Original Article

Denture wearing is associated with nutritional status among older adults requiring long-term care: A cross-sectional study

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Abstract *Background/purpose:* Dentures are important for the reconstruction of occlusal support and masticatory performance for older adults with poor dentition. We aimed to elucidate the oral health factors associated with malnutrition in older adults requiring long-term care, including denture use.

Materials and methods: This cross-sectional study included 322 older adults (63 men, 259 women; mean age, 86.6 ± 6.9 years) who required long-term care in rural Japan. The participant's nutritional status was assessed using the Mini Nutritional Assessment-Short Form (MNA®-SF). Oral health was assessed using participant's dentition and oral function. Barthel Index (BI) and medical history were measured for assessing general health status. Multiple logistic regression analyses were performed to determine the oral health factors associated with malnutrition.

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Results: The proportion of participants with malnutrition was 17.2%. The BI score (odds ratio [OR], 0.95; 95% confidence interval [CI] 0.93–0.98, $p<0.001$), having <20 teeth and dentures (OR 0.42; 95%CI 0.18–0.99; $p = 0.047$), and poor lip-closure ability (OR 2.86; 95%CI 1.32–6.20; $p = 0.008$) were significantly associated with malnutrition.

Conclusion: Denture use, lip-closure ability, and activities of daily living were significantly associated with malnutrition in older adults requiring long-term care, suggesting that wearing dentures for tooth loss and maintaining oral function contributes to nutritional status.

Introduction

In recent years, Japan and other developed countries have faced a super-aging society; therefore, extending healthy life expectancy has become an important social issue. Previous reports have revealed oral health status plays an important role in maintaining nutritional status.[1–4] As the number of missing teeth increases among older populations, the need to wear removable dentures to reconstruct occlusal support has increased.[5] Appropriate denture placement has led to improved dietary content.[6–8] On the other hand, the nutritional intake of older denture-wearing adults has been shown to be lower than that of older adults with more of their own teeth, and the nutritional intake of older adults with fewer than 20 teeth or a full set of dentures is lower than that of older adults with more than 20 teeth.[9] Thus, these findings regarding the relationship between denture wearing and nutritional status are inconsistent.

In addition, most of the studies have focused on community-dwelling independent older adults, and there are few reports describing the relationship between oral function, including denture wear, and nutritional status among older adults requiring long-term with higher risk of malnutrition.[10] Furthermore, while some studies have examined the relationship between nutritional status and oral status in older adults requiring long-term care as single-centered study design, they have only evaluated occlusion and masticatory function, rather than the denture-wearing status among residents in only one long-term care facility.[11,12] It has been reported that the living location of the older adults requiring long-term care in Japan does not include only the facilities such as nursing home; therefore, a multi-centered study is necessary for verification based on the characteristics of the older adults requiring long-term care.[13]

Therefore, we aimed to clarify whether denture-wearing and oral function are related to nutritional status, we conducted a survey and cross-sectional study of older adults requiring long-term care who were living in a variety of environments in a rural area of Japan.

Materials and methods

Study design and population

The study population comprised of adults aged ≥65 years who were living in Akita Prefecture, which is in the northern part of Japan. The participants received long-term care based on the Japanese long-term care system and, as of February 1, 2019, they utilized day-service facilities and home-visit nursing care. Some of the participants lived in long-term care facilities or group homes for people with dementia or were admitted to disability or a general hospital. The framework for this research has been outlined previously.[13–16] Among the 389 individuals, we excluded those with incomplete data and those who received parenteral nutrition.

The survey information to be collected was explained to the nurses, facility staff, and registered dietitians who provided daily care to the participants. Oral health assessments were performed by dentists who participated in a 2-h training session prior to data collection.

This study was approved by the Ethics Review Board of the Research Department of the Tokyo Metropolitan Institute of Gerontology (R17-15). Written informed consent was obtained from each participant.

Nutritional status

The nutritional status of the participants was evaluated using the Mini Nutritional Assessment®-Short Form (MNA®-SF).[17,18] The MNA®-SF is comprised of six items: decrease in food intake, weight loss, mobility, presence of acute disease or psychological stress, neuro-psychological disorders, such as dementia and depression, and body mass index. The total possible scores for the MNA®-SF range from 0 to 14 points, with higher scores indicating a better nutritional state. According to the criteria, 12 points or higher was considered normal, 8 to 11 points was considered a risk for malnutrition, and 7 points or lower was considered an indication of malnourishment. This study divided the group into two groups: a malnourished group and a group with a combined "normal" and "risk for malnutrition," since malnutrition has a higher prevalence in the older adults requiring long-term care than the community dwelling older population.[17]

Dentition status

The number of teeth had was defined as the teeth that were present and missing teeth that had been treated with fixed prostheses, such as pontics and dental implants, as determined on intraoral examination. Each participant's dentition status was classified into one of the following

three groups, according to the number of teeth the participant had and the presence or absence of removal dentures: 1) a group with less than 20 teeth and no dentures, 2) a group with less than 20 teeth and dentures, and 3) a group with more than 20 teeth.[19]

Oral health assessment

Oral diadochokinesis (ODK) was evaluated using an articulatory oral motor skill measuring device (KENKOU-KUN Handy, Takei Scientific Instruments Co., Ltd., Niigata, Japan). The number of repetitions of the monosyllable "ta" per second was recorded. A low ODK value was assigned if the number of counts was less than six.[20,21]

Each participant's lip closure ability was assessed as follows: the participants were instructed to close their lips and inflate their cheeks, and the examiner rated the results as good if they were able to close their lips tightly so that air did not leak and poor if air leaked.

A cough test was conducted to examine swallowing function. The participants orally inhaled a mist of 1% citric acid–physiological saline using a portable mesh nebulizer (NE-U22, Omron, Kyoto, Japan). Each participant was instructed to inhale the nebulized citric acid through the mouth several times, until the first cough occurred. If the first cough was not evoked within 60 s, the outcome was judged as poor.[15]

Oral dryness was evaluated by assessing the presence of saliva on the back of the tongue and assigning a score based on the following four-point clinical diagnostic classification scale: 0: non-dry; 1: saliva shows viscosity; 2: saliva shows tiny bubbles on the tongue; 3: dry tongue without viscosity and little or no saliva. If a participant received a score of 1 (mild) or higher, oral dryness was recorded as 'present'.[22] The degree of tongue coating was evaluated by visual inspection using the tongue coat index (TCI) with ranging from 0 to 100 points. A higher score reflects poor oral hygiene.[23]

Covariates

Each participant's age, sex, body height, body weight, and medical history was transcribed from the nursing care records. Basic activities of daily living (ADLs) were evaluated using the Barthel Index (BI) with ranges from 0 to 100 points, in which higher scores reflect higher ADL function.[24] The skeletal muscle index (SMI) was evaluated using body composition measurements obtained with a multifrequency bioelectrical impedance analysis (InBody S10; InBody Japan, Tokyo, Japan). The SMI was calculated by normalizing the participant's skeletal muscle mass to their height (kg/m^2).[25] The texture of staple food the participant consumed was evaluated based on whether they ate a regular diet or a modified one consisting of soft foods, such as porridge.[13]

Statistical analysis

Each participant's nutritional status was categorized into either a combined "normal and at risk for malnutrition group" or a "malnutrition group," according to their MNA®-SF scores, after which each assessment index was

compared. A bivariate analysis was conducted using the Mann–Whitney U test for continuous variables and the chi-square test for categorical variables to analyze the differences between the groups. To identify the factors associated with malnutrition, a multiple logistic regression analysis (forced entry analysis) was performed with malnutrition as a dependent variable. Variables that resulted in a p-value <0.05 in the bivariate analysis were determined to be independent variables in multiple logistic regression analysis, and explanatory variables with correlation coefficients >0.8 were removed to avoid multicollinearity. SPSS Ver. 23.0 (IBM Japan) software was used for the statistical analyses, and the significance level was set at $p < 0.05$.

Results

Fig. 1 shows a flowchart of the participant selection process of this study. A total of 322 participants (63 men and 259 women: mean age, 86.6 ± 6.9 years) were included after excluding those with incomplete data (N = 38) and parenteral nutrition (N = 29). Table 1 shows the nutritional status characteristics of the study participants. In total, 17.7% of the participants were categorized into the malnutrition group, and 55.3% of the participants required diet modifications. In addition, 7.1% of the participants had 20 or more teeth present, and the proportion of those with fewer than 20 teeth and no dentures and those with fewer than 20 teeth with dentures was 41.3% and 51.6%, respectively. The participants in the malnutrition group had significantly lower BI and SMI scores, and a larger proportion ate a modified diet, had poor dentition and lip closure ability, and presented with oral dryness.

Table 2 shows the results of the multiple regression analysis of the relationship between the "normal and at risk for malnutrition" and "malnutrition" groups and their related factors. After adjusting for other factors, BI score (odds ratio [OR], 0.95; 95% confidence interval [CI] 0.93–0.98, $p<0.001$), having <20 teeth with dentures (OR 0.42; 95%CI 0.18–0.99; $p = 0.047$), and poor lip-closure
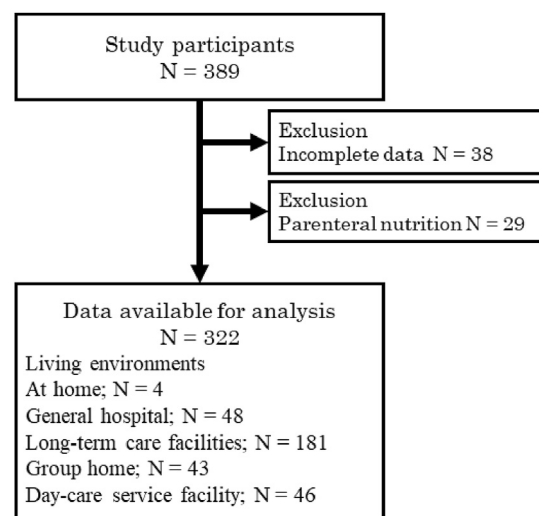

Figure 1 Study flow chart.

Table 1 Comparison of the characteristics according to nutritional status.

	Total (N = 322)		"Normal" and "risk for malnutrition" (N = 265)		Malnutrition (N = 57)		*p*-value
Age, median (IQR)	87.5	(83−92)	87.0	(83−91)	88.0	(84−92)	0.380[b]
Sex, female, N (%)	259	(80.4%)	215	(81.1%)	44	(77.2%)	0.496[a]
Medical history (presence), N (%)							
Aspiration pneumonia,	2	(0.6%)	1	(0.4%)	1	(1.8%)	0.231[a]
Cerebrovascular disorder	100	(31.1%)	77	(29.1%)	23	(40.4%)	0.098[a]
Respiratory disease	23	(7.1%)	18	(6.8%)	5	(8.8%)	0.604[a]
Circulatory disorder	174	(54.0%)	139	(52.5%)	35	(61.4%)	0.229[a]
Neoplastic disease	32	(9.9%)	24	(9.1%)	8	(14.0%)	0.258[a]
Parkinson's disease	15	(4.7%)	10	(3.8%)	5	(8.8%)	0.106[a]
Diabetes mellitus	58	(18.0%)	48	(18.1%)	10	(17.5%)	0.910[a]
Polypharmacy	216	(67.1%)	183	(69.1%)	33	(57.9%)	0.180[a]
BI score, median (IQR)	35.0	(10−75)	50.0	(15−80)	0.0	(0−10)	<0.001[b]
SMI (kg/m^2), median (IQR)	4.8	(3.9−5.6)	5.0	(4.1−5.7)	3.7	(3.0−4.6)	<0.001[b]
Type of staple food, N (%)							
Regular diet	144	(44.7%)	137	(51.7%)	7	(12.3%)	<0.001[a]
Modified diet	178	(55.3%)	128	(48.3%)	50	(87.7%)	
Dentition status, N (%)							
Number of teeth <20 without denture	133	(41.3)	91	(33.3%)	42	(73.7%)	<0.001[a]
Number of teeth <20 with denture	166	(51.6%)	156	(58.9%)	10	(17.5%)	
Number of teeth ≥ 20	23	(7.1%)	18	(6.8%)	5	(8.8%)	
Lip closure ability (poor), N (%)	65	(20.2%)	35	(13.2%)	30	(52.6%)	<0.001[a]
ODK/TA/(poor), N (%)	219	(68.0%)	199	(75.1%)	20	(35.1%)	0.655[a]
Oral dryness (present), N (%)	16	(5.0%)	8	(3.0%)	8	(14.0%)	<0.001[a]
TCI score, median (IQR)	11.1	(5.6−29.2)	11.1	(5.6−33.3)	11.1	(0.0−27.8)	0.411[b]
Cough reflection (absence), N (%)	67	(20.8%)	56	(21.1%)	11	(19.3%)	0.422[a]

CDR, Clinical Dementia Rating; BI, Barthel Index; SMI, Skeletal Muscle Mass Index; ODK, oral diadochokinesis; TCI, Tongue Coating Index; IQR, Interquartile Range.
[a] Chi-square test.
[b] Mann−Whitney U test.

ability (OR 2.86; 95%CI 1.32−6.20; *p* = 0.008) were identified as significant factors for malnutrition.

Discussion

To the best of our knowledge, this is the first investigation of the association between malnutrition and oral function, including the denture wearing status, in an older adult requiring long-term care living in a variety of settings. Our results show that basic ADLs, denture wearing, and lip closure ability are associated with nutritional status.

We used the MNA®-SF, among various nutritional assessment tools introduced such as serum albumin, and weight loss. The MNA®-SF is used widely to conveniently assess the nutritional status of older populations, both those that require long-term care and those that are community-dwelling, making it an appropriate assessment tool for this study population.[7,13,26] Moreover, since malnutrition in the older adults has a higher prevalence and its prevalence in those who need care could affect their life expectancy, this study focused on people with severe nutritional status and examined them in separate groups.[17] Our results indicate that a lower BI score was significantly associated with malnutrition. This result is in line with those of previous studies.[27−30]

Older adults who require long-term care tend to live in a variety of settings, including nursing homes, day care centers, group homes, hospitals, and private homes.[13] In Japan, the more severe the care needs, the more people use institutional services. Since many of the participants in this study had severe care needs, the percentage of those living in long-term care facilities was considerably high.[31] Thus, the population of this study reflects older adults in Japan who require long-term care.

We observed that denture wearing, rather than the number of teeth a participant had, was significantly associated with malnutrition. This would be due to that the participants were older adults requiring long-term care, and the proportion of those with 20 or more present teeth was lower than that of community-dwelling older adults, and the effect of dentures on multiple missing teeth was stronger than the number of present teeth.

Su et al. reported that partial denture replacement for missing teeth could prevent the risk of malnutrition.[7] The results of this study and previous studies suggest that reconstruction of occlusal support and recovery of masticatory ability through denture-wearing could contribute to improving and maintaining the nutritional status of older adults, particularly those who require long-term care and have fewer teeth. Many studies have reported that oral

Table 2 Multiple logistic regression analysis of associated factors with malnutrition.

	Model 1			Model 2			Model 3		
	OR	95% CI	*p*-value	OR	95% CI	*p*-value	OR	95% CI	*p*-value
Age (per one increase)	1.02	[0.97–1.06]	0.471	1.03	[0.98–1.08]	0.268	0.96	[0.91–1.02]	0.239
Sex (men = 0, women = 1)	0.80	[0.40–1.60]	0.529	0.85	[0.39–1.82]	0.668	0.91	[0.36–2.30]	0.848
BI score (per one increase)	0.94	[0.92–0.96]	<0.001				0.95	[0.93–0.98]	<0.001
SMI (per one increase)	0.66	[0.52–0.84]	<0.001				0.89	[0.72–1.10]	0.286
Type of staple food (0 = regular, 1 = modified)	7.85	[3.44–17.94]	<0.001				0.84	[0.27–2.57]	0.755
Dentition status									
Number of teeth < 20 without denture	reference			reference			reference		
Number of teeth < 20 with denture	0.14	[0.07–0.29]	<0.001	0.14	[0.07–0.29]	<0.001	0.42	[0.18–0.99]	0.047
Number of teeth ≥ 20	0.60	[0.21–1.73]	0.346	0.67	[0.23–1.99]	0.475	2.38	[0.61–9.29]	0.212
Oral dryness (0 = absence, 1 = presence)	5.27	[1.89–14.70]	0.002				0.57	[0.16–1.98]	0.378
Lip closure ability (0 = good, 1 = poor)	7.73	[4.10–14.58]	<0.001				2.86	[1.32–6.20]	0.008

BI, Barthel Index; SMI, Skeletal Muscle Mass Index: OR, odds ratio; CI, confidence interval;
Model 1 was crude model.
Model 2 was adjusted by age, sex, and dentition status.
Model 3 was fully adjusted model.

hypofunction affects nutritional status.[11,12,32,33] Hildebrandt et al. reported that many of the foods underconsumed by older adults are meats, vegetables, and fruits that require chewing ability, and people with reduced numbers of functional teeth, including those with dentures, tend to avoid difficult-to-chew foods, such as meat.[34] Restoring the number of functional teeth through denture-wearing may improve masticatory function, resulting in an increased selection of chewable foods, which can improve an individual's nutritional status.

In the present study, poor lip-closure ability was also associated with malnutrition. Lip motor function has been reported to be related to dietary habits and malnutrition, and the present results are consistent with previous studies.[35,36] Adequate lip motor function prevents solid matter and liquid from leaking from the oral cavity and is associated with masticatory function through movement in concert with the tongue and jaw muscles.[37–39] Therefore, lip motor function is significantly associated with the masticatory phase of ingestion, as well as the swallowing function, during oral intake. It has also been reported that the nutritional status of an older population requiring long-term care improved through oral function training, including lip closure force.[2,40] Our results, in combination with the findings from these previous studies, suggest that lip motor function may contribute to the improvement and maintenance of nutritional status.

Sheiham et al. reported that tooth loss was associated with nutritional status, as assessed by blood samples and dietary records, among both independent-living and institutionalized older participants in the United Kingdom.[9] Our results show that denture wearing is significantly associated with nutritional status (as assessed by the MNA®-SF) in an older population requiring long-term care in Japan. Although the nutritional status evaluation methods we used were not the same as those of the Sheiham et al. study, implementation of denture management may contribute to

nutritional status maintenance for both the older population requiring long-term care and the independent older population. An individual's denture wearing status and lip closure ability can be easily evaluated, not only by dental professionals, but also by nurses and nursing staff who can observe daily life activities. The assessment of denture wearing and lip function by multiple professionals would be effective as an index for the early detection of malnutrition risk in older populations requiring long-term care. The intervention study to validate the effect of denture treatment on the nutrition improvement for older persons requiring long-term care will be necessary in the future.

There are several limitations to the present study. First, this was a cross-sectional study; therefore, a causal relationship could not be determined. In the future, longitudinal or interventional studies should be conducted to clarify more detailed associations. In this study, we did not obtain the data regarding the duration of utilizing long-term care services. The possibility of the length of time of long-term care needed affecting the nutritional status cannot be denied. Since nutritional status was associated with both oral and non-oral factors, such as socioeconomic status, other different diseases, and appetite in a previous study, these items should also be considered as confounding factors in future studies.[26]

In conclusion, our results indicate that nutritional status is related to denture wearing, basic activities of daily living, and lip closure ability in older adults requiring long-term care. This indicated that older adults in long-term care environments who have difficulty wearing dentures or decreased lip closure ability could be at an increased risk of malnutrition, denture wearing and maintaining oral function may help maintain or improve nutritional status.

Declaration of competing interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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