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TOOTH LOSS, PERIODONTAL DISEASE, AND MINERAL CONTENT OF CALCIUM AND MAGNESIUM IN THE DIET OR URINE IN THE ELDERLY

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Abstract: *Objective:* The purpose of this study was to assess whether tooth loss or periodontal disease is related to the intake of selected nutrients or to the amount of key nutrients found in urine. *Methods:* We evaluated the number of present teeth and the mean clinical attachment level (CAL) in 57 people aged 74 years. All food intakes were measured by a precise weighing method for 3 consecutive days. Furthermore, selected components of partition urine excretion were measured. Multiple linear regression analysis was performed to assess the relationship between the number of remaining teeth or mean CAL and dietary and urinary Ca/Mg molar ratio. *Results:* Mean clinical attachment level was significantly associated with urinary Ca/Mg molar ratios by standardized coefficients after adjusting for gender smoking habits and the number of remaining teeth. The standardized coefficients were 0.33 (p=0.031). In addition, the number of remaining teeth was significantly associated with both urinary and dietary Ca/Mg molar ratios by standardized coefficients after adjusting for gender and smoking habits. The standardized coefficients were -0.38 (p=0.006) and -0.31 (p=0.020), respectively. *Conclusions:* This study suggests that dietary and urinary Ca/Mg molar ratios are significantly associated with tooth loss. In addition, there is a significant relationship between urinary Ca/Mg molar ratio and periodontal disease, which is the main reason for tooth loss.

Key words: Calcium, magnesium, periodontal disease, tooth loss, epidemiology, elderly.

Introduction

Calcium and magnesium are the most abundant minerals in humans. Nearly 99% of all calcium in the human body exists in the bones and teeth, providing a structural function, whereas the remaining 1% is found in tissues and fluids and is crucial for the maintenance of cell metabolism, nerve transmission, and muscle contraction (1). Calcium plays many important roles in the synthesis, release, and receptor responsiveness to neurotransmitters (2).

Magnesium acts as a critical cofactor for hundreds of enzymes and is a direct antagonist of intracellular calcium (3, 4). However, in the gastrointestinal tract, the roles of calcium and magnesium in the process of calcium absorption are synergistic, as the production of active vitamin 1,25 (OH)2D3, which is needed to absorb calcium from food, is dependent on magnesium (5).

Researchers have been exploring the role played by minerals in the etiology and/or progression of periodontal disease for more than 4 decades. Recent studies have shown a significant relationship between dietary calcium, serum calcium, and periodontal disease (6-8) as well as between the serum magnesium/calcium ratio and periodontal disease (9).

In addition, several animal and human studies point to an association between dietary calcium intake and periodontal disease. For instance, Nishida et al. (6) and Krall et al. (7) have observed a relationship between a calcium-deficient diet and the progression of periodontal disease in humans. Accordingly, it has been hypothesized that low dietary intake of calcium may contribute to the progression of periodontal disease (6, 10).

Previous reports have suggested an association between edentulousness and a low intake of nutrients (11-13), but evidence that a poor diet is common in the

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edentulous population is not convincing when carefully examined, and the association remains unclear. In particular, there are no reports that evaluate the mechanism of nutritional intake, excretion from urine, tooth loss, and periodontal disease in the same subjects.

The purpose of this study was to assess whether tooth loss and periodontal disease are related to the dietary intake of calcium and magnesium, measured by a precise weighing method, as well as to the amounts of calcium and magnesium in the urine.

Materials and Methods

Study subjects

Initially, questionnaires were sent to all 4,542 residents aged 70 years in Niigata City, Japan. Among them, after dividing by gender, 600 people were selected randomly to have approximately the same number of each gender for the baseline survey. Participants agreed to undergo medical and dental examinations and signed informed consent forms regarding the protocol, which was approved by the Ethics Committee of Niigata University School of Dentistry. The study was carried out according to the rules of the Helsinki Declaration. Follow-up surveys have been carried out every year in June using the same methods as in the baseline survey. Among the participants (n=436, screened population) in this follow-up survey conducted after three years, 62 volunteers who were selected randomly took part after receiving a full explanation of the purpose of this detailed nutrient survey. Complete 3-day food intake data were obtained from 57 volunteers, 31 males and 26 females. All subjects were 73 years old. For the screened population, body height, weight, percent body fat, bone mineral density (stiffness), number of remaining teeth, and mean clinical attachment level (CAL) were measured, and body mass index (BMI; kg/m2) was calculated. CAL is a criteria for periodontal disease which is a bacterially induced inflammation of the gingival tissues together with some loss of both the attachment of the periodontal ligament and bony support.

Dietary intakes and urine specimens

This nutritional survey was conducted from November to December to avoid seasonal changes in food intake between the present study and Japan's National Nutrition Survey, which is conducted in November (14). Trained dietitians visited the subjects on the day before the survey was started. Subjects had been fully instructed on how to record all consumed foods, including drinking water (green tea and so on) and usage of nutritional supplements. Each food consumed by the subjects was weighed using the same model of scales (Tanita, Tokyo, Japan) for 3 consecutive days. The dietitians checked the records of dietary intakes weighed by the subjects twice, on the second of 3 consecutive days and after 3 consecutive days. Food consumption data were obtained at the homes of the subjects by 12 trained dietitians. Finally, two dietitians checked the data for all food intakes. After that, nutrient intake was calculated based on the Standard Tables of Food Composition in Japan (5th ed) (15). Items that were unregistered in the food tables were calculated based on similar foods using the same ingredients. Special care was paid to the cooking condition of food for calculation according to the Standard Tables of Food Composition. In case in which "the composition value of cooked food" was listed in the Standard Tables, the values were used for calculation. Alcohol-derived energy was included in total energy intake. Finally, the dietary intake of calcium and magnesium were calculated based on the Japanese Standard Food Tables.

Furthermore, the selected components of partition urine excretion were measured. Concentrations of calcium and magnesium in the urine were tested in a commercial laboratory (BML, Inc., Tokyo, Japan).

Teeth conditions and smoking habits

Four dentists performed clinical evaluations to determine (1) number of remaining teeth and (2) CAL. Mouth mirrors with a light- and pressure-sensitive plastic periodontal probe, set to give a constant probing force of 20 g and graduated at 1-mm intervals were used (Vivacare TPS Probe®, Schaan, Liechtenstein). All functioning teeth, including third molars, were assessed, except for partially erupted teeth. CALs were measured at six sites per tooth (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual, and disto-lingual) and rounded to the nearest whole millimeter. In cases where a restorative margin was apical to the cemento-enamel junction (CEJ), CAL was measured taking into account the anatomical features of the teeth and, if present, the CEJ of the adjacent tooth/teeth. Seventeen volunteer patients were examined by each of the four examiners in the Faculty Hospital of Dentistry, Niigata University, and their results were compared. The percentage of agreement ranged from 70% to 100% for CAL. The kappa ranged from 0.62 to 1.00 for CAL.

We conducted personal interviews with subjects to obtain information regarding smoking habits (0: never, 1: past or current).

Calculation and Statistics

All urinary parameters were corrected, i.e., divided by urinary creatinine concentrations measured simultaneously for statistical analyses. The total energy per body weight per day was calculated. Based on the dietary intake of calcium and magnesium or concentration of calcium and magnesium in the urine, calcium/magnesium (Ca/Mg) molar ratios were calculated. All data were expressed as mean ± standard division (SD). After controlling for gender and smoking habits, multiple linear regression analysis was performed to assess the relationship between the number of remaining teeth or mean CAL and dietary and urinary Ca/Mg molar ratio. The mean CAL was only calculated in dentate subjects (n=53). All calculations and statistical analyses were performed using the STATA™ software package (StataCorp, College Station, TX, USA). Level of statistical significance was considered at α=0.05.

Results

Physiological characteristics and dental status are shown in Table 1. There were no significant differences in body height, weight, BMI, body fat percentage, bone mineral density (stiffness), the number of remaining teeth, and mean CAL between the screened population and subjects in the study. Table 2 shows the dietary and urinary markers of the subjects by gender.

As shown in Table 3, the number of remaining teeth was significantly associated with dietary intake of magnesium and urinary magnesium and Ca/Mg molar ratio by standardized coefficients after adjusting for gender and smoking habits. The standardized coefficients were 0.35 (p=0.012), 0.33 (p=0.021), and -0.31 (p=0.026), respectively. In addition, the CAL was significantly associated with urinary Ca/Mg molar ratio by standardized coefficients after adjusting for gender, smoking habits, and the number of remaining teeth. The standardized coefficients were 0.36 (p=0.012).

Tables 4 and 5 show findings of multiple linear regression analysis that evaluates the relationship between the mean CAL or the number of remaining teeth and dietary or urinary Ca/Mg molar ratio. Mean CAL was significantly associated with urinary Ca/Mg molar ratios by standardized coefficients after adjusting for gender, the number of remaining teeth and smoking habits. The standardized coefficients were 0.33 (p=0.031) (Table 4). In addition, the number of remaining teeth was significantly associated with both urinary and dietary Ca/Mg molar ratios by standardized coefficients after adjusting for gender and smoking habits. The standardized coefficients were -0.38 (p=0.006) and -0.31 (p=0.020), respectively (Table 5).

Discussion

In this study, the urinary Ca/Mg molar ratio was significantly associated with both the number of remaining teeth and the mean CAL. The interesting finding was the positive correlation between the urinary Ca/Mg molar ratio and mean CAL attachment level, showing that a person with progressing periodontal disease tends to excrete more Calcium and less magnesium.

Calcium is a bone mineral that is supplied to the plasma by the bone. However, magnesium is both a bone mineral and an intracellular mineral, and it is not clear from which tissue it is released (16). Excessive magnesium is rapidly excreted into urine (17). The urinary Ca/Mg molar ratio is known to be related to bone mineral density (18). According to earlier studies, magnesium can reduce calcium absorption (19). In addition, calcium and magnesium have a cellular antagonism (20) and achieving a proper balance between calcium and magnesium is important to maintaining optimal bone density. Therefore, the urinary Ca/Mg

Table 1
The comparison in selected characteristics of the subjects between the screened population and the subjects in the study

	Males			Females		
Variables	**Screened population (n=235)**	**Subjects in the study (n=31)**	**p**	**Screened population (n=201)**	**Subjects in the study (n=26)**	**p**
Height (cm)	162.3±5.5	161.9±5.2	NS	149.1±4.9	148.5±5.1	NS
Weight (kg)	58.7±8.4	56.2±7.3	NS	51.0±7.8	52.1±7.3	NS
BMI (kg/m^2)[a]	22.3±2.8	21.5±2.8	NS	22.9±3.3	23.6±2.6	NS
Body fat (%)[b]	19.4±4.9	18.5±5.7	NS	28.4±6.4	29.3±5.0	NS
Stiffness (%)[c]	71.7±11.0[d]	71.9±10.2	NS	58.6±8.2[e]	61.1±9.0	NS
Dental condition						
Remaining teeth	17.0±9.7	18.9±9.7	NS	16.7±9.2	17.5±9.1	NS
Clinical attachment level	3.6±1.6[f]	3.5±1.2[g]	NS	3.1±1.7[h]	3.1±0.9[i]	NS

All the values are means ± SD. NS: not significant. a. BMI: Body mass index; b. Body fat rate was measured by bio-electrical impedance analysis (TANITA, Body composition analyzer/scalesTM); c. Bone mineral density (BMD) of the heel was measured using an Ultra-Sound Bone Densitometer (Lunar, Achills TM). The stiffness is a clinical index combing the velocity (speed of sound; SOS) and frequency attention (broadband ultrasound tention (dB/MHZ;BUA), and is indicated by the monitor of the bone densitometer as the percentage of the value of the normal younger generation. The number of subjects for analysis were d:231, e:200, f:207, g:29, h:184, i:24.

molar ratio might be useful to evaluate the relationship between bone mineral density and calcium, taking magnesium into consideration. General bone mineral density might influence alveolar bone loss directly in some cases. This was the reason that there was significant relationship between both the urinary Ca/Mg molar ratio, and not only the number of remaining teeth but also mean CAL.

Table 2
The dietary intakes and urinary markers of the subjects

Variables	Males (n=31)	Females (n=26)
Dietary intakes		
Energy (kcal/d)	2485±336	1948±297
Total Protein (E %)	16.4±2.5	16.0±2.6
Calcium (mg/1000kcal)	321±72	369±93
Magnesium (mg/1000kcal)	162±26	178±34
Vitamin D (μg/1000kcal)	8.2±5.9	7.9±5.5
Vitamin K (μg/1000kcal)	156.1±75.0	188.1±101.3
Urinary contents		
Calcium (mg/g Cre)	121±78	186±119
Magnesium (mg/g Cre)	83±40	96±39

All the values are means ± SD

Table 3
The relationship between nutrient and urinary specimens, and the number of teeth present and clinical attachment level

Independent variables	Dependent variable: Number of remaining teeth			Dependent variable: Mean clinical attachment level		
	Std. Coef.[a]	R2(%)	p value	Std. Coef.[b]	R2(%)	p value
Dietary minerals						
Calcium (mg/1000kcal)	0.06	1.5	0.666	0.03	16.1	0.816
Magnesium (mg/1000kcal)	0.35	12.7	0.012	0.27	22.0	0.068
Ca/Mg molar ratio	-0.23	6.4	0.097	-0.20	14.6	0.146
Urinary minerals						
Calcium (mg/g Cre)	0.05	1.4	0.727	0.26	22.6	0.054
Magnesium (mg/g Cre)	0.33	11.1	0.021	-0.13	17.5	0.380
Ca/Mg molar ratio	-0.31	10.3	0.026	0.36	36.1	0.012

a. adjusted for gender and smoking habits; b. adjusted for gender, the number of remaining teeth and smoking habits.

Table 4
Relationship between urinary and nutritional Ca/Mg ratio and periodontal disease

Independent variables	Dependent variable: Mean clinical attachment level Coef.	Std. Err.	p value	[95% CFI]		Std. Coef.[a]
Urinary Ca/Mg molar ratio	0.51	0.23	0.031	0.048	-0.97	0.33
Dietary Ca/Mg molar ratio	-0.38	0.53	0.472	-1.441	-0.68	-0.10
Gender (1: males, 2: females)	-0.64	0.41	0.129	-1.465	-0.19	-0.31
Number of remaining teeth	-0.03	0.02	0.059	-0.071	-0.00	-0.28
Smoking habits (0: never, 1: past and current)	0.34	0.40	0.405	-0.475	-1.16	0.17
Constant	4.45	1.03	<0.001	2.389	-6.52	-

a. Standardized coefficients. R2=0.23, p=0.009

Table 5
Relationship between urinary and nutritional Ca/Mg ratio and the number of remaining teeth

Independent variables	Dependent variable: Number of remaining teeth Coef.	Std. Err.	p value	[95% CFI]	Std. Coef.[a]
Urinary Ca/Mg molar ratio	-5.29	1.85	0.006	-9.00 - -1.58	-0.38
Dietary Ca/Mg molar ratio	-10.93	4.56	0.020	-20.09 - -1.77	-0.31
Gender (1: males, 2: females)	-0.54	3.93	0.891	-8.44 - 7.35	-0.03
Smoking habits (0: never, 1: past and current)	1.17	3.85	0.763	-6.56 - 8.90	0.06
Constant	36.07	7.02	<0.001	21.96 - 50.17	-

a. Standardized coefficients. R2=0.20, p=0.026

Furthermore, a significant negative association was found between the number of remaining teeth and both the urinary and dietary Ca/Mg molar ratios and dietary intake of magnesium. Subjects with fewer teeth consumed fewer vegetables and fish, shellfish, and products (21). A lot of magnesium is included in fish, shellfish, and products. The food selection of subjects, which may be based poor chewing ability (22), may cause nutritional deficiencies. The relationship between tooth loss and food intake found in this study supports the dental profession's emphasis on prevention of tooth loss. It is conceivable that associations found in cross-sectional studies may reflect a reverse causation; that is, the results may reflect the effect of diet on dental caries or periodontal disease and consequently on tooth loss, rather than the effect of tooth loss on diet. However, there is little evidence to suggest that the foods and nutrients examined in this study would influence development of dental caries or periodontal disease. In addition, in this study, there was no significant relationship between periodontal disease and dietary minerals intake such as calcium and magnesium. These findings suggest dietary intake such as calcium and magnesium might not influence periodontal disease, which is a major factor of tooth loss. Thus, it is highly unlikely that the associations found in this cross-sectional analysis are due to the effect of dietary factors on tooth loss. In contrast, tooth loss might alter food choice, resulting in lower intake of key nutrients. However, this should be further confirmed by a longitudinal analysis to confirm whether tooth loss is associated with detrimental changes in diet and nutrient intake.

Finally, we should keep in mind a limitation of the present study. According to our results, there were no significant differences in general health and dental conditions between the screened population and the subjects in the study. Therefore, we thought subjects in this study were representative of the community. However, the small sample size of this study may not have detected potential weak associations. Further studies are needed to confirm the observations in this study.

In summary, this study suggests that the dietary and urinary Ca/Mg molar ratios are significantly associated with tooth loss. In addition, there is a significant relationship between the urinary Ca/Mg molar ratio and periodontal disease, which is the main reason for tooth loss.

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