치의학석사학위논문

Association between sour food and dental caries among Korean elders

한국 노인에서 신음식과 치아우식증의 연관성

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서울대학교 대학원
치의과학과 예방치학전공

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-ABSTRACT-

Association between sour food and dental caries among Korean elders

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Aim:

Recently some reports suggested that acidic oral condition could draw bacterial death. However, the relationship between dietary acid and dental caries is not well established. Hence, this study aims to assess the relationship between sour food and dental caries in an elderly Korean population.

Methods:

A cross-sectional study was conducted using participants from Sunchang Longevity Cohort Study. The total number of final participants was 508 (175 males and 333 females; 49 to 93 years old). Dental caries was determined by WHO criteria. Preference to sour food was assessed by interview using a questionnaire. Age, sex, income level, tooth brushing, dry mouth, obesity, sugary food, salty food, dairy food and spicy food were considered as confounders. Multivariable logistic

regression analysis was applied to estimate the adjusted association. Stratified analysis by age, sex, income level, sugary food, obesity was also performed.

Results:

After adjusting for various confounders, the experience of low dental caries was highly associated with sour food (adjusted odds ratio [OR]=0.565, 95% confidence interval [CI]:0.380-0.840). The link was highlighted in elders aged 71 years or older (OR=0.425, 95% CI: 0.242-0.745), males (OR=0.252, 95% CI: 0.113-0.564), those without sweet preference (OR=0.427, 95% CI: 0.231-0.788) and non-denture wearers (OR=0.439, 95% CI: 0.230-0.837).

Conclusions:

Our data showed that the preference to sour food was independently associated with low dental caries experience among Korean elders. The link was highlighted in elders aged 71 years or older, males, non-denture wearers and those without sweet preference. Further studies are needed to clarify the causality and mechanisms of this link.

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Contents

I. INTRODUCTION

Dental caries occurs because of demineralization of enamel and dentin by organic acids formed by bacteria in dental plaque through the anaerobic metabolism of dietary sugars [1]. And caries process is multifactorial [2-4], influenced by multiple factors such as age, sex [5], bacterial flora, oral hygiene[6], saliva, fluoride and dietary behaviors. as well as genetic factors [7].

Among these, dietary behaviors are strongly associated with caries process [8]. A wealth of evidence from many different types of investigation, including human studies, animal experiments and experimental studies has consistently shown that sugars are the most important factor in caries development [9].

Organic acids in plaque are essential for caries development, but extrinsic acids might play different roles in caries development. Acid has been used as a food preservative for millennia, through limiting the growth of bacteria in the food product [10]. The acidic environments encountered in food and in the gastrointestinal tract provide a significant survival challenge for gram-positive bacteria [10]. And acid stress also can induce autolysis of bacteria by modulating gene expressions [11].

Additionally, acids cause erosive demineralization of the tooth crown. It begins with softening of the enamel surface and followed by continuous layer-by-layer dissolution of the enamel crystals [12]. The erosive enamel is vulnerable to abrasive forces such as tooth brushing even hours after softening [12]. These characteristic of acids could prevent plaque accumulation or maturation on tooth surfaces because dental plaque requires stagnant place and enough time to exert cariogenic effect [13].

However, the relationship between acidic foods and dental caries is still controversial in epidemiologic studies. Although many studies have shown that soft drinks were associated with high experience of caries [14-16], some studies indicated that acidic drinks have no significant relationship with caries experience

[17, 18].

Thus we hypothesized that acidic food is associated with low dental caries experience. This study aimed to evaluate the association between the preference to sour food and dental caries experience after controlling for confounders including age, sex, income level, tooth brushing, dry mouth, obesity, preferences of sugary food, salty food, dairy food and spicy food among Korean elders. And we also conducted subgroup analysis on this link.

II. MATERIALS AND METHODS

Ethical consideration

This study was approved by the institutional Review Board for Human Subjects at the Seoul National University School of Dentistry (approval no. SD20090003). All participants provided written informed consent.

Study design and ethical consideration

We conducted a cross-sectional study using the Sunchang longevity cohort study in 2009 and 2010 to test the hypothesis that acidic foods are associated with low dental caries experience.

The Sunchang longevity cohort study has been conducted in Sunchang county, a rural area in which the elderly reportedly have the longest life expectancy in Korea. The study is an ongoing population-based prospective cohort study that began in 2009 [19].

A total of 613 residents (aged from 48 to 93 years; mean age: 68.4±7.5years) were enrolled in this study. Each participant completed the health assessment, oral examination and questionnaires. Participants who have any missing data were

excluded. A total of 508 participants were selected in our analysis. Participants with low dental caries was 299 and high dental caries 209 (Table1).

Assessment of dental caries and denture wearing status

Dental caries was assessed by two trained dentists with artificial light and mirror on a portable chair. The decay, missing, and filled teeth (DMFT) index was obtained in the collection form based on the index recommended by the World Health Organization [20]. Denture wearing status included complete denture and/or removable partial denture wearers.

Assessment of sour food and confounders

The main explanatory variable, preference to sour food was obtained by interviews using a questionnaire by trained interviewers. Confounding factors including age, sex, income level, tooth brushing frequency, dry mouth, preferences to sugary food, salty food, dairy food and spicy food were also obtained using a questionnaire. The questionnaire about dietary information was "How do you like sour/sugary/dairy/salty/spicy food? (dislike/neutral/like)". The questionnaire about Income level was "what grade do you think of your house income for the last ten years? (high/high medium/low medium/low)". Obesity was defined by body mass index (BMI $\geq$ 25kg/m2).

Statistical Analyses

For evaluating the characteristics of participants according to the dental caries experience, dental caries experience was dichotomized by the mean value (10.08) of DMFT index (Low $\leq$ 10, high $\geq$ 11). Since age and daily tooth brushing frequency are not normally distributed (Kolmogorov-Smirnov test, P<0.05), both

variables were assessed by Mann-Whitney test. Sex, income level, dry mouth, denture wearing status, obesity, preferences to sugary food, salty food, dairy food, and spicy food were assessed by chi-square test. We dichotomized income level into two groups by combining high and high medium into high, low medium and low into low. We also dichotomized diet variables into two by combining neutral groups with the smaller group of the dislike and like groups.

Association between sour food and dental caries experience was assessed by multiple multivariable logistic regression analysis: model I was a crude analysis; model II was an adjusted analysis for age, gender, and income level; model III was an adjusted analysis for tooth brushing frequency, dry mouth, obesity, and all variables in Model II; model IV was and adjusted analysis for preferences to sugary food, salty food, dairy food, and spicy food and all variables in Model III.

Stratified analysis was applied according to the subgroups including age, sex, income level, obesity, preference to sugary food, and denture status. Age for stratified analysis was dichotomized according to the mean value (70.32) for the analysis (49-70 years and 71-93 years).

III. RESULTS

The participants with high dental caries were older and composed of more females than those with low dental caries (Table 1). Those with high income and dry mouth showed higher dental caries experience. Denture wearers had higher dental caries experience than non-denture wearers and those with sugary food preference had higher dental caries experience than those without sugary food preference. Tooth brushing frequency, obesity, dairy food, salty food and spicy food were not different between low and high dental caries groups.

In the logistic regression analysis, sour food preference was associated with low dental caries experience (Table 2). The odds ratios (OR) (95% confidence intervals

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[CI]) were 0.561 (0.387-0.812) for crude analysis (model I), 0.559 (0.379-0.825) after controlling for age, gender, and income level (model II), 0.571 (0.386-0.844) after controlling for tooth brushing frequency, dry mouth, obesity, and all variables in model II (model III); and 0.565 (0.380-0.840) after controlling for preferences to sugary food, salty food, dairy food, and spicy food and all variables in Model III (model IV).

In the stratified analyses, the link between sour food and low dental caries was highlighted in the elders aged from 71 to 93 years (OR=0.425, 95% CI: 0.242-0.745), males (OR=0.252, 95% CI: 0.113-0.564), denture non-wearers (OR=0.439, 95% CI: 0.230-0.837) and those who dislike sugary food (OR=0.427, 95% CI: 0.231-0.788) (Table 3). Those with high income level showed almost same association (OR = 0.529, 95% CI: 0.295-0.949) as those with low income level (OR = 0.566, 95% CI: 0.323-0.992). Those with obesity showed stronger association (OR = 0.328, 95% CI: 0.136-0.791) compared to those without obesity (OR = 0.619, 95% CI: 0.389-0.985). In the stratified analysis, the preventive fraction was highest in males and lowest in those without obesity.

IV. DISCUSSION

The relationship between acidic foods and dental caries is still controversial. Acidic diets include sour foods, soft drinks, fruits and their juices, and so on. However, most previous studies were focused on soft drinks and/or fruits. Moreover the participants were almost children. In the 1970s, the National Health and Nutrition Examination Survey (NHANES) of America found a strong association (OR=1.25) between caries experience and soft drink consumption in 0 to 7-year-olds [14]. Another American data showed that higher intakes of soda pop increased the risk of both caries presence and severity in 5-year-old children [16]. However, it is argued that many acidic soft drinks contain sugars, thus the association between

dental caries and soft drinks could be due to the effect of added sugars [21]. Some other studies found no association between acidic drinks and dental caries. A British study conducted with 1.5 to 4.5-year-old children found that there was no association between the consumption of soft drinks and dental caries [22]. A longitudinal study in the Iowa Fluoride Study also reported no association between soda pop and dental caries in 3 to 13-year-old children [18]. A Libyan study conducted with 12-year-old schoolchildren showed that fruit based sugared drinks was associated with caries experience while other acidic drinks such as squashes, natural unsweetened fruit juices, were not associated with caries experience [17]. Meanwhile, our data is the first study showing that sour food was associated with low dental caries experience among adults after controlling for various confounders including age [14], sex [5], income level, and sugary food [16]).

Our data showed that sour food was preventive to dental caries experience among adults. Our data supported some data conducted with children in the U.S [18, 23] which reported that 100 percent juice was associated with low dental caries. And it was demonstrated that 100 percent juice have anti-bacterial effects [24] that might potentially protect against or inhibit the dental caries process. There are several possible explanations for the preventive association of sour food with dental caries. First, acidic foods may have anti-microbial effects on oral bacteria. Acid has the ability limiting the growth of bacteria and it has been used in foods to prevent them from decay for a long time [10]. This antimicrobial activity is shown by the dissociated form of weak acids passing freely through the cell membrane and releasing a proton that leads to acidification of the cytoplasm. This acid stress can induce autolysis of bacteria by modulating gene expressions [11]. In vitro study also showed that most oral bacteria were suppressed by acidic condition of below pH4 [25]. Thus acidic condition may contribute to suppressing plaque accumulation or maturation, which is essential for dental caries progression. Second, acids below pH4 cause tooth surface loss by erosive demineralization and may contribute to less plaque accumulation. The acid affected enamel is vulnerable to abrasive forces such as tooth brushing even hours after softening [12]. Dental plaque requires stagnant place and enough time to exert cariogenic effect [13].

Thus the destruction of tooth surface may decrease the dental plaque accumulation on the tooth surface and it seems like tooth with dental erosion has less dental plaque accumulation [26]. More studies are needed to clarify the mechanisms of this link.

In the stratified analysis, the link between sour food and low dental caries was highlighted in elders aged from 71 to 93 years, males, non-denture wearers and those who dislike sugary food (Table 3). Generally elders tend to have reduced salivary flow rate. Usually sour food stimulates saliva secretion which is important for the prevention of dental caries. Thus the effect of sour food could be stronger in elders. Generally females have more dental caries than males and early eruption of teeth, more sugar consumption and pregnancy seems to increase dental caries in females [27]. These factors may contribute stronger effect on developing dental caries than sour food does, and the effect of sour food on dental caries may be highlighted only in males. Denture wearers usually has many missing teeth, thus the effect of sour food on dental caries can be masked. The impact of sour food on dental caries was stronger in those with high income level and obesity compared to those with low income level and without obesity. However, the impact between low and high income group was similar and it is not certain that these two groups have a difference. Those with obesity may have more chance of have more diets including acidic foods, thus the impact of sour food on dental caries may be stronger. Further studies are indicated to clarify mechanisms of these stratified links.

This study has some limitations. First, this study was a cross-sectional study and we cannot confirm the causality of the links. Second, dietary information was collected by a questionnaire. And it didn't provide any detailed information about each food item, consuming frequency and amount of the item. Future studies with prospective design and detailed dietary information is indicated. Notwithstanding these limitations of this study, our data was valid enough to evaluate the association between sour food and dental caries experience. Our data suggests future research direction that sour food can be preventive on dental caries. Acidic food may be

beneficial for decreasing dental caries. Thus, we suggest that further studies about oral acidic status around pH4-5 which may be anti-bacterial.

V. CONCLUSIONS

Our data showed that the preference to sour food was independently associated with low dental caries experience among Korean elders. The link was highlighted in elders aged 71 years or older, males, non-denture wearers and those who dislike sugary food. Further studies including experimental and prospective epidemiologic studies are needed to clarify the causality and mechanisms of this link.

Table 1. Characteristics of participants according to dental caries experience (n=508)

Variable	Dental caries[*]		p-value[†]
	Low (n=299)	High (n=209)	
Age (years)	69.17±7.76	71.98±7.62	**<0.001[‡]**
Gender, n(%)			**<0.001**
Male	123(41.1)	52(24.9)	
Female	176(58.9)	157(75.1)	
Income level[§], n(%)			**0.037**
Low	181(60.5)	107(51.2)	
High	118(39.5)	102(48.8)	
Tooth brushing (n/day)	2.82±0.85	2.97±0.89	0.476[‡]
Dry mouth, n(%)			**0.039**
No	142(47.5)	80(38.3)	
Yes	157(52.5)	129(61.7)	
Denture, n(%)			**<0.001**
Non-wearer	160(53.5)	71(34.5)	
Wearer	139(46.5)	138(66.0)	
Obesity[¶]			0.141
No	214(71.6)	161(77.4)	
Yes	85(28.4)	47(22.6)	
Dairy food, n(%)			0.213
Dislike	131(43.8)	80(38.3)	
Like	168(56.2)	129(61.7)	
Sugary food, n(%)			**0.009**
Dislike	157(52.5)	85(40.7)	
Like	142(47.5)	124(59.3)	
Salty food, n(%)			0.397
Dislike	143(47.8)	92(44.0)	
Like	156(52.2)	117(56.0)	
Spicy food, n(%)			0.801
Dislike	112(37.5)	76(36.4)	
Like	187(62.5)	133(63.6)	

Data represent means ± standard deviations for continuous variables.
[*]Dental caries: Low (DMFT<11), High (DMFT≥11), dichotomized by the mean DMFT value.
[†]p-value obtained by chi-square test.
[‡]p-value obtained by Mann-Whitney test.
[§]Income level is dichotomized according to subjective judgments.
[¶]Obesity: No (Body Mass Index<25), Yes (Body Mass Index≥25), dichotomized by Body Mass Index.
Bold denotes p-value < 0.05.

Table 2. Associations between preference to sour food and dental caries experience using logistic regression models (N=508)

Variables	Odds ratio[*] (95% confidence interval)			
	Model I	Model II	Model III	Model IV
Sour food				
Dislike	1	1	1	1
Like	**0.561(0.387-0.812)**	**0.559(0.379-0.825)**	**0.571(0.386-0.844)**	**0.565(0.380-0.840)**
Age (years)		**1.059(1.032-1.086)**	**1.055(1.028-1.083)**	**1.055(1.027-1.083)**
Gender				
Male		1	1	1
Female		**2.427(1.611-3.656)**	**2.368(1.531-3.660)**	**2.456(1.579-3.820)**
Income level[†]				
Low		1	1	1
High		**1.906(1.296-2.802)**	**1.932(1.309-2.852)**	**1.868(1.259-2.772)**
Tooth brushing (n/day)			1.076(0.863-1.342)	1.102(0.881-1.379)
Dry mouth				
No			1	1
Yes			1.160(0.786-1.712)	1.149(0.775-1.703)
Obesity				
No			1	1
Yes			0.731(0.470-1.138)	0.699(0.447-1.094)
Sugary food				
Dislike				1
Like				**1.503(1.018-2.217)**
Salty food				
Dislike				1
Like				0.999(0.673-1.483)
Dairy food				
Dislike				1
Like				1.207(0.818-1.782)
Spicy food				
Dislike				1
Like				1.390(0.924-2.091)

*Odds ratios of sour food were crude in Model I; adjusted for age, gender and income level in Model II; adjusted for all variables in Model II, tooth brushing, dry mouth and obesity in Model III; adjusted for all variables in Model III, sugary food, salty food, dairy food, and spicy food in Model IV.
†Income level is dichotomized according to subjective judgments.
‡Obesity: No (Body Mass Index<25), Yes (Body Mass Index≥25), dichotomized by Body Mass Index.
Bold denotes p-value < 0.05.
2 Log likelihood / Cox & Snell R square : 678.625/0.019 for Model I; 639.637/0.097 for Model II; 633.633/0.102 for Model III; 625.787/0.116 for Model IV

Table 3. Stratified adjusted associations between preference to sour food and dental caries experience (N=508)

Subgroup		Sour food	N	Odds ratio[*] (95% confidence interval)
Age[†]				
	49-70 years	Dislike	145	1
	(n=255)	Like	110	0.737(0.414-1.312)
	71-93 years	Dislike	162	1
	(n=253)	Like	91	**0.425(0.242-0.745)**
Gender				
	Males	Dislike	100	1
	(n=175)	Like	75	**0.252(0.113-0.564)**
	Females	Dislike	207	1
	(n=333)	Like	126	0.731(0.453-1.177)
Income level[‡]				
	Low	Dislike	183	1
	(n=288)	Like	105	**0.566(0.323-0.992)**
	High	Dislike	124	1
	(n=220)	Like	96	**0.529(0.295-0.949)**
Sugary food				
	Disike	Dislike	137	1
	(n=242)	Like	105	**0.427(0.231-0.788)**
	Like	Dislike	170	1
	(n=266)	Like	96	0.724(0.422-1.242)
Obesity[§]				
	No	Dislike	232	1
	(n=375)	Like	143	**0.619(0.389-0.985)**
	Yes	Dislike	75	1
	(n=133)	Like	58	**0.328(0.136-0.791)**
Denture				
	Non-wearer	Dislike	130	1
	(n=231)	Like	101	**0.439(0.230-0.837)**
	Wearer	Dislike	177	1
	(n=277)	Like	100	0.662(0.386-1.136)

*Odds ratios were adjusted for age, gender, income level, tooth brushing, dry mouth, BMI, and preferences to sugary food, salty food, dairy food and spicy food except for the subgroups
†Age is dichotomized by the mean value (70.32).
‡Income level is dichotomized according to subjective judgments.
§Obesity: No (Body Mass Index<25), Yes (Body Mass Index≥25), dichotomized by Body Mass Index
Bold denotes p-value < 0.05.

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한국 노인에서 신음식과
치아우식증의 연관성

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이강우

연구목적

최근 연구들에 의하면 산성 구강환경은 구강 세균의 괴사를 유발할 수 있다. 그러나 산성 음식과 치아우식증의 관계는 아직 명확하지 않다. 이 연구의 목적은 한국 노인에서 신음식과 치아우식증 간의 연관성을 평가함이다.

연구대상 및 방법

본 연구는 순창 장수 코호트 연구의 참여자로 구성된 단면연구로 최종 참여자는 남성 175명, 여성 333명, 총 508명이었다 (49세에서 93세). 치아우식증은 WHO 기준에 따라 측정되었다. 신음식에 대한 기호는 설문을 이용한 면접 조사로 평가되었다. 연령, 성별, 경제 수준, 잇솔질 회수, 구강건조증, 비만, 단음식, 짠음식, 유제품 선호를 혼란변수로 고려하였다. 보정 연관성 추정을 위해 다변수 로지스틱 회귀 분석을 적용하였다. 연령별, 성별, 경제 수준별, 단음식 선호별, 비만 유무별 층화분석을 시행하였다.

결 과

다양한 혼란변수를 통제한 후, 신음식에 대한 선호는 낮은 치아우식경험

과 독립적인 연관성을 보였다 (보정 오즈비 [OR]=0.565, 95% 신뢰구간 [CI]:0.380−0.840). 층화분석 결과 이 연관성은 71세 이상 노인 (OR=0.425, 95% CI: 0.242−0.745), 남자 (OR=0.252, 95% CI: 0.113−0.564), 단 음식 비선호자 (OR=0.427, 95% CI: 0.231−0.788), 그리고 의치 미장착자에서 (OR=0.439, 95% CI: 0.230−0.837) 더 높게 나타났다.

결론

본 연구 결과 한국 노인에서 신음식 선호는 낮은 치아우식경험과 독립적 연관성이 있었다. 그 연관성은 71세 이상 노인, 남성, 의치 미장착자, 단 음식 비선호 집단에서 높았다. 이 연관성의 인과관계와 기전을 명확히 밝히기 위해 후속 연구가 필요하다.