Received: 30 January 2018 | Revised: 16 January 2019 | Accepted: 29 January 2019
DOI: 10.1002/jgf2.240

ORIGINAL ARTICLE

Journal of General and Family Medicine
WILEY

# Elderly patients with lower-jaw mobility require careful food texture modification: A cohort study

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## Abstract

**Background:** Few studies have investigated the relationship between lower-jaw mobility and oral ingestible food texture choices in elderly patients. This study aimed to evaluate whether lower-jaw mobility affects levels of food texture modification.

**Methods:** This prospective cohort study targeted inpatients aged ≥65 years with pneumonia or urinary tract infection from August 2014 through July 2015. We defined "lower-jaw mobility" as movement of the lower jaw (more than about 1 cm) when gently supported from both sides of the mandibular angle with index fingers. The primary outcome was food texture at discharge, which was evaluated using "Japanese Dysphagia Diet 2013": non per os, codes 0-4 (in the order of increasing swallowing difficulty), and normal meal.

**Results:** We evaluated 38 patients in the mobility group (mean age: 86.5 years) and 251 patients in the nonmobility group (mean age: 83.2 years). Percentages of patients capable of ingesting each food texture were as follows (mobility vs nonmobility): normal meal, 5.3% vs 50.1%; code 4, 39.5% vs 31.9%; code 3, 5.3% vs 8.8%; code 2, 10.5% vs 4.4%; code 1, 2.6% vs 0.8%; code 0, 0.0% vs 0.4%; and non per os, 36.8% vs 2.8%. Food texture codes were lower in the mobility group ($P < 0.001$). These relationships remained significant even after adjusting for potential confounding factors in multivariate analysis ($P < 0.001$).

**Conclusion:** Elderly patients with lower-jaw mobility were restricted to texture-modified foods. Lower-jaw mobility can be assessed easily even by nonmedical personnel, and regular assessment could help identify elderly patients requiring dietary adjustment.

KEYWORDS
elderly patients, food texture, lower-jaw mobility, oral frailty

## 1 | INTRODUCTION

As the elderly population rapidly grows in Japan, frailty and sarcopenia have become great concerns.[1] Many factors including age and muscle mass affect frailty. Frailty is reportedly related to oral function in elderly adults,[2] and sarcopenia has been reported to be associated with chewing ability[3] and swallowing problems.[4] In addition, oropharyngeal dysphagia is a risk factor for malnutrition and lower respiratory tract infection in older persons.[5] Pneumonia is the third most common cause of death in Japan,[6] and the rate of aspiration pneumonia is higher in older persons.[7] Therefore, dysphagia and oral function should be assessed routinely so that intraoral intake adjustments can be made to prevent aspiration pneumonia. However, no simple methods for identifying poor oral function in elderly patients at risk of dysphagia are available, particularly those that even nonmedical personnel can use.

The lower-jaw position of elderly patients with aspiration pneumonia differs from that of the normal position in that the lower-jaw drops and easily moves. Some of these elderly patients likely require texture-modified foods, and we hypothesized that lower-jaw mobility could affect the texture of food that elderly patients can eat. However, few studies have reported on the relationship between lower-jaw mobility and oral ingestible food texture choices. Accordingly, this study aimed to evaluate whether lower-jaw mobility affects the levels of food texture modification required by elderly inpatients.

## 2 | MATERIALS AND METHODS

This prospective cohort study targeted inpatients of the Department of General Internal Medicine (DGIM) of Fukuchiyama City Hospital, which is a regional center hospital in the northern part of Kyoto. The hospital has 354 beds (310 beds for acute phase inpatients and 44 beds for the subacute rehabilitation unit) and an emergency medical care center. There are about 100 000 residents in the medical district covered by this hospital. As there is no other central hospital in the district, many patients visit the hospital for inpatient treatment in the acute phase.

This study was conducted as part of the “Exploring infectious diseases in DGIM inpatients over the course of 1 year” project that was in effect from August 2014 through July 2015 at Fukuchiyama City Hospital. In that project, the characteristics of infectious diseases in DGIM inpatients were examined over the course of a year. There were 376 inpatients enrolled in that project, and we used the patient database from the project in the present study.

This study was approved by the ethics committee of Fukuchiyama City Hospital. We provided patients and their relatives with the opportunity to opt out, and this information was provided on the Fukuchiyama City Hospital website.

### 2.1 | Study subjects

From August 2014 through July 2015, patients aged ≥65 years who were hospitalized in the DGIM for the treatment of pneumonia or urinary tract infection were enrolled.

Almost all patients who had acute phase pneumonia and/or urinary tract infection and required hospitalization were admitted to the DGIM. A majority of these patients were elderly patients, with some being frail or near frail. Thus, these patients were at risk of developing dysphagia.

Diagnoses of pneumonia and urinary tract infection were determined on admission by several physicians based on patient history, physical examination, chest x-ray (or chest computed tomography scan), and laboratory findings. All diagnoses were confirmed at DGIM conferences, which were held every 3 or 4 days.

Patients who were transferred to other medical departments to treat comorbidities, and in-hospital death cases, were excluded from the analysis.

Patient characteristics including age, gender, Barthel Index, serum albumin on admission, body mass index, length of hospital stay, type of residence after discharge (discharge to home or discharge to a place other than home such as a nursing home and another hospital) were collected.

### 2.2 | Variables

#### 2.2.1 | Lower-jaw mobility

Lower-jaw mobility was assessed at rest within 1 week after hospital admission. We gently supported both sides of the mandibular angle of a patient in the dorsal position with index fingers, and then evaluated whether the lower jaw could move upward (approximately in a direction parallel to the upper jaw). When the lower jaw could easily move more than about 1 cm, the patient was considered to have “lower-jaw mobility” and the patient was classified into the mobility group (Figure 1). Other patients were classified into the nonmobility group.

Lower-jaw mobility was assessed by at least two DGIM physicians. In many cases, one of the physicians was the attending physician. If assessments were inconsistent, physicians discussed until a consensus was reached, or lower-jaw mobility was confirmed during morning rounds, which were held almost every weekday and which almost all DGIM physicians attended.

A pilot study was conducted in advance of the present study. The pilot study involved an evaluation of lower-jaw mobility of 10 patients during DGIM rounds in order to standardize lower-jaw mobility measurements.

#### 2.2.2 | Levels of food texture modification

Levels of food texture modification at the time of discharge were classified according to the Japanese Dysphagia Diet 2013 by the dysphagia diet committee of the Japanese Society of Dysphagia Rehabilitation[8] (code 0-code 4, in order of increasing swallowing difficulty). Patients with severe dysphagia can only ingest code 0 food (main content of code 0 was jelly). Patients with slightly decreased swallowing ability are able to ingest code 4 food (soft boiled rice as a staple food). Normal meal (NM) was defined separately. Examples of each food code in this study are shown in Figure 2. Patients with oral feeding difficulty (ie, tube feeding or infusion therapy without oral intake) were also classified separately and defined as non per os (NPO). NM patients who had minor issues due to decreased swallowing ability were given code 4 food. These patients were evaluated for the ability to eat without swallowing problems. When the patients had difficulty with

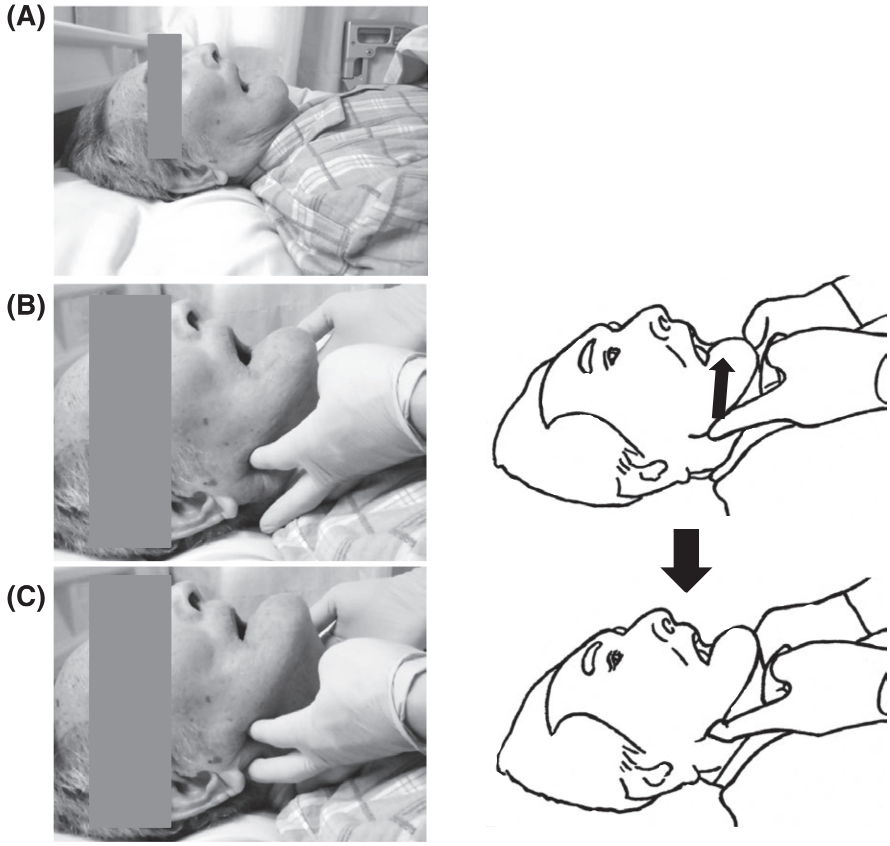


**FIGURE 1** Evaluation of "mobility of the lower jaw". A, Patient in the dorsal position; B, Both sides of the mandibular angle are gently supported with index fingers. C, We evaluated whether the lower jaw could move upward (approximately in a direction parallel to the upper jaw). If the lower jaw can easily move more than about 1 cm, the patient was considered to have "lower-jaw mobility" and was classified into the mobility group

code 4 foods, code 3 foods were tried. Each inpatient was introduced to the most appropriate diet according to their food texture choice before admission, as well as swallowing assessment by the attending nurse or doctor soon after admission.

Food intake was typically evaluated by attending nurses at every meal. In some complicated cases, attending physicians and a nutrition support team (including doctors, nurses, dedicated nutritionist, and speech therapist who helped with swallowing practice) also evaluated food intake. Food intake was assessed based on the below protocol, which was adapted from a previous study[9]:

1. Time required for food intake is within 30 minutes.
2. Ingestion of more than 70% of the meals served.
3. Conditions 1 and 2 are satisfied in more than 3 meals.

When all these criteria were met, a higher-code food texture was tried and evaluated. If there were problems with eating and swallowing the food, then a lower-code food texture was tried and evaluated. Patients on partial oral feeding and tube feeding or drip infusion were categorized by food texture. If the food texture code differed between the principal diet and accompanying dish, the higher code was used.

The relationships between lower-jaw mobility and levels of food texture modification at discharge were examined.

We also evaluated the texture of food that patients were eating prior to admission by interviewing family members and/or staff of the facility where the patients lived. Food texture before admission was classified in the same manner described above. Food texture at discharge was then compared with food texture before admission, and the number of patients whose food texture code worsened was compared between the mobility group and nonmobility group.

#### 2.2.3 | Oral cavity condition and use of artificial denture

The condition of the oral cavity was assessed by DGIM physicians using Eilers' Oral Assessment Guide (OAG),[10] which consists of 8 items. Each item is scored on a scale of 1 (normal) to 3 (severe problems), with total scores ranging from 8 (no oral problems) to 24 (severe oral problems). Patients were classified as having normal oral health (total OAG score of 8), mild to moderate oral problems (total OAG score of 9-12), or severe oral problems (total OAG score of 13-24).

The use of artificial dentures was also evaluated. Patients were classified as having more than half of their own teeth remaining and/or wearing dentures regularly during the day, or wearing no dentures or wearing dentures only at meal time.

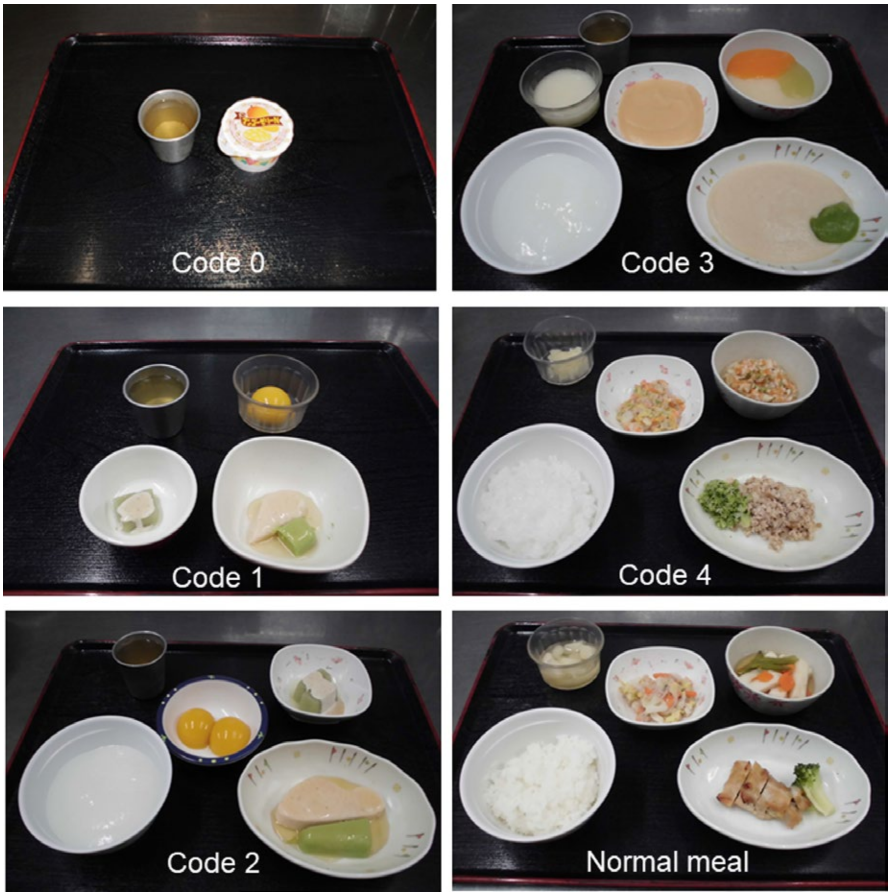


**FIGURE 2** General sample of each food code. Code 0: jelly; Code 1: mousse diet; Code 2: pasted food; Code 3: rice gruel and minced accompanying dish with thickness, which does not cause much water separation; Code 4: soft boiled rice and minced accompanying dish. Normal meal (NM): normal boiled rice and normal accompanying dish without altering texture

### 2.3 | Subgroup analysis and multivariate analysis

Patients were divided into two groups based on the type of residence after discharge: home (patient's or family's home) or other than home (nursing home or another hospital). Relationships between lower-jaw mobility and levels of food texture modification at discharge were then examined in each group.

With food texture at discharge as the objective variable, we performed multivariate analysis using ordered logistic regression. Given the relatively small study population, we selected explanatory variables that were potential confounding factors and include them in the analysis with the forced entry method. The Barthel Index is related to swallowing function,[11] and hospital stay can lead to frailty in older patients.[12] Two models were analyzed (Model A and Model B). Model A included the following explanatory variables: age, gender, Barthel Index on admission, length of hospital stay, and type of residence after discharge. Model B included all explanatory variables from Model A except for type of residence after discharge.

Continuous variables were transformed to the categorical variables as follows: (a) age: by decade; (b) Barthel Index: quartile of Barthel Index score, 0-15, 20-40, 45-70, and 75-100; and (c) length of hospital: ≤10, 11-20, 21-30, and >30 days.

The Brant test was used to evaluate the parallel regression assumption of the ordered logistic regression model.

### 2.4 | Statistical analysis

Variables were compared between the mobility group and nonmobility group using the statistical tests described below. Age, Barthel Index, serum albumin, body mass index, and length of hospital stay were analyzed using Student's *t* test. Disease, gender, type of residence after discharge, food texture code at discharge, food texture before admission, comparison of food texture between at discharge and before admission, oral condition assessed by OAG, and denture use were compared using the chi-square test. Codes of food texture in the subgroup analysis (two groups according to type of residence) were compared using Fisher's exact test. Statistical analyses were performed using STATA software, version 15.0 (StataCorp LLC, Texas, USA).[13]

## 3 | RESULTS

In total, 319 patients were enrolled in the present study. One patient was transferred to the Department of Circulation to treat infectious

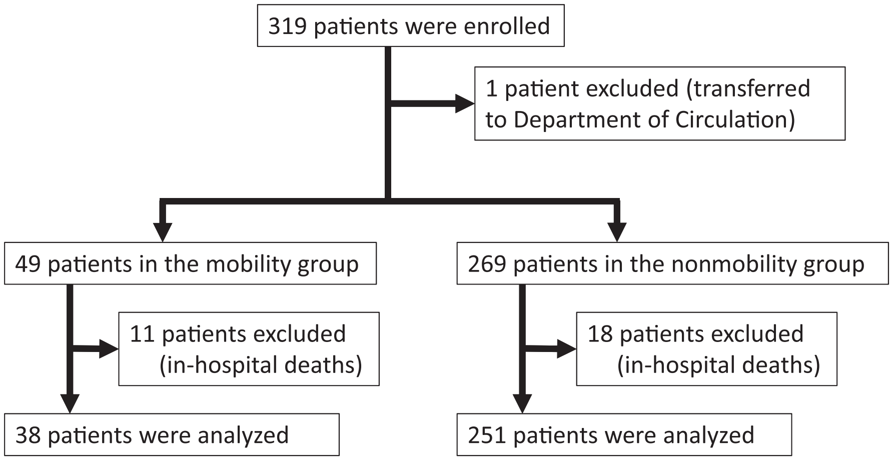


**FIGURE 3** Flowchart of patient recruitment

endocarditis. Eleven patients in the mobility group and 18 patients in the nonmobility group died during hospitalization (Figure 3). After excluding in-hospital death cases, there were 38 patients in the mobility group (mean age: 86.5 years) and 251 patients in the nonmobility group (mean age: 83.2 years). Table 1 summarizes the characteristics of these patients. Table 2 shows food texture at discharge for both groups. Codes of food texture were lower in the mobility group compared to the nonmobility group. Table 3 shows information about food texture before admission obtained through interviews. Next, food texture at discharge was compared with food texture before admission, after excluding missing data. In the mobility group, food texture codes of 16 patients (45.7%) at discharge were lower than codes before admission (codes were not lower in 19 patients). In the nonmobility group, food texture codes of 82 patients (33.3%) at discharge were lower than codes before admission, while codes of 164 patients were not lower at discharge ($P < 0.001$).

Results of oral condition evaluations by OAG were as follows (mobility group vs nonmobility group): normal oral health, 4 (10.5%) vs 104 patients (41.4%); mild to moderate oral problems, 21 (55.3%) vs 102 patients (40.6%); and severe oral problems, 12 (31.6%) vs 38 patients (15.1%) ($P < 0.001$; 1 patient with missing data in the mobility group and 7 patients in the nonmobility group). Roughly 61.0% of patients in the nonmobility group and only roughly 18.4% of patients in the mobility group ($P < 0.001$) were classified as having more than half of their own teeth remaining or wearing dentures regularly during the day.

**TABLE 1** Characteristics of patients

| | Mobility group | Nonmobility group | *P*-value |
|---|---|---|---|
| N | 38 | 251 | |
| Age | | | |
| Mean | 86.5 ± 8.02 | 83.2 ± 8.05 | 0.01* |
| Median | 87 | 84 | |
| Gender | | | |
| Male n (%) | 24 (61.5%) | 104 (41.4%) | 0.012** |
| Disease[a] | | | |
| Pneumonia (n) | 33 | 171 | 0.043** |
| Urinary tract infection (n) | 7 | 86 | |
| Barthel Index | 27.5 | 65.8 | <0.001* |
| Serum albumin (g/dL) | 3.13 | 3.33 | 0.02* |
| Body mass index (kg/m$^2$) | 17.3 | 20.3 | <0.001* |
| Length of hospital stay (day) | 25.2 | 13.8 | <0.001* |
| Discharge to home n (%) | 15 (39.4) | 186 (74.1) | <0.001** |

[a]Some patients had both pneumonia and urinary tract infection.
*$t$ test; **Chi-square test.

## 3.1 | Subgroup analysis and multivariate analysis

Results of the subgroup analysis by type of residence after discharge are shown in Table 4. Codes of food texture were lower in the mobility group for both subgroups.

Table 5 shows the results of ordered logistic regression analysis and the Brant test. The *P*-value in the Brant test for type of residence after discharge in Model A was <0.05, and we could not rule out the possibility of the violation of the parallel regression assumption. In contrast, in Model B, all *P*-values for the Brant test were not greater than 0.05. Lower-jaw mobility and Barthel Index on admission were independent significant variables in the multivariate analysis. Patients with lower-jaw mobility and lower Barthel Index on admission tended to eat foods with a lower code texture.

# 4 | DISCUSSION

Elderly patients with lower-jaw mobility were restricted to texture-modified foods, with only a few able to eat normal meals. Moreover, patients in the mobility group had poorer oral condition than patients in the nonmobility group and did not use "their teeth"

**TABLE 2** Food texture comparison between mobility group and Nonmobility group at discharge

| | Food texture at discharge | | | | | | |
|---|---|---|---|---|---|---|---|
| | Normal meal | Code 4 | Code 3 | Code 2 | Code 1 | Code 0 | Non per os |
| Mobility group, n (%) | 2 (5.3) | 15 (39.5) | 2 (5.3) | 4 (10.5) | 1 (2.6) | 0 (0.0) | 14 (36.8) |
| Nonmobility group, n (%) | 128 (50.1) | 80 (31.9) | 22 (8.8) | 11 (4.4) | 2 (0.8) | 1 (0.4) | 7 (2.8) |

*P* < 0.001 by chi-square test.

**TABLE 3** Food texture comparison between mobility group and nonmobility group before admission

| | Food texture before admission | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Normal meal | Code 4 | Code 3 | Code 2 | Code 1 | Code 0 | Non per os | Data missing |
| Mobility group, n (%) | 13 (34.2) | 12 (31.6) | 0 (0.0) | 5 (13.2) | 0 (0.0) | 0 (0.0) | 5 (13.2) | 3 |
| Nonmobility group, n (%) | 193 (76.9) | 43 (17.1) | 2 (0.8) | 3 (1.2) | 1 (0.4) | 0 (0.0) | 4 (1.6) | 5 |

*P* < 0.001 by chi-square test.

**TABLE 4** Food texture comparison at discharge for type of residence after discharge

| | Food texture at discharge | | | | | | |
|---|---|---|---|---|---|---|---|
| | Normal meal | Code 4 | Code 3 | Code 2 | Code 1 | Code 0 | Non per os |
| Discharge to home | | | | | | | |
| Mobility group, n (%) | 2 (13.3) | 9 (60.0) | 1 (6.7) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 3 (20.0) |
| Nonmobility group, n (%) | 113 (60.8) | 54 (29.0) | 13 (7.0) | 1 (0.5) | 0 (0.0) | 1 (0.5) | 4 (2.2) |
| Discharge to nursing home or another hospital | | | | | | | |
| Mobility group, n (%) | 0 (0.0) | 5 (21.7) | 2 (8.7) | 4 (17.4) | 1 (4.3) | 0 (0.0) | 11 (47.8) |
| Nonmobility group, n (%) | 15 (23.1) | 26 (40.0) | 9 (13.8) | 10 (15.4) | 2 (3.1) | 0 (0.0) | 3 (4.6) |

*P* < 0.001 by Fisher's exact test.

**TABLE 5** Multivariate analysis using ordered logistic regression

| | Model A | | | | Model B | | | |
|---|---|---|---|---|---|---|---|---|
| | Adjusted odds ratio | 95% CI | *P*-value | *P*-value for the Brant test | Adjusted odds ratio | 95% CI | *P*-value | *P*-value for the Brant test |
| Lower-jaw mobility | 0.25 | 0.12-0.53 | <0.001 | 0.236 | 0.21 | 0.10-0.44 | <0.001 | 0.147 |
| Age | 0.79 | 0.59-1.06 | 0.121 | 0.069 | 0.82 | 0.61-1.10 | 0.198 | 0.143 |
| Gender | 0.99 | 0.60-1.64 | 0.962 | 0.494 | 0.93 | 0.56-1.54 | 0.779 | 0.497 |
| Barthel Index on admission | 3.02 | 2.28-4.00 | <0.001 | 0.334 | 3.43 | 2.62-4.50 | <0.001 | 0.483 |
| Length of hospital stay | 0.89 | 0.65-1.22 | 0.481 | 0.036 | 0.84 | 0.62-1.13 | 0.253 | 0.202 |
| Type of residence after discharge | 0.50 | 0.34-0.74 | 0.001 | 0.002 | | | | |

regularly and properly. Although residence type after discharge was a potential confounder of the association between lower-jaw mobility and food texture at discharge, subgroup analysis revealed that codes of food texture were lower in the mobility group regardless of residence type after discharge. Multivariate analysis also found that patients with lower-jaw mobility tended to eat foods with a lower code texture after adjusting for age, gender, length of hospital stay, and Barthel Index on admission.

Both the number of residual teeth and occlusal force affect masticatory performance.[14,15] Reduced occlusal force could limit the types of meals patients can ingest, regardless of their socioeconomic status or the number of remaining teeth.[16] Previous studies have reported that a decrease in tongue pressure reflects symptoms of dysphagia[17] and that head lifting strength is associated with dysphagia.[18] Various muscle forces and functions inside and outside the mouth are related to swallowing function. A decline in these muscle forces causes “oral frailty,” which leads to impaired oral intake.

Lower-jaw mobility measured in the present study likely reflects reduced muscle strength around the oral cavity. The mobility group had a higher in-hospital mortality rate, lower Barthel Index score, and lower body mass index compared to the nonmobility group, suggesting that this group included patients with advanced frailty. This could explain why their food intake was restricted, requiring food texture modification to allow for oral feeding. Moreover, the mobility group had a poorer oral environment. Given that the oral environment is reportedly associated with the development of pneumonia,[19] the mobility group may represent a patient population requiring more active interventions, such as oral care.

Reduced oral function leads to restricted oral intake and malnutrition. The lower the ability to tolerate oral intake, the more undernourished and frail the patient becomes; this is a vicious frailty cycle.[20] Oropharyngeal dysphagia is a risk factor for malnutrition and lower respiratory tract infection.[5] In the present study, the proportion of patients who had more than half of their own teeth remaining or wore dentures regularly during the day was lower in the mobility group. This finding suggests that the number of functional teeth was lower in the mobility group. As our findings highlight, it is important to identify patients with swallowing or oral problems, perform appropriate interventions, and prevent the frailty cycle by improving oral intake. Lower-jaw mobility can be easily and regularly assessed by nonmedical workers such as family members or care staff, in addition to medical workers. It can lead to the early detection of conditions requiring dietary adjustments, and concurrently enables a proactive response to feeding difficulties by patients and their family members.

The relationship between lower-jaw mobility and oral ingestible food texture was also confirmed by asking family members and/or care staff about prehospitalization food texture. The percentage of patients with food texture levels at discharge that were lower than prehospitalization levels was larger in the mobility group compared to the nonmobility group. This suggests that more patients in the mobility group were likely not provided with appropriate foods they could eat without problems before admission. Lower-jaw mobility does not develop after admission or after the onset of pneumonia and/or urinary tract infection. Rather, lower-jaw mobility results from frailty. Our findings suggest the importance of regularly assessing oral frailty, for example, by evaluating lower-jaw mobility.

This study has some limitations. First, we did not consider disease severity. The degree of frailty varied from patient to patient, and patient characteristics differed between the two groups. However, these differences are unlikely to have influenced our conclusion, in view of the objectives of the present study. Second, we did not consider the presence or absence of underlying diseases that could increase muscle tonus, such as Parkinson's disease. Moreover, we did not consider comorbidities or temporomandibular joint-related diseases such as temporomandibular disorder. Third, participants were limited to elderly inpatients with pneumonia or urinary tract infection (1 patient who was transferred to another department was excluded). This may have led to selection bias. Notwithstanding, many elderly inpatients with pneumonia or urinary tract infection are frail or near frail. Thus, this population appeared to be suitable for the purpose of this study. Fourth, since the study was not performed in a blinded manner, there may have been information bias (eg, observer bias). Moreover, some cases were assessed by the authors, who are DGIM physicians. Fifth, although we attempted to standardize lower-jaw mobility measurements in the pilot study, the measurements were not examined rigorously. Moreover, although lower-jaw mobility is not a region-specific property, the present study used data from a single center, and thus, caution should be exercised when generalizing the results.

In conclusion, the present study revealed that elderly patients with lower-jaw mobility are restricted to texture-modified diets. Our findings will contribute to the further development of geriatric care.

## ACKNOWLEDGEMENTS

The authors thank Dr. Keisuke Enomoto and Ms. Yukiko Nakai for their lots of assistance in making Figures. We would also like to thank all members of Department of General Internal Medicine for their contribution to this study.

## CONFLICT OF INTEREST

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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**How to cite this article:** Wada M, Hanamoto A, Kawashima A. Elderly patients with lower-jaw mobility require careful food texture modification: A cohort study. *J Gen Fam Med*. 2019;20:93–100. https://doi.org/10.1002/jgf2.240