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Original Article

# Lower SMI is a risk factor for dysphagia in Japanese hospitalized patients with osteoporotic vertebral and hip fracture: A retrospective study

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ABSTRACT

*Objectives:* Many patients with osteoporotic fragile fracture often suffer from dysphagia that results in malnutrition, further deterioration of physical strength, and rehabilitation difficulties. This study aims to investigate the risk factors for dysphagia in hospitalized patients with osteoporotic vertebral and/or hip fractures.

*Methods:* Between January 2020 and December 2021, 569 inpatients were managed for osteoporotic vertebral or hip fractures. Of these, 503 patients were analyzed and 66 were excluded as the required data could not be obtained or dysphagia with causative diseases such as cerebrovascular disease. The patients were divided into 2 groups: patients with dysphagia (P-group) and patients without dysphagia (N-group). We investigated gender, fracture site, age, systemic skeletal muscle mass index (SMI), bone mineral density (BMD), and body mass index (BMI) in early stage of hospitalization and studied their relationship with dysphagia.

*Results:* There were no significant differences in gender and fracture site between the 2 groups. A significant difference was observed in age, SMI, BMD, and BMI ($P < 0.01$). We performed a logistic regression analysis with the P-group as the objective variable and age, SMI, BMD, and BMI as explanatory variables. We divided objective groups into all patients, patients with vertebral fracture, patients with hip fracture, men, and women. SMI was an independent risk factor in all groups.

*Conclusions:* Lower SMI was a risk factor for dysphagia in hospitalized patients with osteoporotic vertebral and hip fractures. We carefully observed swallowing function of patients with decreased SMI to maintain the nutritional status and prevent rehabilitation difficulties.



## 1. Introduction

Many patients with osteoporotic fragile vertebral and hip fractures hospitalized for inability to walk are naturally weak of their physical strength and further deteriorate after hospitalization. Dysphagia is present in a large number of the elder osteoporotic hip fracture population and there are many cases in which rehabilitation does not proceed as expected [1,2]. Furthermore, many patients with dysphagia result in malnutrition, further deterioration of physical strength, and difficulty in rehabilitation [1]. In patients with osteoporotic fragile vertebral and hip fractures, dysphagia may be major reason for weakness of their physical strength.

In recent years, patients with dysphagia often do not present with causative diseases such as cerebrovascular disease, neuromuscular disease, head and neck cancer, and drugs. In these cases, it is thought that sarcopenia causes dysphagia [3]. Dysphagia in sarcopenia is called sarcopenic dysphasia, and refers to a condition wherein eating and swallowing functions are impaired due to an

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overall decrease in skeletal muscle strength and muscle mass and has recently come to be regarded as a disease concept [3,4]. Sarcopenic dysphagia has been reported to coexist with various diseases such as dementia, liver cirrhosis, chronic obstructive pulmonary disease (COPD), and COVID-19 [5–8]. Since most patients with sarcopenic dysphagia are elderly and may therefore have a high risk of fragile fractures due to osteoporosis.

Under these circumstances, it is important to identify early after hospitalization inpatients with osteoporotic fragile fractures who were likely to have difficulty swallowing, to facilitate rehabilitation and early discharge and provide early swallowing training. Love et al [1] reported that early identification of dysphagia has important implications for the provision of timely dysphagia management that may prevent secondary complications and potentially reduce the hospital length of stay of osteoporotic hip fracture. Kuroda et al [4] reported that low systemic skeletal muscle mass index (SMI) is a risk factor for aspiration pneumonia and dysphagia. Lower SMI also indicated a higher incidence of dysphagia after hip fracture surgery [1,2].

However, it is difficult to measure SMI soon after hospitalization, as many instruments require the patient to maintain a standing position for a certain period of time. Therefore, it is often difficult to measure the SMI of patients with vertebral and hip fractures. However, the measuring instrument used in our hospital helps determine the bone mineral density (BMD) and SMI with the patient in the supine position. Previously, in our hospital we had been providing osteoporosis liaison services involving multiple departments, and all cases of orthopedic inpatients; BMD was determined for men aged $\geq$ 60 years and women aged $\geq$ 50 years. Therefore, to identify patients who were prone to dysphagia among patients who were hospitalized with osteoporotic fragile fractures and SMI and body mass index (BMI) were measured at the time of BMD measurement soon after hospitalization, and we investigated the risk factor for dysphagia. We aim to examine whether it could be used in interventions such as swallowing rehabilitation, oral care, maintenance of nutritional status, and an implementation plan for smooth rehabilitation.

## 2. Methods

### 2.1. Patients

Between January 2020 and December 2021, 569 patients that were hospitalized for fragile osteoporotic vertebral or hip fractures were enrolled into this study. Osteoporotic fragile fracture was defined as a non-traumatic fracture caused by a slight external force such as a fall from a standing height or lower, according to the report of Soen et al [9]. From a total of 569 cases, we selected and assessed 503 cases. We excluded 50 cases as the required data could not be measured due to restlessness, poor general condition, or other reasons, and 16 cases who had dysphagia with causative diseases such as neurological and respiratory medical comorbidities. There were 111 men and 392 women; overall 148 had vertebral fractures and 355 had hip fractures. Patients undergoing surgery were 378 (hip fracture:354) and patients with conservative therapy were 125 (hip fracture:1).

### 2.2. Evaluation of swallowing ability

We stratified the patients such that patients with dysphagia, including aspiration pneumonia, who underwent swallowing training were assigned to the Patient group (P-group), and the others were assigned to the Normal group (N-group). Although most inpatients with fragile vertebral body or hip fractures could not maintain a sitting position for a certain period of time, we ensured that they were evaluated only after being able to maintain the sitting position for at least a short period, such as during mealtimes. The patients who had aspiration pneumonia were judged to have dysphagia (the P-group). In patients without aspiration pneumonia, the patients with a Food Oral Intake Scale (FOIS) level [10] of $\leq$ 5 were diagnosed with dysphagia, and were defined as the P-group. We evaluated the state of swallowing ability by 2 or more swallowing evaluation trainers or speech therapists.

### 2.3. Statistical method

Gender, fracture site (vertebra or hip), age, SMI, BMD, and BMI were compared between the P- and N-groups, and risk factors for dysphagia were analyzed.

### 2.4. Data collection

SMI (kg/m$^2$), BMD (%), and BMI (kg/m$^2$) were measured in the supine position using Prodigy Fuga Advance (GE Healthcare, Madison, WI, USA) by the dual-energy X-ray absorptiometry measurement method (DXA method). For patients who could not maintain the supine position during measurement due to dementia or other reasons, radiologists lightly suppressed the limbs and the calves when measuring the lumbar spine and proximal femur, respectively, for BMD. The percentage of young adult mean is adopted as BMD values. Of the mean of L1-4 anterior view and the proximal femur on one side, a lower BMD was adopted. In patients with both of hip fractures, the L1-4 mean BMD value was used. When we measured BMD of L1-4 anterior view, we included the fractured vertebral body/bodies as well, even if patients had fractures in some of L1-4 vertebrae.

### 2.5. Statistical analysis

For univariate analyses, statistical processing was tested by the unpaired *t*-test or the chi-square test. The significant level of statistical analysis was set at the level of P-value $< 0.05$. For multivariate analysis, we used logistic regression analysis with the P-group as the objective variable and the factors with a significant difference in univariate analyses as explanatory variables.

### 2.6. Ethics approval and consent to participate

Based on the 1964 Declaration of Helsinki and its later amendments, the data were analyzed by replacing them with a code number so that no individual could be identified, and consideration was given to personal information management. In addition, the study has been approved by our hospital's Institutional Review Board (Receipt Number: YOKORIN-202101). Written informed consent has been obtained at the time of admission that personal data may be used for research.

## 3. Results

The P-group had 76 cases, and the N-group had 427 cases.

### 3.1. Univariate analyses

There were no significant differences in gender and fracture site between the 2 groups although hip fracture group had a higher proportion of patients with dysphagia than vertebral fracture group. For the other 4 variables (age, SMI, BMD, and BMI), a significant difference was observed between the 2 groups ($P < 0.01$). The mean values and standard deviations of these 4 variables are shown in Table 1. Figs. 1–4 show the differences in the distribution of age, SMI, BMD, and BMI between the P- and N-groups.

**Table 1**
Univariate analysis of gender, fracture site, age, SMI, BMD, and BMI between P-group and N- group.

| | | P-group | N-group | P-value |
|---|---|---|---|---|
| Gender | Men | 21 | 90 | 0.20 |
| | Women | 55 | 337 | |
| Fracture site | Vertebra | 18 | 130 | 0.23 |
| | Hip | 58 | 297 | |
| Age, yr | Mean | 87.8 | 83.8 | < 0.001 |
| | SD | 6.34 | 8.86 | |
| SMI, kg/m$^2$ | Mean | 4.36 | 5.05 | < 0.001 |
| | SD | 0.69 | 0.84 | |
| BMD, % | Mean | 55.6 | 61.9 | < 0.001 |
| | SD | 13.8 | 13.1 | |
| BMI, kg/m$^2$ | Mean | 18.4 | 20.5 | < 0.001 |
| | SD | 3.38 | 3.95 | |

SMI, systemic skeletal muscle mass index; BMD, bone mineral density, BMI; body mass index; SD: standard deviation; P-group, patient group; N-group, normal group.

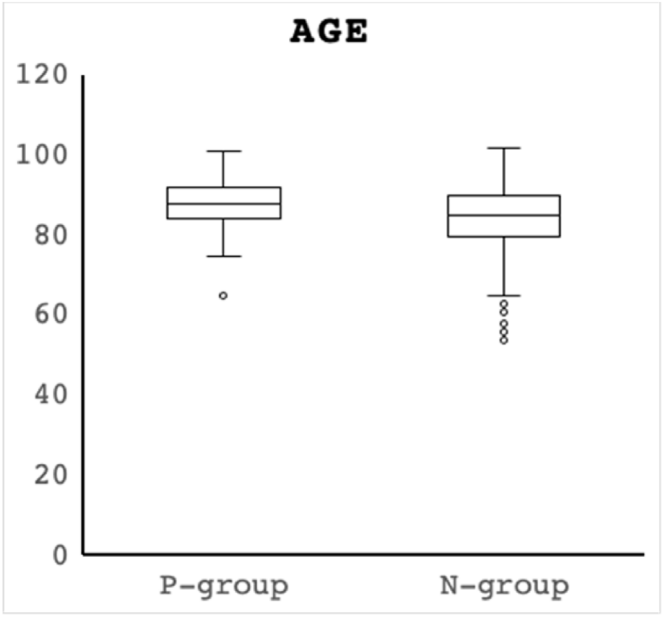


**Fig. 1.** Two-group box plots of age for P- and N-groups in all cases. P-group, patient group; N-group, normal group.

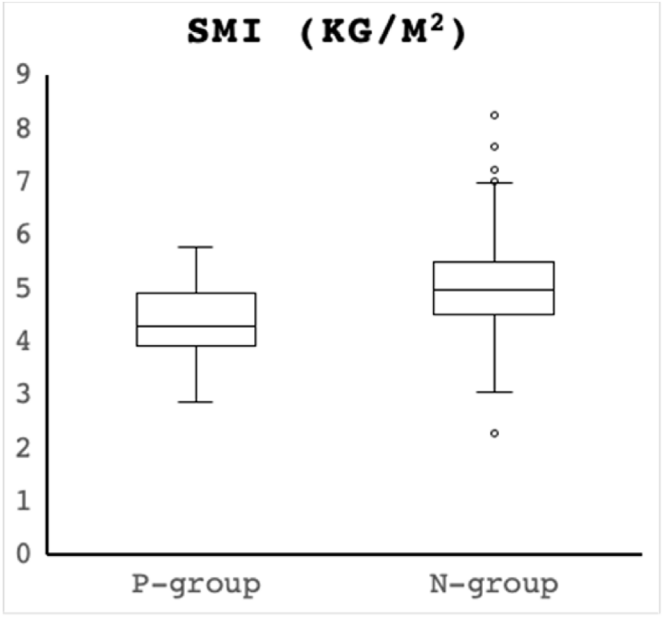


**Fig. 2.** Two-group box plots of SMI for P- and N-groups in all cases. SMI, systemic skeletal muscle mass index; P-group, patient group; N-group, normal group.

### 3.2. Multivariate analysis

Logistic regression analysis with the P-group as objective variables and age, SMI, BMD, and BMI as explanatory variables showed that the regression coefficient of SMI had over 1, and those of the other egression coefficients were near zero. The odds ratio of SMI was the highest at 3.355, and the 95% confidence interval of that did not contain 1. SMI was significantly associated with the development of dysphagia. The odds ratios of the other 3 factors were around 1. This suggested that only lower SMI was an independent risk factor for dysphagia. The results of logistic regression analysis in all cases are shown in Table 2.

The same logistic analysis was performed for each fracture site and gender. Although the 95% confidence intervals were slightly wider in male group and vertebral fracture group, the results were similar to those in the analysis of all cases. In all groups, only lower SMI was an independent risk factor for dysphagia (Tables 3–6).

## 4. Discussion

Sarcopenia is a condition wherein physical function declines due to muscle weakness associated with a decline in skeletal muscle mass [11]. Furthermore, in 2010, the European Working Group on Sarcopenia in Older People (EWGSOP) defined it as a condition with skeletal muscle weakness and either muscle weakness or physical function deterioration [12]. In 2014, the Asian Working Group for Sarcopenia set gender-specific cut-off values for skeletal muscle mass and strength for Asians [13]. In 2016, sarcopenia was included in the International Classification of Diseases, ICD-10 and became recognized as a distinct syndrome internationally [14]. At present, many research groups around the world have set various criteria for muscle mass, strength, and physical fitness, and their definitions and diagnostic criteria are different. However, SMI as an index of muscle mass is an indispensable evaluation item in all criteria, although there are differences in numerical value of SMI included in various diagnostic criteria of sarcopenia.

On the other hand, in 2000, it was reported that aging and malnutrition cause dysphagia, suggesting a relationship between dysphagia and sarcopenia [15]. Dysphagia coexisting with sarcopenia is associated with weakness in swallowing-related muscle groups [16–18], and it has been reported that the strength of these muscles is associated with factors such as maximum tongue

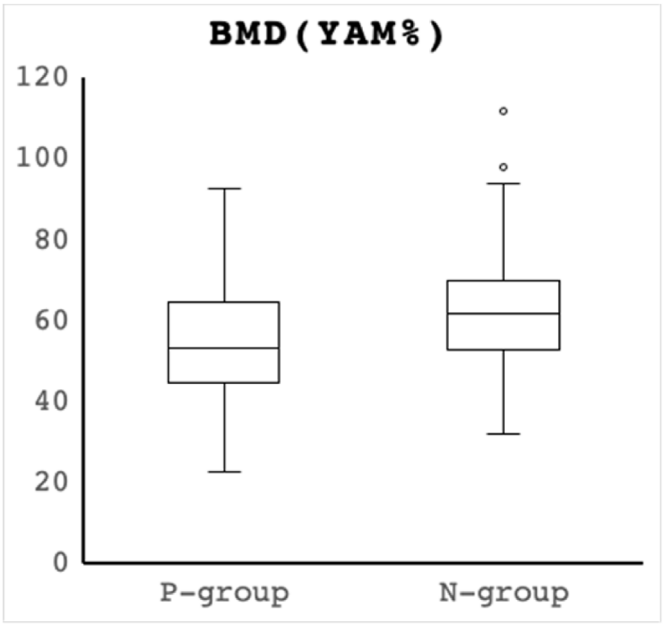


**Fig. 3.** Two-group box plots of BMD for P- and N-groups in all cases. BMD, bone mineral density; YAM, young adult mean; P-group, patient group; N-group, normal group.

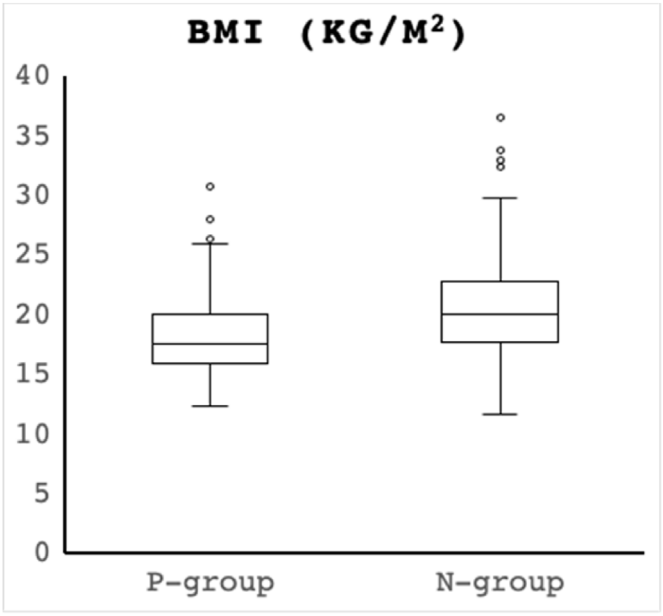


**Fig. 4.** Two-group box plots of BMI for P- and N-groups in all cases. BMI, body mass index; P-group, patient group; N-group, normal group.

pressure and age [19–22]. However, it is not easy to evaluate muscle weakness in swallowing-related muscle groups. In relation to systemic muscle mass, hospitalized elderly patients with systemic sarcopenia were prone to dysphagia [20], and in cancer patients with dysphagia, severe dysphagia was associated with decreased systemic skeletal muscle mass [23]. In 2012, it was reported that low SMI is a risk factor for aspiration pneumonia and dysphagia [4]. In a study for elderly inpatients without dysphagia before admission and who had been forbidden to eat for 2 days or more because of dysphagia after admission, it had been reported that low SMI, low BMI and low Barthel Index were risk factors for the development of dysphagia [24].

Regarding the relationship between dysphagia and osteoporotic fragile fractures, Love et al [1] reported that dysphagia was found in about 30% of post-operative patients with hip fractures. Several reports described that in patients with hip fracture higher age, lower SMI, lower grip strength, presence of post-operative delirium, and living in a residential aged care facility prior to hospital admission were associated with the post-operative dysphagia [1,2,25]. There are no reports about the risk factors of dysphagia in patients with vertebral fractures nor patients with conservative therapy for osteoporotic fractures.

Based on these observations, early after hospitalization we assessed the gender, fracture site, age, SMI, BMD, and BMI in our hospitalized patients with osteoporotic fragile fractures and investigated the relationship between these and dysphagia. We targeted not only patients with hip fractures but also patients with vertebral fracture and patients with conservative treatment.

For the first time, we report that decreased SMI was the risk factor of dysphagia for patients with osteoporotic fragile fractures including vertebral fractures treated with either of surgical or conservative therapy. This finding is very significant because SMI is easy to measure soon after hospitalization, even in patients with delirium and/or dementia.

According to The Asian Working Group for Sarcopenia (AWGS) 2019, sarcopenia is generally diagnosed based on multiple factors, that are SMI, muscle strength such as handgrip strength, physical performance such as 5-time chair stand test, and calf circumference [26]. On the other hand, the Japanese Association on Sarcopenia and Frailty includes an SMI measurement of 7.0 kg/m$^2$ for men and less than 5.4 kg/m$^2$ for women in the diagnostic criteria for sarcopenia as measured by the DXA method [26]. Although muscle strength, physical performance could not be measured in this study, the average value of SMI in the P- and N-group was lower than these for both men and women. It was suggested that many patients with fragile osteoporotic fractures had sarcopenia. Yoshimura et al [27] reported that osteoporosis and sarcopenia are interrelated and the results of this study seemed to support this. Since we excluded patients with diseases that directly cause dysphagia, it was highly likely that many of the patients with dysphagia had sarcopenic dysphasia in this study.

The limitations of this study were that the criteria for dysphagia

**Table 2**
Logistic regression analysis with P-group as the objective variable and age, SMI, BMD, and BMI as explanatory variables in all cases.

| Variables | Regression coefficient | | | Odds ratio | |
|---|---|---|---|---|---|
| | Coefficient | 95% confidence interval | P-value | Odds ratio | 95% confidence interval |
| Age, yr | −0.071 | −0.114 ~ −0.027 | 0.001 | 0.932 | 0.892–0.973 |
| SMI, kg/m$^2$ | 1.210 | 0.692–1.729 | 0.000 | 3.355 | 1.998–5.634 |
| BMD, % | 0.013 | −0.011–0.038 | 0.281 | 1.013 | 0.989–1.038 |
| BMI, kg/m$^2$ | −0.023 | −0138–0.092 | 0.692 | 0.977 | 0.871–1.096 |

SMI, systemic skeletal muscle mass index; BMD, bone mineral density; BMI, body mass index; P-group, patient group.

**Table 3**
Logistic regression analysis with P-group as the objective variable and age, SMI, BMD, and BMI as explanatory variables in patients with vertebral fracture.

| Variables | Regression coefficient | | | Odds ratio | |
|---|---|---|---|---|---|
| | Coefficient | 95% confidence interval | P-value | Odds ratio | 95% confidence interval |
| Age. yr | −0.089 | −0.171 ~ −0.007 | 0.032 | 0.915 | 0.843–0.993 |
| SMI, kg/m$^2$ | 2.347 | 0.961–3.734 | 0.001 | 10.445 | 2.613–41.831 |
| BMD, % | 0.048 | −0.014 ~ −0.109 | 0.128 | 1.049 | 0.986–1.115 |
| BMI, kg/m$^2$ | −0.169 | −0.398–0.059 | 0.147 | 0.844 | 0.672–1.061 |

SMI, systemic skeletal muscle mass index; BMD, bone mineral density; BMI, body mass index; P-group, patient group.

**Table 4**
Logistic regression analysis with P-group as the objective variable and age, SMI, BMD, and BMI as explanatory variables in patients with hip fracture.

| Variables | Regression coefficient | | | Odds ratio | |
|---|---|---|---|---|---|
| | Coefficient | 95% confidence interval | P-value | Odds ratio | 95% confidence interval |
| Age, yr | −0.068 | −0.116 ~ −0.020 | 0.006 | 0.934 | 0.890–0.980 |
| SMI, kg/m$^2$ | 0.953 | 0.409–1.498 | 0.001 | 2.594 | 1.505–4.471 |
| BMD, % | 0.007 | −0.019–0.034 | 0.586 | 1.007 | 0.981–1.034 |
| BMI, kg/m$^2$ | 0.009 | −0.120–0.138 | 0.891 | 1.009 | 0.887–1.148 |

SMI, systemic skeletal muscle mass index; BMD, bone mineral density; BMI, body mass index; P-group, patient group.

**Table 5**
Logistic regression analysis with P-group as the objective variable and age, SMI, BMD, and BMI as explanatory variables in male patients.

| Variables | Regression coefficient | | | Odds ratio | |
|---|---|---|---|---|---|
| | Coefficient | 95% confidence interval | P-value | Odds ratio | 95% confidence interval |
| Age, yr | −0.049 | −0.113–0.015 | 0.134 | 0.952 | 0.893–1.015 |
| SMI, kg/m$^2$ | 1.819 | 0.525–2.854 | 0.001 | 6.163 | 2.189–17.350 |
| BMD, % | 0.060 | 0.001–0.119 | 0.046 | 1.062 | 1.001–1.127 |
| BMI, kg/m$^2$ | −0.021 | −0.227–0.004 | 0.185 | 0.979 | 0.797–1.203 |

SMI, systemic skeletal muscle mass index; BMD, bone mineral density; BMI, body mass index; P-group, patient group.

**Table 6**
Logistic regression analysis with P-group as the objective variable and age, SMI, BMD, and BMI as explanatory variables in female patients.

| Variables | Regression coefficient | | | Odds ratio | |
|---|---|---|---|---|---|
| | Coefficient | 95% confidence interval | P-value | Odds ratio | 95% confidence interval |
| Age, yr | −0.096 | −0.152 ~ −0.040 | 0.001 | 0.909 | 0.859–0.961 |
| SMI, kg/m$^2$ | 1.205 | 0.593–1.817 | 0.000 | 3.338 | 1.810–6.155 |
| BMD, % | 0.013 | −0.017–0.043 | 0.402 | 1.013 | 0.983–1.044 |
| BMI, kg/m$^2$ | −0.038 | −0.181–0.104 | 0.587 | 0.962 | 0.835–1.110 |

SMI, systemic skeletal muscle mass index; BMD, bone mineral density; BMI, body mass index; P-group, patient group.

and for hospitalization of patients with vertebral fractures were unclear. To assess dysphagia, there are various evaluation criteria, such as a questionnaire (EAT-10) [28], water-swallowing test [29] findings, repetitive saliva swallowing test [30] findings, and videofluorographic swallowing study [31], however, often, these tests cannot be administered to patients with delirium and/or dementia or those who cannot maintain a sitting position for a certain period of time due to pain, and the burden on the patient is high. The number of cases examined was also small. In the future, it is necessary to clarify swallowing evaluation, increase the number of cases examined, and to determine the cutoff line.

## 5. Conclusions

Our results provide the insights into a risk factor of dysphagia as having lower SMI in patients hospitalized for osteoporotic fragile vertebral and hip fractures. We suggest the careful observation of the swallowing function in patients with decreased SMI on early stage after hospitalization, and interventions such as swallowing rehabilitation, oral care, and maintenance of nutritional status should be initiated as needed.

## CRediT author statement

**Kaoru Suseki:** Project administration, Methodology, Investigation, Writing - orinal draft, Writing – review & editing, Supervision. **Masaomi Yamashita:** Project administration, Methodology, Writing - review & editing, **Yoshiaki Kojima:** Investigation. **Yojiro Minegishi:** Investigation. **Koichiro Komiya:** Investigation, Project administration. **Masashi Takaso:** Writing - review & editing, Supervision.

## Conflicts of interest

The authors declare no competing interests.

## Acknowledgments

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