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Association of the number of remaining teeth with kidney function in community-dwelling healthy older adults: a cross-sectional study

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Abstract (J Korean Assoc Oral Maxillofac Surg 2023;49:243-251)

Objectives: Although a few studies have investigated the relationship between kidney and oral function (number of remaining teeth), their results remain inconclusive. Therefore, this study aimed to investigate the relationship between kidney function and oral health in community-dwelling healthy elderlies and examine the factors associated with kidney function.

Materials and Methods: We used cross-sectional data from the Shimane prefecture cohort recruited by the Center for Community-Based Health Research and Education in 2019. We collected clinical data on dental status, background factors and kidney function (estimated glomerular filtration rate [eGFR], mL/min/1.73 m^2 and creatinine levels, mg/dL).

Results: The study enrolled 481 participants, whose mean age was 66.7±7.4 years, and 223 (46.4%) participants were men. Multivariate analysis revealed significant correlations between eGFR (B=0.17, *P*=0.04), creatinine (B=–0.54, *P*<0.01), and the number of remaining teeth. The number of remaining teeth was associated with creatinine and eGFR, which are indicators of kidney function.

Conclusion: This study suggests that preserving the teeth may prevent decline in kidney function. Dental professionals should provide instructions and professional care to reduce the risk of systemic diseases such as kidney dysfunction.

Key words: Kidney function, Oral function, Remaining teeth, Chronic kidney disease

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I. Introduction

Kidney function, which is known to decline with age, is associated with lifestyle-related diseases such as hypertension, diabetes, and dyslipidemia[1]. The complications arising from the deterioration in kidney function can also result in life-threatening conditions such as heart failure[2]. Some studies also suggest that individuals who develop kidney function impairment between young adulthood to middle age are at a higher risk of cognitive decline[3]. Thus, given the wide-ranging effects of kidney function on the whole body, it stands to reason that many unknown factors may affect kidney function. Chronic kidney disease (CKD) (characterized by chronic impairment in kidney function) is defined as chronic (longer than 3 months) persistent decline in kidney function expressed as an estimated glomerular filtration rate (eGFR) of <60 mL/min/1.73 m^2. CKD encompasses all persistent chronic conditions in which the presence of kidney damage is evident in abnormal results of urine, imaging, blood, or pathological examinations[4]. Physical activity reportedly decreases in patients due to concerns about the deterioration in kidney function as exercise increases proteinuria[5]. Moreover, restricted protein intake owing to dietary therapy for kidney dysfunction has been shown to cause sarcopenia and a decrease in muscle mass[6]. Basic and clinical studies have shown that patients with CKD develop sarcopenia, which can occur at any stage of CKD[7].

Previous studies have indicated that 25% of patients with CKD with eGFR less than 60 mL/min/1.73 m^2 develop sar-

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copenia[8]. Additionally, low nutritional status and sarcopenia can increase the incidence of frailty[9]. Patients with CKD with frailty reportedly face a higher risk of end-stage renal failure and death, suggesting an association with several systemic functions[10]. Frailty refers to a condition in which the physiological reserve declines with age, leading to functional disability in daily living, need for nursing care, and death[11]. Frailty due to CKD causes loss of muscle mass and strength because of inadequate caloric intake associated with protein restriction[11].

In recent years, the significant association between oral frailty, the manifestation of a minor decline in oral function, and the risk of sarcopenia, requiring nursing care, and culminating in death, has constituted one of the most important topics of research[12]. Recent studies have classified the age-related decline in oral function over time into three stages, viz. oral frailty, oral hypofunction, and masticatory and swallowing disorders. Oral frailty is defined as a minor decline in oral function, such as choking or slurring speech, and is reversible to the healthy state[13]. Oral hypofunction is defined as impairment in three or more of the seven examination items: oral bacterial count, tongue pressure, oral dryness, masticatory function, swallowing function, tongue and lip motor function, and occlusal force. Masticatory and swallowing disorders require examination and treatment by specialists at specialized facilities[14]. Oral frailty and hypofunction may be involved in a wide range of systemic diseases by causing sarcopenia and locomotive syndrome through the frail cycle over the course of the pathological condition[15].

Although only a few studies have investigated the relationship between kidney and oral function, one study suggested that abnormal bone metabolism occurs in patients with impaired kidney function, whose effect extends to the mandible. Studies have postulated that the resulting pathway leads to exacerbation of periodontal disease and tooth loss via alveolar bone resorption[16]. In-depth investigations have also shown that a 10% increase in periodontal inflammation in patients with CKD is associated with a 3% decrease in kidney function, and a 10% decrease in kidney function is associated with a 25% increase in periodontal inflammation[16]. Another study suggested that the urinary albumin-to-creatinine ratio is related to the number of remaining teeth[17]. In addition, previous studies have found significant associations between kidney function and tongue-lip motor function related to swallowing[18]. However, many studies have not adjusted for possible confounding factors that may be associated with kidney function, failing to reach a definitive conclusion on the association between oral and renal function.

Naturally, sarcopenia caused by age-related oral dysfunction and sarcopenia caused by kidney dysfunction have different pathways, and therefore different pathomechanisms. However, the oral cavity, a part of the digestive tract, and daily diet are closely related and may indirectly influence the development of renal disease. Periodontal diseases may also be directly related to inflammatory cytokines. Therefore, we hypothesized that the most basic evidence-based indicators (kidney function [creatinine and eGFR] and number of remaining teeth) would be relevant to the question, "Are the kidneys and oral cavity related?"

Therefore, this study aimed to investigate the relationship between kidney function and oral function in the community-dwelling healthy elderly and examine the factors associated with kidney function.

II. Materials and Methods

1. Data collection

The present study used the dataset derived from health examinations of the Shimane prefecture cohort in Japan, which was used in the Center for Community-Based Health Research and Education (CoHRE) study. However, the current study is distinct from the CoHRE study because it includes a different set of participants, variables, and methods of analysis. This study was approved by the Medical Research Ethics Committee of Shimane University Faculty of Medicine (No. 20220619-1). Written informed consent was obtained from all participants before data collection.

2. CoHRE study

The CoHRE study is an ongoing prospective cohort study conducted by the Shimane University Center for Community-based Healthcare Research and Education to predict and prevent lifestyle-related diseases in the town of Onan, Shimane prefecture for which data collection has been conducted since 2012. The research entails a survey of health and medical information, various clinical laboratory parameters, lifestyle factors, human relations, social resources, and medical costs.

3. Study design

In this study, we used cross-sectional data from 2019, the most recent dataset from the Shimane cohort, since no sur-

veys were conducted after 2019 due to the COVID-19 pandemic.

4. Inclusion criteria

The inclusion criteria were as follows: (1) residents enrolled in the National Health Insurance System, (2) residents of Onan, a mid-mountain area in Shimane prefecture, and (3) residents who participated in the 2019 survey.

5. Exclusion criteria

Data of residents with missing values were excluded, and only complete data were analyzed.

6. Collected data

1) Background data

We collected data on the following variables: sex (male or female), age (years; ≤70 or >70 years)[19], body mass index (kg/m^2), high-density lipoprotein cholesterol (HDL-C) (mg/dL), low-density lipoprotein cholesterol (LDL-C) (mg/dL), triglycerides (mg/dL), γ-glutamyl transpeptidase (GTP; IU/L), blood glucose level (mg/dL), glycated hemoglobin (HbA1c) (%), sodium concentration (mEq), potassium concentration (mEq), estimated 24-h salt excretion (g/day), bone mineral density (%), muscle mass (%), basal metabolic rate (kcal/day), and number of teeth. All examinations were performed by physicians, nurses, dentists, and dental hygienists, and the dental care providers accurately counted the number of remaining teeth.

2) Assessment of kidney function

Kidney function was evaluated using eGFR (mL/min/1.73 m^2) and creatinine based on urine tests performed at any time (mg/dL).

7. Statistical analysis

After confirming the normality of data distribution using the Shapiro–Wilk test, continuous data were expressed as means and standard deviations, while categorical data were expressed as numbers (%).

Pearson's correlation coefficient was calculated to determine the relationship between eGFR and creatinine, respectively, and the number of remaining teeth. The coefficient of determination and line equation were also calculated. Additionally, scatter plots were drawn for the number of teeth and creatinine and eGFR, respectively.

Multivariate linear regression analysis (forced entry method) was used to control possible confounding variables related to eGFR and creatinine. Partial regression coefficients for the eGFR and creatinine outcomes were estimated after adjusting for all other variables included in the model. The items adjusted included sex, age, body mass index, HDL-C, LDL-C, triglyceride, GTP, blood glucose level, HbA1c, sodium concentration, potassium concentration, salt excretion, bone mineral density, muscle mass, basal metabolic rate, and the number of teeth. All statistical analyses were conducted using IBM SPSS (ver. 26; IBM). Two-tailed *P*-values were calculated for all analyses.

III. Results

1. Participant characteristics

The participants' characteristics are summarized in Table 1. This study enrolled 481 participants, of which 223 (46.4%) were men, and the mean age was 66.7±7.4 years. The mean body mass index was 23.0±3.7 kg/m^2. The mean HDL-C

Table 1. Participants' demographic data (n=481)

Variable	Category	Value
Sex	Male	223 (46.4)
	Female	258 (53.6)
Age (yr) (n=480)[1]		66.7±7.4
Age group (n=480)[1]	≤70	234 (48.8)
	>70	246 (51.3)
Body mass index (kg/m^2)		23.0±3.7
HDL-C (mg/dL)		61.7±15.1
LDL-C (mg/dL)		121.8±27.4
TG (mg/dL)		101.9±65.3
γ-GTP (IU/L)		37.7±54.1
Blood glucose (mg/dL)		100.0±25.7
HbA1c (%)		6.0±0.7
eGFR (mL/min/1.73 m^2)		69.4±13.1
Creatinine (mg/dL)		85.9±55.9
Sodium (mEq)		119.7±56.3
Potassium (mEq)		54.5±30.7
Salt excretion (g/day)		9.5±2.1
Bone mineral density (%)		88.3±12.2
Muscle mass (%)		41.2±8.5
Basal metabolic rate (kcal/day)		1,208.3±230.8
No. of teeth		23.5±7.8

(HDL-C: high-density lipoprotein cholesterol, LDL-C: low-density lipoprotein cholesterol, TG: triglyceride, γ-GTP: γ-glutamyl transpeptidase, HbA1c: glycated hemoglobin, eGFR: estimated glomerular filtration rate)

[1]There was only one missing value in the age data.

Values are presented as number (%) or mean±standard deviation.

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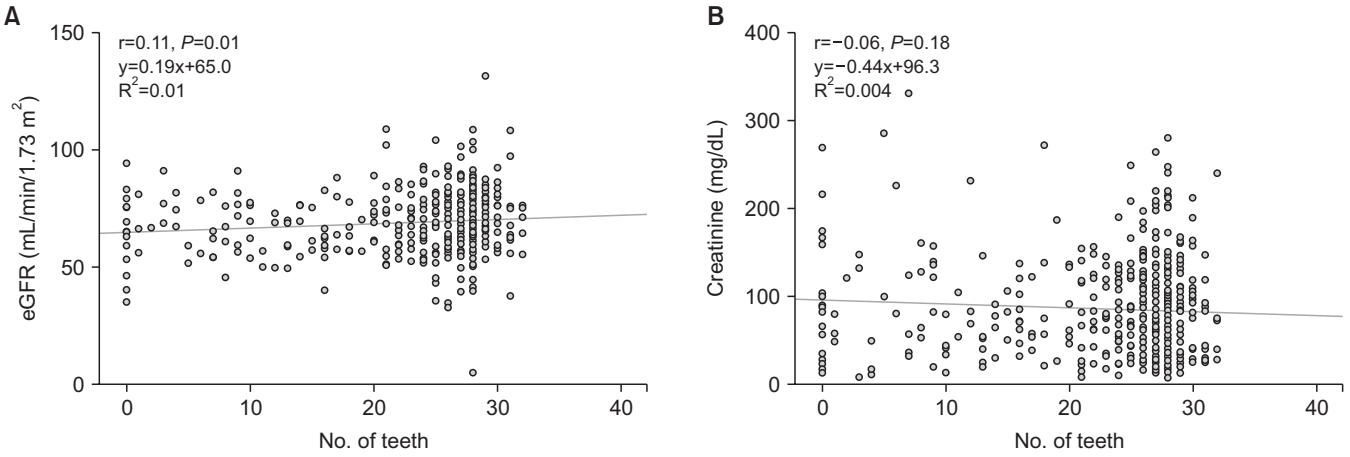

Fig. 1. Correlation of estimated glomerular filtration rate (eGFR) and creatinine values with the number of teeth. A. Scatter plot of the number of teeth and eGFR values. B. Scatter plot of number of teeth and creatinine values.
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and LDL-C were 61.7±15.1 mg/dL and 121.8±27.4 mg/dL, respectively. The mean triglyceride level was 101.9±65.3 mg/dL. The mean γ-GTP was 37.7±54.1 IU/L. The mean blood glucose level was 100.0±25.7 mg/dL. The mean HbA1c was 6.0%±0.7%. The mean eGFR was 69.4±13.1 mL/min/1.73 m^2 and the mean creatinine level was 85.9±55.9 mg/dL. The mean basal metabolic rate was 1,208.3±230.8 (kcal/day). The mean number of teeth was 23.5±7.8.

2. Pearson's correlation coefficient

Pearson's correlation coefficient for the relationship between eGFR, creatinine, and the number of remaining teeth was 0.11 (*P*=0.01) and –0.06 (*P*=0.18), respectively. The equations for the straight lines were y=0.19x+65.0 and y=–0.44x+96.3, respectively. The coefficients of determination were R^2=0.01 and R^2=0.004, respectively. The scatter plots are shown.(Fig. 1)

3. Univariate and multivariate logistic regression analyses for eGFR

Univariate analysis revealed significant correlations between eGFR and sodium (B=0.02, *P*=0.05), salt excretion (B=1.09, *P*<0.01), and the number of teeth (B=0.19, *P*=0.01). Sex (B=–1.12, *P*=0.35), age group (B=0.78, *P*=0.51), body mass index (B=0.13, *P*=0.41), HDL-C (B=0.003, *P*=0.95), LDL-C (B=0.01, *P*=0.73), triglyceride (B=–0.01, *P*=0.61), γ-GTP (B=0.01, *P*=0.22), blood glucose level (B=0.03, *P*=0.23), and HbA1c (B=0.17, *P*=0.85) were not correlated with eGFR.(Table 2)

Multivariate analysis revealed significant correlations between eGFR and sex (B=–8.66, *P*=0.04), salt excretion (B=1.21, *P*<0.01), bone mineral density (B=–0.11, *P*=0.04), muscle mass (B=–2.45, *P*=0.04), basal metabolic rate (B=0.08, *P*=0.04), and number of teeth (B=0.17, *P*=0.04). Age group (B=0.89, *P*=0.45), body mass index (B=–0.70, *P*=0.06), HDL-C (B=0.01, *P*=0.88), LDL-C (B=0.01, *P*=0.69), triglyceride (B=–0.01, *P*=0.26), γ-GTP (B=0.02, *P*=0.16), blood glucose level (B=0.04, *P*=0.18), HbA1c (B=–0.81, *P*=0.54), sodium (B=0.003, *P*=0.82), and potassium (B=0.03, *P*=0.30) were not correlated with eGFR.(Table 2)

The value of adjusted R^2, the coefficient of determination for the multiple regression model, was 0.05.(Table 2)

4. Univariate and multivariate logistic regression analyses for creatinine

Univariate analysis revealed significant correlations between eGFR and sex (B=–36.8, *P*<0.01), body mass index (B=2.15, *P*<0.01), γ-GTP (B=0.12, *P*<0.01), sodium (B=0.42, *P*<0.01), potassium (B=1.31, *P*<0.01), salt excretion (B=–13.70, *P*<0.01), bone mineral density (B=0.74, *P*<0.01), muscle mass (B=2.21, *P*<0.01), and basal metabolic rate (B=0.08, *P*<0.01). Age group (B=–8.27, *P*=0.11), HDL-C (B=–0.18, *P*=0.29), LDL-C (B=–0.03, *P*=0.76), TG (B=0.04, *P*=0.30), blood glucose level (B=0.06, *P*=0.57), HbA1c (B=–4.58, *P*=0.24), and the number of teeth (B=–0.44, *P*=0.18) were not correlated with creatinine.(Table 3)

Multivariate analysis revealed significant correlations

Table 2. Multivariate linear regression analysis of the relationship between estimated glomerular filtration rate and each factor

Variable	Univariate					Multivariate					Adjusted R^2
	β	B	95% CI		*P*	β	B	95% CI		*P*	
			Lower	Upper				Lower	Upper		
Sex	–0.04	–1.12	–3.47	1.22	0.35	–0.33	–8.66	–17.08	–0.24	0.04*	0.05
Age group	0.03	0.78	–1.57	3.13	0.51	0.03	0.89	–1.44	3.21	0.45	
Body mass index	0.04	0.13	–0.19	0.46	0.41	–0.20	–0.70	–1.43	0.04	0.06	
HDL-C	0.003	0.003	–0.08	0.08	0.95	0.01	0.01	–0.08	0.10	0.88	
LDL-C	0.02	0.01	–0.04	0.05	0.73	0.02	0.01	–0.04	0.05	0.69	
TG	–0.02	–0.01	–0.02	0.01	0.61	–0.06	–0.01	–0.03	0.01	0.26	
γ-GTP	0.06	0.01	–0.01	0.04	0.22	0.07	0.02	–0.01	0.04	0.16	
Blood glucose	0.06	0.03	–0.02	0.07	0.23	0.09	0.04	–0.02	0.11	0.18	
HbA1c	0.01	0.17	–1.62	2.00	0.85	–0.04	–0.81	–3.42	1.80	0.54	
Sodium	0.09	0.02	0.0003	0.04	0.05*	0.01	0.003	–0.03	0.03	0.82	
Potassium	–0.02	–0.01	–0.05	0.03	0.73	0.07	0.03	–0.03	0.09	0.30	
Salt excretion	0.18	1.09	0.55	1.63	<0.01*	0.20	1.21	0.44	1.98	<0.01*	
Bone mineral density	–0.07	–0.07	–0.17	0.03	0.15	–0.10	–0.11	–0.22	–0.01	0.04*	
Muscle mass	0.07	0.11	–0.03	0.25	0.12	–1.59	–2.45	–4.76	–0.13	0.04*	
BMR	0.08	0.01	0.0004	0.01	0.08	1.47	0.08	0.01	0.16	0.04*	
No. of teeth	0.11	0.19	0.04	0.34	0.01*	0.10	0.17	0.01	0.32	0.04*	

(CI: confidence interval, HDL-C: high-density lipoprotein cholesterol, LDL-C: low-density lipoprotein cholesterol, TG: triglyceride, γ-GTP: γ-glutamyl transpeptidase, HbA1c: glycated hemoglobin, BMR: basal metabolic rate)
*P<0.05.
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Table 3. Multivariate linear regression analysis of the relationship between creatinine and each factor

Variable	Univariate					Multivariate					Adjusted R^2
	β	B	95% CI		*P*	β	B	95% CI		*P*	
			Lower	Upper				Lower	Upper		
Sex	–0.33	–36.8	–46.30	–27.32	<0.01*	–0.38	–42.24	–57.61	–26.87	<0.01*	0.83
Age group	–0.07	–8.27	–18.28	1.74	0.11	0.003	0.31	–3.93	4.55	0.89	
Body mass index	0.14	2.15	0.79	3.51	<0.01*	–0.12	–1.80	–3.14	–0.46	<0.01*	
HDL-C	–0.05	–0.18	–0.51	0.15	0.29	0.02	0.06	–0.10	0.23	0.47	
LDL-C	–0.01	–0.03	–0.21	0.15	0.76	–0.02	–0.03	–0.11	0.05	0.44	
TG	0.05	0.04	–0.04	0.12	0.30	0.004	0.004	–0.04	0.04	0.85	
γ-GTP	0.12	0.12	0.03	0.22	<0.01*	–0.01	–0.01	–0.05	0.04	0.70	
Blood glucose level	0.03	0.06	–0.14	0.25	0.57	0.06	0.13	0.01	0.25	0.04*	
HbA1c	–0.05	–4.58	–12.22	3.06	0.24	–0.06	–5.16	–9.92	–0.40	0.03*	
Sodium (Na)	0.42	0.42	0.34	0.50	<0.01*	0.42	0.42	0.37	0.47	<0.01*	
Potassium (K)	0.72	1.31	1.20	1.42	<0.01*	0.24	0.44	0.34	0.54	<0.01*	
Salt excretion	–0.53	–13.70	–15.69	–11.71	<0.01*	–0.65	–16.83	–18.23	–15.42	<0.01*	
Bone mineral density	0.16	0.74	0.33	1.15	<0.01*	–0.01	–0.05	–0.24	0.14	0.58	
Muscle mass	0.04	2.21	1.66	2.77	<0.01*	–1.69	–11.14	–15.37	–6.91	<0.01*	
BMR	0.32	0.08	0.06	0.10	<0.01*	1.84	0.45	0.30	0.59	<0.01*	
No. of teeth	–0.06	–0.44	–1.08	0.20	0.18	–0.08	–0.54	–0.83	–0.26	<0.01*	

(CI: confidence interval, HDL-C: high-density lipoprotein cholesterol, LDL-C: low-density lipoprotein cholesterol, TG: triglyceride, γ-GTP: γ-glutamyl transpeptidase, HbA1c: glycated hemoglobin, BMR: basal metabolic rate)
*P<0.05.
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between creatinine and sex (B=–42.24, P<0.01), body mass index (B=–1.80, P<0.01), blood glucose level (B=0.13, P=0.04), HbA1c (B=–5.16, P=0.03), sodium (B=0.42, P<0.01), potassium (B=0.44, P<0.01), salt excretion (B=–16.83, P<0.01), muscle mass (B=–11.14, P<0.01), basal metabolic rate (B=0.45, P<0.01), and the number of teeth (B=–0.54, P<0.01). Age group (B=0.31, P=0.89), HDL-C (B=0.06, P=0.47), LDL-C (B=–0.03, P=0.44), triglyceride (B=0.004, P=0.85), γ-GTP (B=–0.01, P=0.70), and bone mineral density (B=–0.05, P=0.58) were not correlated with creatinine.(Table 3)

The value of adjusted R^2, the coefficient of determination for the multiple regression model, was 0.83.(Table 3)

IV. Discussion

The most salient finding of this study was that the number of remaining teeth was associated with creatinine and eGFR,

indicators of kidney function. This result could be attributed to three major pathways. First, tooth loss due to periodontal disease may have had a direct impact on kidney function. Although the detailed mechanism underlying the effect of periodontal disease on kidney disease is unclear, several studies have suggested an association between them[20,21]. Basic research has suggested that obese rats with periodontitis are more likely to have impaired kidney function[22]. Clinical studies have suggested that clinical attachment loss greater than 6 mm is significantly associated with kidney function and bone metabolic markers[23]. Another study demonstrated a relationship between serum cystatin C levels and the number of missing teeth, suggesting that the decline in kidney function is associated with tooth loss[24]. Moreover, another study reported that the frequency of periodontal disease was higher in patients on dialysis than that in healthy individuals[25]. Thus, the background factors associated with tooth loss, such as periodontitis, may decrease kidney function.

Second, xerostomia is among the various oral abnormalities observed in several patients CKD; one study reported a significantly higher risk of missing teeth and dental caries in patients with CKD compared to those without CKD[26]. The salivary flow rate was also decreased in patients with CKD: lower creatinine clearance of 1 mL/min was associated with a higher tooth defect index of 0.02 teeth and a lower salivary flow rate of 0.003 (mL/min)[26]. This may be attributed to fluid restriction during the treatment of CKD and the complications of diabetes. Xerostomia limits the self-cleansing action of saliva, thereby increasing the risk of periodontal disease and dental caries[27,28]. Thus, it is possible that xerostomia may constitute one pathway explaining the association between the number of teeth and kidney function observed in our study. Taste disorders may also play an indirect role. Several patients with CKD reportedly develop taste disorders due to xerostomia[29]. In general, taste sensation is perceived by taste receptors while chewing, and the components of the food are mixed with and dissolve in saliva[29]. The decrease in salivary secretion manifests as a decrease in taste sensation. Alterations in the oral environment caused by changes in dietary habits may increase the risk of diseases that can culminate in tooth loss, such as dental caries and periodontal disease, although this is a distant but possible cause. In any case, the results suggest that not only does declining renal function cause problems with oral function but also that multiple age-related deterioration in oral function may act in concomitance to affect the overall condition of the patient.

Third, the number of remaining teeth may influence kidney function via factors related to dietary habits, including intermediate factors, such as salt intake and blood glucose levels. Excessive salt intake leads to blood pressure elevation and decreased kidney function[30]. Oral dysfunction has been shown to cause changes in food diversity, and one study reported excessive salt intake in more than 80% of participants over 50 years of age with oral dysfunction[31]. Another study reported that excessive salt intake was associated with masticatory ability[32].

In contrast, diabetes, an abnormality of glucose metabolism, causes complications such as cardiovascular disease and end-stage kidney disease[33]. Diabetic nephropathy is another complication of diabetes characterized by reduced kidney function due to elevated blood glucose levels[34]. The risk of diabetes has also been suggested to be increased by reduced food diversity due to poor oral function, which is suspected to be related to the number of remaining teeth[31,35].

Therefore, it is possible that the number of remaining teeth may have contributed to the worsening of dietary habits and decline in kidney function; however, the possibility of a third pathway is unlikely because salt intake, blood glucose, and HbA1c were included as variables in the multivariate analysis in the present study, and the number of remaining teeth showed an independent association with the creatinine level in addition to these variables. Thus, dental professionals should develop oral health protocols aimed at reducing the risk of systemic diseases, such as kidney function decline.

Oral prophylaxis provided by dentists and dental hygienists can prevent periodontitis and preserve teeth[36]. The prevention of periodontitis can be highly effective because it has the potential to improve both pathways. In other words, both above-mentioned pathways are modifiable that can be managed by dental professionals. Since this was a cross-sectional study, the reverse causal effect of reduced kidney function on the number of remaining teeth must also be considered. The importance of periodontal treatment has been noted in patients with CKD because their periodontal status may be worse than that of healthy individuals[37]. Another study identified an association between periodontitis and increased risk of mortality in patients undergoing long-term hemodialysis[38].

Nevertheless, dental professionals should consider closer collaboration with renal specialists for patients with impaired kidney function, since approximately 70% of hemodialysis facilities do not have an associated dental clinic in Japan[39]. The present study also clearly suggests an association between invariable factors (sex and body mass index) and kidney function, akin to previous studies[40,41]. Additionally, nu-

merous systematic reviews and meta-analyses have reported associations of variable factors such as bone mineral density, muscle mass, and basal metabolic rate with CKD, and their results are consistent with those of the present study[42-44].

This study has three limitations. First, this study incorporated a cross-sectional design, which precluded the establishment of a causal relationship between oral and renal dysfunction. In particular, the relationship between oral cavity and renal function has not yet been reported in a large number of cases. Therefore, it is also difficult to predict a causal relationship. Since it is assumed that the participants are healthy and physically active to begin with to participate in the health checkups, the possibility that the group is also highly aware of their own health behaviors influences the results. Second, there is a possibility of bias in the target population due to the healthy volunteer effect. Third, the lack of direct data on periodontal disease assessment means that the relationship of kidney function with periodontal disease cannot be estimated. In recent years, it has been recommended that the Periodontal Inflamed Surface Area (PISA) be utilized to determine the relationship between periodontal disease and diseases in the medical field; therefore, it was considered necessary to obtain PISA and other data for future studies. Therefore, future longitudinal studies with more detailed data on the causes of tooth loss are required.

V. Conclusion

The number of remaining teeth was associated with creatinine and eGFR, which are indicators of kidney function. Thus, preserving the dentition may prevent decline in kidney function. Dental professionals should devise oral health interventions with the aim of reducing the risk of systemic diseases, such as kidney function decline.

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Authors' Contributions

Y.N. wrote the manuscript. Y.M. conceptualized the entire study with the authors. S.W. and M.T. helped with data organization and manuscript preparation. T.A., K.T., and M.I. participated in data collection and helped with analysis; and T.K. was responsible for overseeing the planning and execution of study activities, including supervision of the study team. All authors read and approved the final manuscript.

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Ethics Approval and Consent to Participate

This study was approved by the Medical Research Ethics Committee of Shimane University Faculty of Medicine (No. 20220619-1). Written informed consent was obtained from all participants before data collection.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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