The Relationship between Oral Health and Stroke in Adults Based on the 6th (2015) Korea National Health and Nutrition Examination Survey

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Stroke is the second cause of death worldwide, although the survival period is increasing after the occurrence of stroke, severe physical disability is caused with aftereffect. Oral inflammation is not limited to the oral cavity, it can cause malignant changes in other tissues and organs. In previous studies, we confirmed the relationship between tooth loss and stroke due to periodontal inflammation. The purpose of this study was to investigate the relationship between oral health and stroke such as oral hygiene behavior, tooth loss and periodontal disease among Korean adults over 40 years of age. This study was analyzed using the 6th Korea National Health and Nutrition Examination Survey (KNHANES) data. A total of 3,389 adults over 40 years of age were analyzed as final subjects. Socioeconomic statuses and oral health status was analyzed using a complex sample analysis technique. Logistic regression was used to analyze the relationship of oral health and stroke, and 95% confidence intervals were computed using SPSS. When the prevalence of stroke according to oral hygiene behavior was checked, the prevalence of strokes was lower in subjects who had a lot of brushings per day and subjects who used oral hygiene products (p<0.05). The risk of stroke was 2.17 times (95% confidence interval, 1.43~3.28) higher in the group with less than 19 remaining teeth, but it was not statistically significant as a result of adjusting for age and sex, income level, education level, drinking and smoking (p>0.05). Loss of teeth was found to be associated with the risk factor of stroke. Therefore, loss of teeth due to periodontal disease is an additional issue that should be considered as a risk factor for stroke.

Key Words: Adult, Korea National Health and Nutrition Examination Survey, Oral health, Stroke

Introduction

Stroke refers to a disease that can cause temporary or permanent neurological impairment due to localized brain tissue damage caused by a pathological abnormality in the cerebral blood flow[1]. In 2015, the World Health Organization reported that stroke was the second most common cause of death and third most common cause of disability worldwide[2]. According to a 2015 survey by Statistics Korea, stroke was the third most common cause of death in Korea, accounting for 8.9% of cases[3]. Medical advances have prolonged the survival period following a stroke event, but have also increased the incidence of sequelae such as serious physical disabilities[4,5]. Moreover, stroke causes increased medical costs due to long-term hospitalization, home treatments, or maintenance therapy; as such, its socioeconomic significance has increased in anticipation of an increased prevalence within an increasingly aging population[6].

Various genetic and environmental risk factors for stroke have been identified, including age, gender, hypertension, and hyperlipidemia[7]. However, there remain other risk factors that have yet to be identified[8,9]. The recovery of brain tissues damaged by stroke is not

possible; thus, primary prevention is important, which makes the identification of the risk factors for stroke important[10]. For stroke prevention, it is essential to understand potential and uncommon etiologies[11].

Previous studies have examined the association between oral health and general health[12-14]. According to these studies, oral and general health share common risk factors. Furthermore, oral inflammation is not necessarily localized in the oral cavity and may cause malignant changes to other tissues or organs[15]. Periodontal microorganisms that originate from the oral cavity during chewing or other functions may lead to bacteremia in the systemic vasculature and the vascular endothelium of major arteries, with the extent of bacteremia proportional to the severity of periodontal diseases[16-18].

Moreover, previous studies also confirmed that periodontitis and tooth loss due to periodontitis were associated with stroke and other studies have examined the association between dental caries and oral hygiene environment and the relative risk for stroke[19,20]. Although various studies have examined the association between oral health and stroke, they have failed to produce consistent results. With recent changes in lifestyle and dietary habits in Korea, there has been an increasing trend in the prevalence of stroke among those 40～59 years of age[3]; thus, the present study used data from the third year (2015) of the 6th Korea National Health and Nutrition Examination Survey (KNHANES VI) to investigate the association between stroke and oral health in order to examine the relationship between oral health factors such as oral hygiene behavior, tooth loss, and periodontal disease and stroke and what relative risks they pose in Korean adults aged 40 years and older.

Materials and Methods

1. Subjects

The present study analyzed data from the third year (2015) of KNHANES VI. For data analysis, raw KNHANES data were obtained in accordance with the raw data request procedures. Among a total of 4,372 adults aged 40 years and older, 983 were excluded due to missing values and a lack of proper oral examinations. As a result, a total of 3,389 people were included as the subjects in the final analysis. The present study was approved by the Institutional Review Board at Kyungpook National University (IRB no. 2017-0116).

2. Methods

1) General characteristics

Age, gender, education level, and income level were included as socioeconomic factors. Based on the mean age, the subjects were divided into two age groups: middle age (40～59 years) and old age (≥60 years). Education level was divided into three groups: below middle school graduate, below high school graduate, and college graduate or above. Income level was divided into quartiles based on monthly equalized household income (monthly household income/$\sqrt{\text{number of house hold members}}$): low, middle-low, middle-high, and high. In addition, the drinking and smoking experiences of the subjects were assessed in order to examine the overall general health status of the subjects.

2) Stroke survey

The prevalence of stroke was surveyed using a self-reporting questionnaire. The prevalence was determined based on diagnosis by a physician, with the response given as "yes" or "no."

3) Oral health status survey

Periodontal disease was determined by visual inspection and palpation by a dentist using the community periodontal index (CPI), in accordance with the oral health status survey method in the KNHANES. Among subjects aged 19 years and older, those with pocket depth ≥4 mm on periodontal probing of the maxillary and mandibular left and right first and second molars, maxillary right central incisor, and mandibular left central incisor were classified as having a periodontal disease. For gingivitis, periodontal tissues were assessed and assigned 0, 1, 2, 3, and 4 points for healthy, hemorrhagic, plaque forming, shallow periodontal pocket forming, and deep periodontal pocket forming periodontal tissue, respectively, and 8 points for others. The maximum value from six oral

segments was used as the representative value and the subjects were divided into two groups based on their scores: 0~2 points as normal and 3~4 points as periodontitis. Based on survey data on the number of remaining teeth (NRT), cases marked as "4: missing tooth surface due to caries," "5: missing tooth surface due to reasons other than caries," and "8: unerupted tooth surface" were considered missing teeth and assigned a score of "0", whereas all other teeth were assigned a score of "1" to tally the score of a total of 32 teeth. The subjects were divided into NRT groups of ≤19 and ≥20 and surveyed accordingly.

3. Analysis method

A complex sampling design analysis was used to ensure that the results produced by the samples were representative. When the planning file was constructed, the following planning variables were considered: Korean stratification variables; survey groups for cluster variables; and combined weights of examination and questionnaire for the weight. A complex samples crosstabs procedure was used to analyze the association between stroke and the general characteristics, oral hygiene behavior, periodontal disease, and NRT of the subjects. Moreover, the association between oral health indicators and stroke was analyzed using a complex samples logistic regression procedure to determine the risk. The collected data were analyzed using IBM SPSS Statistics for Windows (ver. 23.0; IBM Co., Armonk, NY, USA) with a significance level of 5% for the determination of statistical significance.

Results

1. General subject characteristics

Among 3,389 adults aged ≥40 years, 1,466 (47.8%) were males and 1,923 (52.2%) were females, with a mean age of 59.57±11.52 years (range, 40~80 years). There were 1,742 (63.8%) and 1,647 (36.2%) patients in the 40- to 59-year and ≥60-year age groups. With respect to education level, 1,574 (39.6%) were below middle school graduates; 1,017 (33.2%) were below high school graduates, and 798 (27.2%) were college graduates or above. A total of 2,835 subjects (85.9%) had drinking

experience, while 1,336 subjects (43.7%) had smoking experience. There were 2,677 (82.8%) subjects with ≥20 teeth, 1,360 (39.7%) had periodontitis based on CPI results, and 120 (3.0%) subjects were diagnosed with a

Table 1. Sociodemographic Characteristics (n=3,389)

Variable	n (%)
Age (y)	
40~59	1,742 (63.8)
≥60	1,647 (36.2)
Gender	
Male	1,466 (47.8)
Female	1,923 (52.2)
Income	
Low	824 (25.1)
Middle-low	834 (24.2)
Middle-high	868 (25.3)
High	863 (25.4)
Education	
≤Middle school	1,574 (39.6)
High school	1,017 (33.2)
≥College	798 (27.2)
Alcohol	
No	554 (14.1)
Yes	2,835 (85.9)
Smoking	
No	2,053 (56.3)
Yes	1,336 (43.7)
Residual tooth (n)	
≥20	2,677 (82.8)
0~19	712 (17.2)
Community periodontal index	
Healthy	2,029 (60.3)
Periodontitis	1,360 (39.7)
Stroke	
No	3,269 (97.0)
Yes	120 (3.0)
Self-perceived oral health status	
Good	1,742 (51.9)
Not good	1,647 (48.1)
Oral examination/1 year	
Yes	1,057 (33.0)
No	2,332 (67.0)
Tooth brushing (time/d)	
≥3	1,581 (49.0)
1~2	1,683 (47.9)
0	125 (3.1)
Use of oral hygiene products (n)	
≥2	490 (15.5)
1	1,163 (35.8)
0	1,736 (48.7)

stroke. A total of 1,742 (51.9%) subjects reported "good" self-perceived oral health status and 1,057 (33.0%) of subjects had received an oral examination in the past year. Moreover, 1,581 subjects (49.0%) indicated that they brushed their teeth at least three times a day, while 490 (15.5%) reported using at least two auxiliary oral care products (Table 1).

2. Oral health status according to general characteristics

Table 2 shows the oral health status based on general conditions. The number of subjects with NRT ≤19 was statistically significant among those ≥60 years and with lower income and education levels (p<0.05). Moreover, investigation of periodontal status based on CPI showed that a significantly higher number of subjects in the ≥60-year age group had periodontitis (p=0.004). With respect to gender, a higher percentage of male subjects had periodontitis and the morbidity of periodontitis was significantly higher for lower income and education levels

(p<0.05). Although drinking status did not show significant differences, a significantly higher percentage of subjects who were smokers had periodontitis (p=0.001).

3. Prevalence of stroke based on oral hygiene behavior

Among the subjects with "good" self-perceived oral health status, 51 (2.6%) were stroke patients. With respect to a dentist visit within the past year and the prevalence of stroke, 19 (1.5%) stroke patients had visited a dentist within the past year, while 101 patients (3.7%) had not; however, the difference was not statistically significant. The prevalence of stroke was lower in those who brushed their teeth more often and used auxiliary oral care products, whereas the prevalence was higher in those with NRT ≤19. Moreover, 62 (3.8%) and 58 (2.4%) stroke patients did and did not have periodontitis, respectively, a statistically significant difference (p<0.05; Table 3).

Table 2. Characteristics of Subjects according to Oral Health Status

Variable	Residual teeth			Community periodontal index		
	0~19	≥20	p-value	Healthy	Periodontitis	p-value
Age (y)						
40~59	90 (5.9)	1,652 (94.1)	<0.001*	1,089 (62.5)	653 (37.5)	0.004*
≥60	622 (37.2)	1,025 (62.8)		940 (56.6)	707 (43.4)	
Gender						
Male	326 (17.3)	1,140 (82.7)	0.877	776 (54.0)	690 (46.0)	<0.001*
Female	386 (17.1)	1,537 (82.9)		1,253 (66.1)	670 (33.9)	
Income						
Low	203 (20.9)	621 (79.1)		454 (54.8)	370 (45.2)	
Middle-low	198 (19.2)	636 (80.8)	0.002*	470 (56.7)	364 (43.3)	0.001*
Middle-high	168 (15.5)	700 (84.5)		545 (64.6)	323 (35.4)	
High	143 (13.4)	720 (86.6)		560 (64.9)	303 (35.1)	
Education						
≤Middle	536 (31.6)	1,038 (68.4)		881 (55.5)	693 (44.5)	
High	126 (9.7)	891 (90.3)	<0.001*	605 (59.1)	412 (40.9)	<0.001*
≥College	50 (5.3)	748 (94.7)		543 (68.9)	255 (31.1)	
Alcohol						
No	207 (35.2)	347 (64.8)	<0.001*	322 (57.5)	232 (42.5)	0.196
Yes	505 (14.2)	2,330 (85.8)		1,707 (60.8)	1,128 (39.2)	
Smoking						
No	401 (16.4)	1,652 (83.6)	0.239	1,328 (65.9)	725 (34.1)	<0.001*
Yes	311 (18.2)	1,025 (81.8)		701 (53.1)	635 (46.9)	

Values are presented as n (%).
Statistical analysis by chi-square test.
*p<0.05.

Table 3. Oral Health of the Study Subjects according to Stroke

Variable	Stroke		p-value
	Healthy	Stroke	
Self-perceived oral health status			
Good	1,691 (97.4)	51 (2.6)	0.316
Not good	1.578 (96.6)	69 (3.4)	
Oral examination/1 year			
Yes	1,038 (98.5)	19 (1.5)	0.005*
No	2,231 (96.3)	101 (3.7)	
Tooth brushing (time/d)			
≥3	1,543 (97.9)	38 (2.1)	
1~2	1,608 (96.3)	75 (3.7)	0.036*
0	118 (95.0)	7 (5.0)	
Use of oral hygiene products (n)			
≥2	486 (99.0)	4 (1.0)	
1	1,133 (98.0)	30 (2.0)	0.004*
0	1,650 (95.8)	86 (4.2)	
Residual teeth (n)			
≥20	2,602 (97.5)	75 (2.5)	<0.001*
0~19	667 (94.8)	45 (5.2)	
Community periodontal index			
Healthy	1,971 (97.6)	58 (2.4)	0.038*
Periodontitis	1,298 (97.6)	62 (3.8)	

Values are presented as n (%).
*p<0.05.

4. Association between stroke and oral health behaviors

Table 4 shows the results of logistic regression analysis of the association between stroke and oral health behaviors of the subjects. In the first model (unadjusted), statistically significant differences were found in dentist visit within the past year, number of tooth brushings per day, use of auxiliary oral care products, NRT, and periodontitis (p<0.05). In Model 2 (adjusted for age and gender), a significant association was observed for a visit to a dentist within the past year (p<0.05) but the difference was not significant after adjusting for age, gender, income level, education level, drinking, and smoking (p>0.05).

Discussion

Oral health is an essential element of general health. Numerous studies have investigated the association between oral health and general health[21]. Among various general diseases, the present study investigated the

Table 4. Logistic Regression Analysis for Association between Oral Health Status and Stroke

Variable	I	II	III
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Self-perceived oral health status			
Good	Reference	Reference	Reference
Not good	1.314 (0.768~2.248)	1.143 (0.654~1.996)	1.022 (0.592~1.765)
Oral examination/1 year			
Yes	Reference	Reference	Reference
No	2.461 (1.290~4.693)*	1.995 (1.064~3.740)*	1.579 (0.829~3.009)
Tooth brushing (time/d)			
≥3	Reference	Reference	Reference
1~2	1.828 (1.064~3.142)*	1.262 (0.749~2.124)	0.995 (0.588~1.682)
0	2.501 (0.847~7.390)	1.195 (0.416~3.439)	0.918 (0.287~2.939)
Use of oral hygiene products (n)			
≥2	Reference	Reference	Reference
1	1.969 (0.522~7.423)	1.591 (0.424~5.972)	1.360 (0.349~5.304)
0	4.180 (1.170~14.938)*	2.528 (0.703~9.092)	1.822 (0.473~7.023)
Residual teeth (n)			
≥20	Reference	Reference	Reference
0~19	2.166 (1.430~3.281)*	0.976 (0.642~1.484)	0.803 (0.505~1.277)
Community periodontal index			
Healthy	Reference	Reference	Reference
Periodontitis	1.594 (1.023~2.483)*	0.393 (0.882~2.199)	1.353 (0.827~2.098)

I: unadjusted model, II: age, gender adjusted model, III: age, gender, Income, education, alcohol, smoking adjusted model, OR: odds ratio, CI: confidence interval.
*p<0.05.

association between stroke and oral health using health-related indicators in Korean adults based on data from the KNHANES. Investigation of the prevalence of stroke based on the oral hygiene behavior of the subjects showed that prevalence was lower in those who brushed their teeth more often, used auxiliary oral care products, and had received a dental examination within the past year. Kim et al.[22] reported periodontal diseases to be associated with the occurrence and recurrence of cardiovascular diseases, as well as diabetes and stroke, while poor oral hygiene and exacerbation of periodontal disease had various negative effects on stroke patients. Moreover, the study also reported that stroke patients have a tendency to neglect their oral hygiene care, which leads to a relatively poor oral hygiene status. Syrjanen et al.[23] compared patients with cerebral vascular disease and healthy controls, finding that patients with cerebral vascular disease under 50 years of age had poor oral health, was similar to the findings in the present study. However, it is difficult to make a general comparison between the present study and those by Kim et al.[22] and Syrjanen et al.[23] since the present study had a different method for comparing the associations between oral health and stroke. Among studies on the association between periodontal diseases and stroke, Abnet et al.[24] reported that patients with periodontitis had a 1.11-fold increased risk of stroke than that of patients with healthy periodontal tissue. Wu et al.[25] reported that patients with gingivitis had a statistically significantly higher risk of stroke (2.11-fold higher) than people with healthy periodontal tissue and that the risk of stroke in patients with periodontitis was not statistically significant. The present study used CPI and observed a 1.59-fold increased risk of stroke in patients with periodontitis compared to that in those with healthy periodontal tissue; however, the difference was not statistically significant after adjusting for age, gender, household income, education level, drinking, and smoking. Beck et al.[26] reported that the risk of stroke was 2.8-fold higher in subjects with periodontal disease or tooth loss due to periodontal disease, while a meta-analysis by Lafon et al.[27] showed that the risk of stroke increased significantly according to periodontitis and tooth loss (periodontal disease, 1.63; tooth loss, 1.39).

In a study by You et al.[28], people with ≥17 missing teeth had a risk of chronic stroke that was 1.28 folds higher than that in those with no tooth loss, while those with ≤16 missing teeth did not show an increased risk of stroke. In this study, investigation of the association between NRT and stroke showed that the NRT ≤19 group had a relatively higher prevalence of stroke than that in the group with NRT ≥20, while regression analysis results also showed 2.17-fold higher risk. However, after adjusting for age and gender, there was no significant association between NRT and stroke; therefore, more thorough analysis is needed to reconfirm any association. Besides the associations between stroke and periodontal disease or missing teeth, Towfighi and Saver[4] and Nakano et al.[29] reported *Streptococcus mutans* infection to be a potential risk factor of hemorrhagic stroke and that proper measures based on a clear understanding of this association can reduce the mortality rate and morbidity of primary or recurrent stroke. As shown, various studies have reported the association between oral health and stroke and have identified significant correlations. However, these studies do not always show consistent results. The significance of the present study may be found in the fact that it analyzed KNHANES data, which are highly representative of health levels of Koreans, in confirming the association between oral health and stroke. The limitations in the present study included the following: Firstly, because the number of subjects diagnosed with stroke was smaller than those who were not, it is difficult to generalize the results. Secondly, since the prevalence of stroke was confirmed based on a self-reporting questionnaire, it was difficult to accurately determine the presence of disease. Thirdly, because the subjects were divided into two groups with a cut-off age of 60 years, it is difficult to generalize the comparison between age groups. Lastly, the KNHANES data are cross-sectional, which makes it difficult to surmise the causal relationships. Therefore, additional studies and in-depth analyses are needed to accurately identify the correlation between stroke and oral health. In the future, a combination of various analyses and clinical trials, as well as additional surveys, are necessary.

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