, IL, USA) was used for data analysis with statistical significance level set to $p < 0.05$.

Results

The entire study population consisted of 9497 adults, ≥40 years old, and their mean age was 55.71 ± 0.17; 5207 people (68.1%) in the 40—59 age group and 4042 people (31.9%) in the ≥60 age group. There were 5379 females (52.7%) and 5141 people (62.1%) with an education level of high school graduate or higher. The number of people with drinking and smoking experience was 7840 (87.1%) and 3559 (43.2%), respectively. The prevalence of stroke was significantly high in the following groups: the group consisting of older males; the group consisting of those with lower education level, lower income (with a high percentage of these receiving medical care assistance), and unemployed; and the group consisting of those with drinking and smoking experience ($p < 0.05$) (Table 1).

The stroke group showed lower daily tooth brushing frequency and less use of auxiliary oral hygiene devices, such as dental floss, than the no-stroke group ($p < 0.001$). Moreover, there was a significantly higher number of people with poor chewing level or ≤19 residual teeth ($p < 0.001$). Even in the CPI variables, the results were significantly different based on the presence of stroke. In other words, people in the stroke group more often had a poor periodontal health status than those in the control group ($p < 0.001$) (Table 2).

The results from logistic regression analysis for assessment of the associations between oral health and stroke were as shown in Table 3. In the crude model, using the group with average daily tooth brushing frequency of ≥3 times as the reference, the group with frequency of 1—2 times and 0 times showed odds ratios [ORs] of 2.01 and 3.45, respectively, and 95% confidence intervals (CIs) of 1.46—2.78 and 1.59—7.50, respectively, while for chewing level, the poor group had an OR of 2.43 and 95% CI of 1.70—3.47 compared to the good group. The groups with CPI code 3 and 4 had higher ORs of 2.60 and 1.83, respectively, and 95% CIs of 1.61—4.18

Table 1 General characteristics of study participants.

Variables		No stroke (N = 9249)	Stroke (N = 248)	*P*-value	AOR (95% CI)
Age	40–59	5207 (68.1)	43 (26.4)	**<0.001***	NA
	≥60	4042 (31.9)	205 (73.6)		NA
Sex	Male	3870 (47.3)	125 (56.7)	**0.011***	NA
	Female	5379 (52.7)	123 (43.3)		NA
Education	Elementary	2783 (24.3)	138 (51.4)	**<0.001***	**3.77(1.96–7.24)****
	Middle	1325 (13.6)	48 (18.8)		**3.70(1.87–7.30)****
	High	2933 (35.1)	42 (20.3)		1.69 (0.84–3.40)
	≥ College	2208 (27.0)	20 (9.5)		1
Home income	Low	1981 (18.0)	118 (47.5)	**<0.001***	**3.26(1.84–5.76)****
	Middle-low	2408 (24.9)	59 (22.1)		1.45 (0.80–2.63)
	Middle-high	2315 (27.0)	40 (14.2)		0.95 (0.52–1.71)
	High	2545 (30.1)	31 (16.2)		1
National health insurance					
	Medical care-assistance	341 (3.6)	31 (14.5)	**<0.001***	**3.80(2.00–7.21)****
	Workplace	5192 (61.3)	127 (49.9)		0.78 (0.55–1.12)
	Region	2869 (35.1)	75 (35.6)		1
Employment status					
	Unemployed	3860 (36.8)	178 (66.9)	**<0.001***	**2.34(1.55–3.53)****
	Employed	5389 (63.2)	70 (33.1)		1
Alcohol	Experienced	7840 (87.1)	188 (79.8)	**0.001***	0.66 (0.47–0.93)
	Never	1409 (12.9)	60 (20.2)		1
Smoking	Experienced	3559 (43.2)	119 (53.5)	**0.005***	**1.69(1.10–2.59)****
	Never	5690 (56.8)	129 (46.5)		1
Diabetes	Yes	901 (9.4)	83 (33.0)	**<0.001***	**2.92(2.07–4.13)****
	No	7501 (90.6)	150 (67.0)		1
Hypertension	Yes	2422 (23.9)	158 (62.9)	**<0.001**	**3.24(2.22–4.74)****
	No	5980 (76.1)	75 (37.1)		1
BMI	Overweight	3283 (35.5)	99 (39.7)	0.232	0.71 (0.29–1.71)
	Health	5753 (62.2)	140 (56.6)		0.60 (0.25–1.43)
	Underweight	213 (2.3)	9 (3.7)		1

N: unweighted (%:weighted), NA: not applicable.
*P < 0.05 by chi-square test.
**Adjusted for sex and age.
AOR, adjusted odds ratio; CI, confidence interval.

and 1.22–2.74, respectively, as compared to the group with code 0. In the model adjusted for age and sex, the groups with average daily tooth brushing frequency of 1–2 times and 0 times showed ORs of 2.15 and 1.52, respectively, and 95% CIs of 1.01–4.58 and 1.10–2.10, respectively, while chewing level OR was 1.61 and 95% CI was 1.10–2.34. Meanwhile, the groups with CPI code 3 and 4 showed ORs of 2.25 and 1.58, respectively, and 95% CIs of 1.38–3.65 and 1.05–2.39, respectively. Finally, in the model adjusted for age, sex, education, household income, national health insurance, employment status, alcohol use, smoking, diabetes, hypertension, BMI, and oral health behaviors, the group with CPI code 4 showed an OR of 1.71 and 95% CI of 1.03–2.85.

Discussion

The findings in the present study showed a significant association between periodontitis and the prevalence of stroke among subjects who were representative of Korean adults aged ≥40 years old. In other words, the subjects with severe periodontitis (pocket depth ≥6 mm) had a significantly high OR of 2.60 and 95% CI of 1.61–4.18 for the prevalence of stroke in the crude logistic model as compared to those with healthy periodontal tissues. Moreover, even the logistic model adjusted for systemic factors (age, sex, education level, household income, drinking, smoking, diabetes, hypertension, and BMI) and oral hygiene-related factors (tooth brushing frequency and the use of auxiliary oral hygiene devices) also showed a significantly high OR of 1.71 and 95% CI of 1.03–2.90. Based on such findings, we propose that severe periodontitis can serve as a risk factor for stroke.

Stroke is an acute disease in which the normal brain function is lost due to cerebrovascular ischemia.[15] The primary cause of brain ischemia is blockage in the vascular lumen due to atherosclerotic process or thrombus, which involves the same mechanism that causes coronary artery atherosclerosis or myocardial infarction.[16,17] Recently, it

Table 2 Oral health status of study participants.

Variables	No stroke (n = 9249)	Stroke (n = 248)	P-value
Self-perceived general health			
Poor	1950 (19.5)	128 (50.3)	**<0.001***
Good	7299 (80.5)	120 (49.7)	
Self-perceived Oral health			
Poor	4278 (45.9)	133 (52.8)	0.087
Good	4971 (54.1)	115 (47.2)	
Daily tooth brushing frequency			
0	141 (1.4)	8 (3.3)	
1–2	4704 (49.6)	160 (66.2)	**<0.001***
≥3	4404 (49.0)	80 (30.5)	
Use of oral hygiene products			
0	4692 (48.9)	171 (71.3)	
1	3214 (35.9)	60 (22.3)	**<0.001***
≥2	1343 (15.2)	17 (6.4)	
Having toothache			
Yes	3627 (39.4)	109 (43.6)	0.290
No	5622 (60.6)	139 (56.4)	
Chewing level			
Poor	2676 (26.7)	116 (44.2)	
Fair	1640 (17.5)	43 (16.5)	**<0.001***
Good	4933 (55.8)	89 (39.3)	
Having untreated tooth			
Yes	2877 (31.3)	84 (33.5)	0.533
No	6372 (68.7)	164 (66.5)	
Number of residual teeth			
0–19	1629 (14.4)	89 (32.0)	**<0.001***
≥20	7620 (85.6)	159 (68.0)	
CPI			
4	1164 (12.8)	49 (22.6)	
3	2548 (27.3)	84 (34.5)	
2	2746 (30.1)	52 (18.9)	**<0.001***
1	536 (5.3)	17 (5.9)	
0	2255 (24.5)	46 (18.1)	

N: unweighted (%:weighted).
*$P < 0.05$ by chi-square test.

has been suggested that the atherosclerotic process is an immune or a metabolic response by the blood vessels to various harmful factors.[18] In other words, the increased inflammation-mediating factors, cellulohumoral immunity, and immune active substances act as harmful factors for blood vessels to facilitate the atherosclerotic process.[19] From this perspective, it was suggested that in the presence of periodontal disease, an increase in the pro-inflammatory mediators or inflammation-mediating factors, such as interleukin (IL)-1beta, tumor necrosis factor (TNF)-alpha, and C-reactive protein (CRP) due to vascular infiltration by the causative bacteria or a chronically inflamed state of the periodontal tissues can affect the atherosclerotic process.[20] In addition, other studies have reported that the increased oxidation stress and proteolytic activities in the blood vessels due to periodontal disease may result in the rupture or formation of atherosclerotic lesions.[21–23] Considering these precedent studies, it is believed that a chronically inflamed state due to periodontal disease may trigger a pro-atherogenetic response at various points, including the blood vessels in the brain, and may also be associated with the onset of stroke.[6] Therefore, based on these studies, we consider the findings in the present study to be feasible.

In the multiple logistic regression model used in the present study, variables such as age, hypertension, diabetes, smoking, drinking, and BMI were adjusted to take into account the common risk factors of periodontitis and stroke. Some diseases, such as hypertension and diabetes, are independently related to stroke incidence, which is similar to the observations in our study.[24] Those who suffered from hypertension or diabetes had more incidents of stroke than those who did not. These diseases are also reported to be related to periodontitis, which may affect the relationship between periodontitis and stroke.[25,26] To avoid this, we adjusted for both diabetes and hypertension in logistic regression analysis. Although the significant relationship between periodontitis and stroke got weaker after this adjustment, there was still a significant OR in CPI code 4 (OR, 1.71; 95% CI, 1.03–2.85).

Moreover, the present cross-sectional study could not assess the sequential order of stroke and periodontitis, and thus, variables such as the average daily tooth brushing frequency and the use of auxiliary oral hygiene devices were adjusted to supplement this shortcoming. These oral hygiene care activities are essential for oral health and to prevent tooth loss. Risk factors of stroke such as diabetes and arteriosclerosis are lifestyle-related diseases that have many individual characteristics in common with reasons for tooth loss.[27] However, after adjusting for variables related to oral hygiene care activities and remaining teeth, a significant relationship between periodontitis and stroke was observed as outlined above (OR, 1.71; 95% CI, 1.03–2.85).

To the best of our knowledge, the study by Lee et al.[12] is the only study to date to use nationally representative samples that analyzed data from US NHANES. The study by Lee et al. suggested a significant association between periodontitis and cumulative stroke history, but the study did not adjust for factors related to oral hygiene behavior. Patients with a history of stroke may face difficulties in brushing their teeth due to physical impairment, and thus, adjustment for daily tooth brushing frequency and the use of auxiliary oral hygiene devices would be required. The present study was the first to assess the association between periodontitis and stroke history in a nationally representative sample of Korea after adjusting for various potential confounders.

However, the present study had the following limitations. First of all, stroke history was assessed based on the responses given to the questions in the KNHANES questionnaire. In KNHANES, the stroke history was surveyed by personal interviews conducted by a trained surveyor to prevent survey errors. Secondly, KNHANES is a cross-sectional survey, and thus, the sequential order between

Table 3 Logistic regression analysis for association between periodontal health and stroke.

Variables	I	II	III
	OR (95% CI)	AOR (95% CI)	AOR (95% CI)
Daily tooth brushing frequency			
0	**3.45(1.59−7.50)***	**2.15(1.01−4.58)***	
1−2	**2.01(1.46−2.78)***	**1.52(1.10−2.10)***	NA
≥3	1	1	
Use of oral hygiene products			
0	**3.47(1.67−6.11)***	**2.23(1.24−3.99)***	
1	1.47 (0.80−2.68)	1.25 (0.68−2.27)	NA
≥2	1	1	
Self-perceived oral health			
Poor	1.33 (0.95−1.85)	1.19 (0.85−1.67)	0.99 (0.69−1.42)
Good	1	1	1
Having toothache			
Yes	127 (0.91−1.78)	1.25 (0.86−1.75)	1.13 (0.81−1.58)
No	1	1	1
Chewing level			
Poor	**2.43(1.70−3.47)***	**1.61(1.10−2.34)***	1.11 (0.74−1.66)
Fair	1.37 (0.86−2.18)	1.16 (0.72−1.86)	1.02 (0.62−1.67)
Good	1	1	1
Having untreated tooth			
Yes	1.20 (0.86−1.65)	1.31 (0.94−1.82)	1.14 (0.81−1.62)
No	1	1	
Number of residual teeth			
0−19	2.75 (1.98−3.82)	1.33 (0.92−1.92)	0.96 (0.64−1.43)
≥20	1	1	1
CPI			
4	**2.60(1.61−4.18)***	**2.25(1.38−3.65)***	**1.71(1.03−2.85)***
3	**1.83(1.22−2.74)***	**1.58(1.05−2.39)***	1.24 (0.82−1.87)
2	1.17 (0.73−1.88)	1.37 (0.86−2.19)	1.23 (0.75−2.00)
1	1.41 (0.75−2.64)	1.25 (0.67−2.32)	1.03 (0.54−1.96)
0	1	1	1

*$P < 0.05$.
OR, crude odds ratio; CI, confidence interval.
I: Crude model.
II: Age, sex, adjusted model.
III: Age, sex, education, household income, national health insurance, employment status, alcohol use, smoking, diabetes, hypertension, BMI, tooth brushing, and oral hygiene products adjusted model.

stroke and its risk factors is unknown. Thirdly, the stroke history did not distinguish between ischemic and hemorrhagic stroke. Because these 2 types of stroke have different pathogenesis, it is desirable to distinguish 1 from the other. Finally, the present study was a cross-sectional study, and thus the causal relationship between periodontitis and stroke could not be determined.

Nevertheless, the significance of the present study can be found in the fact that it presented a significant association between periodontitis and stroke using nationally representative data from 9497 Korean adults ≥40 years of age.

Conclusively, the findings in the present study indicated a significant association between periodontitis and stroke. Even after adjusting for various potential confounders, including oral hygiene behavior variables, people with severe periodontitis (periodontal pocket depth ≥6 mm) had a significantly higher risk of stroke than those with healthy periodontal tissues (OR, 1.71; 95% CI, 1.03−2.85). Therefore, it is hoped that dentists will continue to emphasize the importance of oral health, encourage patients to actively participate in oral health education activities, and stress to their patients the connection between good oral health and the prevention of stroke.

Author contributions

Indicate authors' role in study concept and design, acquisition of subjects and/or data, analysis and interpretation of data, and preparation of manuscript.
Study concept and design: Min-Jeong Cho, Eun-Kyong, Kim.
Acquisition of subjects and/or data: Young-Seok, Kim, Eun Young Park.
Analysis and interpretation of data: Young-Seok, Kim.
Preparation of manuscript: Min-Jeong Cho, Eun-Kyong, Kim.

Sponsor's role

None.

Declaration of Competing Interest

The authors have no conflicts of interest relevant to this article.

Acknowledgments

The authors declare that there are no potential conflicts of interest with respect to the authorship and/or publication of this article.

References

1. National Collaborating Centre for Chronic C. *National institute for health and clinical excellence: guidance. Stroke: national clinical guideline for diagnosis and initial management of acute stroke and transient ischaemic attack (TIA)*. London: Royal College of Physicians of London, 2008.
2. Feigin VL, Lawes CM, Bennett DA, Anderson CS. Stroke epidemiology: a review of population-based studies of incidence, prevalence, and case-fatality in the late 20th century. *Lancet Neurol* 2003;2:43—53.
3. Hong KS, Bang OY, Kang DW, et al. Stroke statistics in Korea: part I. Epidemiology and risk factors: a report from the Korean stroke society and clinical research center for stroke. *J Stroke* 2013;15:2—20.
4. Jung KH, Lee SH, Kim BJ, et al. Secular trends in ischemic stroke characteristics in a rapidly developed country: results from the Korean Stroke Registry Study (secular trends in Korean stroke). *Circ Cardiovasc Qual Outcomes* 2012;5:327—34.
5. Reichert S, Schulz S, Benten AC, et al. Periodontal conditions and incidence of new cardiovascular events among patients with coronary vascular disease. *J Clin Periodontol* 2016;43:918—25.
6. Kim J, Amar S. Periodontal disease and systemic conditions: a bidirectional relationship. *Odontology* 2006;94:10—21.
7. Bartova J, Sommerova P, Lyuya-Mi Y, et al. Periodontitis as a risk factor of atherosclerosis. *J Immunol Res* 2014;9.
8. Kamel H, Iadecola C. Brain-immune interactions and ischemic stroke: clinical implications. *Arch Neurol* 2012;69:576—81.
9. Choe H, Kim YH, Park JW, Kim SY, Lee SY, Jee SH. Tooth loss, hypertension and risk for stroke in a Korean population. *Atherosclerosis* 2009;203:550—6.
10. Sim SJ, Kim HD, Moon JY, et al. Periodontitis and the risk for non-fatal stroke in Korean adults. *J Periodontol* 2008;79:1652—8.
11. Pradeep AR, Hadge P, Arjun Raju P, Shetty SR, Shareef K, Guruprasad CN. Periodontitis as a risk factor for cerebrovascular accident: a case-control study in the Indian population. *J Periodontal Res* 2010;45:223—8.
12. Lee HJ, Garcia RI, Janket SJ, et al. The association between cumulative periodontal disease and stroke history in older adults. *J Periodontol* 2006;77:1744—54.
13. Ainamo J, Barmes D, Beagrie G, Cutress T, Maartin J, Sardo-Infirri J. Development of the World Health Organization (WHO) community periodontal index of treatment needs (CPITN). *Int Dent J* 1982;32:281—91.
14. Ueno M, Yanagisawa T, Shinad K, Ohara S, Kawaguchi Y. Masticatory ability and functional tooth units in Japanese adults. *J Oral Rehabil* 2008;35:337—44.
15. Walker HK, Hall WD, Hurst JW. *Clinical methods: the history, physical, and laboratory examinations*. Boston: Butterworths, 1990.
16. Gao T, Zhang Z, Yu W, Zhang Z, Wang Y. Atherosclerotic carotid vulnerable plaque and subsequent stroke: a high-resolution MRI study. *Cerebrovasc Dis* 2009;27:345—52.
17. Wasserman BA, Wityk RJ, Trout 3rd HH, Virmani R. Low-grade carotid stenosis: looking beyond the lumen with MRI. *Stroke* 2005;36:2504—13.
18. Rafieian-Kopaei M, Setorki M, Doudi M, Baradaran A, Nasri H. Atherosclerosis: process, indicators, risk factors and new hopes. *Int J Prev Med* 2014;5:927—46.
19. Harangi M, Szodoray P, Paragh G. *Atherosclerosis: a complex interplay of inflammatory processes*. 2009.
20. Paraskevas S, Huizinga JD, Loos BG. A systematic review and meta-analyses on c- creactive protein in relation to periodontitis. *J Clin Periodontol* 2008;35:277—90.
21. Batista AC, Silva TA, Chun JH, Lara VS. Nitric oxide synthesis and severity of human periodontal disease. *Oral Dis* 2002;8:254—60.
22. Berdeli A, Gurkan A, Emingil G, Atilla G, Kose T. Endothelial nitric oxide synthase Glu298Asp gene polymorphism in periodontal diseases. *J Periodontol* 2006;77:1348—54.
23. Soder PO, Meurman JH, Jogestrand T, Nowak J, Soder B. Matrix metalloproteinase-9 and tissue inhibitor of matrix metalloproteinase-1 in blood as markers for early atherosclerosis in subjects with chronic periodontitis. *J Periodontal Res* 2009;44:452—8.
24. Hu G, Sarti C, Jousilahti P, et al. The impact of history of hypertension and type 2 diabetes at baseline on the incidence of stroke and stroke mortality. *Stroke* 2005;36:2538—43.
25. Martin-Cabezas R, Seelam N, Petit C, et al. Association between periodontitis and arterial hypertension: a systematic review and meta-analysis. *Am Heart J* 2016;180:98—112.
26. Taylor JJ, Preshaw PM, Lalla E. A review of the evidence for pathogenic mechanisms that may link periodontitis and diabetes. *J Clin Periodontol* 2013;40:S113—34.
27. Yoshida M, Akagawa Y. The relationship between tooth loss and cerebral stroke. *Jpn Dent Sci Rev* 2011;47:157—60.