Influence of Oral Health on Frailty in Patients with Type 2 Diabetes Aged 75 Years or Older

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Research Article

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Abstract

Background

Poor oral health conditions are known to affect frailty in the elderly. Diabetes is a risk factor for both poor oral health and frailty, and, therefore, oral health status may affect frailty in diabetic patients more than in the general population. The purpose of this study was to evaluate the influence of oral health on frailty in elderly patients with type 2 diabetes.

Methods

Patients with type 2 diabetes aged 75 years or older were included in this retrospective study. Eligible patients were surveyed by questionnaire for frailty, oral health status, and cognitive and living functions. Factors influencing pre-frailty, frailty, and individual frailty score categories were evaluated.

Results

Of the 111 patients analyzed, 66 cases (59.5%) were categorized as robust, 33 cases (29.7%) as pre-frailty, and 12 cases (4.5 %) as frailty. The oral frailty index, the cognitive and living functions score, and BMI were found to be factors influencing pre-frailty or frailty. In the evaluation of individual frailty score categories, BMI only had an influence on those with a frailty score ≤ 2. The cognitive and living functions score was a factor influencing those with frailty scores ≤ 3. The oral frailty index was found to have a significant influence on all frailty score categories.

Conclusion

Poor oral health has an influence on frailty in patients with type 2 diabetes aged ≥ 75. In this patient population, as frailty progresses, the impact of oral health on frailty may increase.

Trial registration:

This study was retrospectively registered in UMIN-CTR (UMIN000044227).

Background

Frailty is a condition in which physical and mental vulnerability develops with aging and has a great impact on the prognosis of the elderly. There are various risk factors for frailty, such as underlying disease, nutritional status, and sarcopenia, which interact with each other to develop vulnerability [1]. Poor oral health conditions are known to affect frailty in the elderly. Kamden et al. reported that

decreased masticatory function was a significant influential factor for frailty [2]. Tanaka et al. also reported that poor oral health status based on evaluation of masticatory function, tongue pressure, salivation, and so on, was a significant risk factor for frailty [3]. It has been suggested that the influence of poor oral health on frailty involves tooth loss, decreased salivation, periodontal disease, and dental caries [4]. Loss of teeth reduces masticatory function and worsens nutritional status [5, 6]. Saliva secretion is reduced by aging, medication such as anti-hypertensives and anti-depressants, or radiation therapy [4], and the decrease in saliva is likely to cause dental caries, leading to decreased chewing and swallowing functions. Poor oral health including periodontal disease and dental caries reduces masticatory function and worsens nutritional status through tooth loss [4].

Poor glycemic control in patients with diabetes has been reported to exacerbate various oral health conditions including dental caries, decreased salivation and periodontal disease [7]. Izuora et al. reported that in diabetic patients averaged 58.9 years old, only 6.4% had their original 32 teeth and 15.3% had lost all of their teeth [8]. As periodontal disease progresses, it leads to tooth loss, and the prevalence of periodontal disease is higher in diabetics than in the general population [9]. Periodontal disease also causes systemic inflammation and adversely affects diabetes through insulin resistance [10]. In addition, diabetic patients reportedly have decreased salivation, 46% of which had dry mouth [11]. As described above, these various changes in the oral cavity of diabetic patients interact with each other, resulting in deterioration of masticatory and swallowing function.

Diabetes itself is reportedly to be a risk factor for frailty. Insulin is involved in promoting protein synthesis and suppressing proteolysis but, with diabetes, insulin resistance suppresses protein synthesis, affecting muscle strength and motor function [12, 13]. Diabetes is a risk factor for both poor oral health and frailty, and, therefore, oral health status may affect frailty in diabetic patients more than in the general population.

The impact of nutritional status on health may vary with patient age. In Japan, the elderly aged 75 and over are termed the ‘late-stage elderly’ in the medical system. In a study of diabetic patients in Japan, Yamaoka et al. found that reduced protein intake was a significant risk factor for all-cause mortality only in patients aged 75 years and older, and thus adequate nutrition is required especially for patients aged 75 and older [14]. A strict diet to prevent obesity is important for younger patients with diabetes, but prevention of frailty and sarcopenia becomes more important as they age [15]. Against this background, we evaluated the effect of oral health on frailty in patients with type 2 diabetes aged 75 years and older.

Materials And Methods

Patients

This study was conducted to evaluate the influence of oral health on frailty in elderly patients with type 2 diabetes. This is a retrospective study of data from Okamoto Internal Medicine Clinic, Shizuoka, Japan, collected from December 2019 to March 2020. The subjects of this study were patients with type 2 diabetes aged 75 years and older and those with gait disturbance were excluded.

Methods

Of the 229 patients enrolled, 111 eligible patients were surveyed by questionnaire for frailty, oral health status, and cognitive and living functions (Fig. 1). To evaluate oral health status, the oral frailty index-8 (OFI-8), an eight-question oral health assessment tool reported by Tanaka et al., was used [16]. The adjusted odds ratio with a 95%CI of the OFI-8 score to frailty was estimated. Adjusted odds ratios were calculated for pre-frailty, frailty, and individual frailty scores. In addition, factors influencing oral health were examined. Data on age, sex, BMI, duration of diabetes, and HbA1c were collected.

For the evaluation of frailty, a self-evaluation questionnaire developed by Yamada et al. consisting of five items—weight loss, gait speed, exercise frequency, short-term memory, and feeling of fatigue—was used [17]. Cases corresponding to 1 or 2 items were defined as pre-frailty, and cases corresponding to 3 or more items were defined as frailty.

Cognitive and living functions were evaluated using the Dementia Assessment Sheet for Community-based Integrated Care System-8 (DASC-8) items developed by Toyoshima et al [18]. Patients were classified into three categories (I, II, and III) determined by DASC-8 score—I: normal cognitive function and activities of daily living (ADL) independence; II: mild cognitive impairment or mild dementia or instrumental ADL decline, and basic ADL independence; and III: moderate or severe dementia or decreased basic ADL or many comorbidities or dysfunctions [18].

The OFI-8 score was the sum of the scores for each of the following questions below. Q1: Do you have any difficulties eating tough foods compared to 6 months ago? (2 points for Yes), Q2: Have you choked on your tea or soup recently? (2 points for Yes), Q3: Do you use dentures? (2 points for Yes), Q4: Do you often have a dry mouth? (1 point for Yes), Q5: Do you go out less frequently than you did last year? (1 point for Yes), Q6: Can you eat hard foods like squid jerky or pickled radish? (1 point for No), Q7: How many times do you brush your teeth in a day? (3 or more times/day) (1 point for No), and Q8: Do you visit a dental clinic at least annually? (1 point for No) [16].

Statistics

Descriptive statistics are expressed as n (%) and mean ± SD. The Kruskal-Wallis test was used to compare continuous variables, and the chi-square test was used to compare categorical variables. For the evaluation of factors influencing pre-frailty, frailty and individual frailty score categories, the adjusted odds ratio [95% CI] was calculated from multiple logistic analysis using the variables extracted by the stepwise method from the following variables: sex, age, duration of diabetes, HbA1c, OFI-8, DASC-8, and BMI. Furthermore, the scores for factors influencing frailty were converted into deviation values, and the relationship between the frailty score and change in the deviation value of each influencing factor was evaluated. For the evaluation of the factors influencing the OFI-8 scores, multiple regression analysis was used using the variables extracted by the stepwise method from the following variables: sex, age, BMI, duration of diabetes, HbA1c, DASC-8, and frailty score. For the influence of diabetic duration on oral health, an OFI-8 score ≥ 4 was defined as oral frailty [16] and a cutoff value was calculated using receiver

operating characteristic (ROC) analysis. The two-sided α was set to be 0.05. Statistical analysis was performed using SPSS (IBM).

Results

Patient characteristics

Of the patients treated for type 2 diabetes from December 2019 to March 2020, 229 patients aged 75 years and older were enrolled; 81 were excluded because of gait disturbance (Fig. 1). Questionnaire surveys on OFI-8, frailty scoring, and DASC-8 were conducted in 148 of the patients. Of those, 37 patients were excluded due to incomplete answers, and the remaining 111 patients were analyzed. The age range was 75 to 92 years, with the number of patients decreasing as the age increased (Fig. 2a). The absolute number of patients with frailty or pre-frailty increased in the older population, with 67% of frailty patients aged 83 and over (Fig. 2b). The mean age was 79.7 years, with an average duration of diabetes of 20.4 years, of which 54 (48.6%) had a duration of diabetes of 20 years or more (Table 1). Regarding frailty, 66 (59.5%) cases were defined as robust, 33 (29.7%) cases as pre-frailty, and 12 (4.5%) as frailty. The rate for each category of the DASC-8 was 72.1% (I), 22.5% (II) and 5.4% (III). Significant differences were found in sex, age, OFI-8 score, and DASC-8 category in multiple comparisons among the robust, pre-frailty, and frailty groups.

Factors influencing frailty

Multiple logistic analysis showed that OFI-8 score, DASC-8 score, and BMI were factors influencing pre-frailty, and that OFI-8 score and DASC-8 were factors influencing frailty (Table 2). The adjusted odds with 95% confidence interval (95%CI) of the OFI-8 scores were 1.34 [1.04, 1.72] for pre-frailty and 1.55 [1.10, 2.18] for frailty (Fig. 3a). In the evaluation by individual frailty score categories, BMI was not found to be a factor influencing a frailty scores ≥ 3 (Fig. 3b). The DASC-8 score was not a factor influencing a frailty scores ≥ 4. The OFI-8 score was a significant factor influencing all frailty score categories. The adjusted odds ratios with 95%CI of OFI-8 scores were 1.34 [1.04, 1.72] for frailty scores ≥ 1, 1.45 [1.05, 2.00] for scores ≥ 2, 1.55 [1.10, 2.18] for scores ≥ 3 and 7.09 [1.08, 46.6] for scores ≥ 4. Figure 4 shows the deviation values of OFI-8, DASC-8, and BMI by frailty score. The deviation values of OFI-8 and DASC-8 increased as the frailty score increased ($p = 0.0009$ and $p < 0.0001$), but the deviation values of BMI did not clearly show change ($p = 0.5571$). For the frailty scores that showed progression from 0 to 4, the difference in mean deviation value was greatest with 25.2 for OFI-8, followed by 17.3 for DASC-8 and 1.0 for BMI.

Factors influencing the OFI-8 score

Multiple regression analysis showed that frailty scores and duration of diabetes were significant influencing factors on the OFI-8 score (Table 2). The cut-off value of the duration of diabetes for oral frailty from ROC analysis was 12 years (AUC: 0.75). The proportion of patients with oral frailty was 32.0% in duration of diabetes < 12 years and 59.3% in that of > 12 years (Fig. 5a). The proportion of patients

with oral frailty by sex and duration of diabetes were 25.0% (< 12 years) vs. 51.8% (≥ 12 years) in male and 44.4% vs. 73.0% in female (Figs. 5b and 5c).

Discussion

The influence of oral health on frailty was investigated in 111 patients with type 2 diabetes aged 75 years and older. Frailty was found in 10.8% (12/111), 67% of whom were aged 83 years or older. A higher OFI-8 score was a significant factor influencing all frailty score categories.

In the elderly, poor oral health represented by deterioration of masticatory function and swallowing function has been shown to affect sarcopenia and frailty [4, 19]. Elderly people with impaired masticatory function often avoid eating hard-to-eat foods such as meat, fruits, and vegetables [20–22], and these changes in eating habits increase the risk of malnutrition and frailty [19, 23]. Our results support the results of these previous studies. To our knowledge, this is the first report showing the relationship between oral health and frailty in diabetic patients aged ≥ 75.

In this study, the OFI-8 score, DASC-8 score and BMI were shown to be factors influencing pre-frailty or frailty. High BMI has been reported to be a risk factor for frailty [24–26]. Excessive lipid deposition and infiltration of lipids into muscle fibers affect muscle weakness and activity [27], and excessive lipid deposition has been suggested to increase the risk of frailty through systemic inflammation [28]. In our study, BMI was found to be a risk factor for pre-frailty, suggesting that prevention of obesity and metabolic syndrome is important for the elderly or middle-aged persons even for those having a robust status prior to pre-frailty.

On the other hand, our study showed that BMI was not a significant risk factor for frailty or frailty scores ≥ 3. As mentioned above, previous studies have shown that BMI was a risk factor for frailty [24–26], but the studies by Niederstrasser et al. and Hubbard et al. were conducted in subjects aged ≥ 50 [24, 26], and the study by Watanabe et al. was conducted in subjects aged ≥ 65 [25]. Our study was conducted in patients with diabetes aged ≥ 75, a population at higher risk of frailty than those in previous studies. Considering the above, the influence of BMI on frailty may vary depending on patient age and severity of frailty. In the evaluation of individual frailty score categories, BMI was not a factor influencing frailty scores ≥ 3 and DASC-8 was not a factor influencing frailty scores ≥ 4, but the OFI-8 score was consistently a significant factor influencing all categories of frailty scores. Furthermore, in the evaluation of the data converted into deviation values, we found that for the frailty scores showing an increase from 0 to 4, the change in the deviation value was the largest for OFI-8 data, and no significant change was observed in the deviation value for BMI. These results indicate that as frailty progresses, the impact of oral health on frailty increases and the effects of BMI and DASC-8 show a relative decrease. Previous studies showed there is an interaction between diabetes and oral health [7, 9], and the impact of oral health on frailty may be stronger with older age. The fact that duration of diabetes had a significant influence on the OFI-8 score in this study supports this speculation.

In our study, the cut-off value for the duration of diabetes for oral frailty, defined as OFI-8 score ≥ 4, [16] was 12 years. The proportions of patients with oral frailty by sex and duration of diabetes were 25.0% (< 12 years) vs. 51.8% (≥ 12 years) for males and 44.4% vs. 73.3% for females, indicating that female patients develop oral frailty earlier than male patients. Tongue pressure, one of the indicators of oral function, may have contributed to these results. The tongue is mostly composed of muscle and an association between arm muscle mass and tongue thickness has been shown [29]. It has also been reported that tongue pressure and tongue thickness are significantly lower in women compared to in men [30, 31], and thus, masticatory function may differ between males and females in the elderly population as well. Considering these facts, the function of the tongue relative to muscle mass may be one of the causes of the differences between the sexes in the development of oral frailty.

There are several limitations to this study. This was a retrospective study conducted in a single institution. The OFI-8 score as an index of oral health is based on a questionnaire, and oral function including masticatory function and swallowing function was not evaluated by dental or oral specialists. Energy and protein intake that affects frailty and status of diabetes treatment was not considered in this study. The results of this study need to be interpreted with these factors in mind.

Conclusion

This is the first study to show that oral health influences frailty in diabetic patients aged 75 years and older. Oral health is a factor influencing frailty, and as frailty progresses, the impact of oral health on frailty may increase.

Abbreviations

ADL
activities of daily living, DASC-8:Dementia Assessment Sheet for Community-based Integrated Care System-8, OFI-8:oral frailty index-8, ROC:receiver operating characteristic

Declarations

Ethics

This study was conducted in compliance with the Declaration of Helsinki and according to the Ethical Guidelines for Medical and Health Research Involving Human Subjects established by the Ministry of Health, Labour, and Welfare in Japan. The study protocol was approved by the ethical review committee of the Okamoto Internal Medicine Clinic, the Seishinkai Group. Written informed consent was obtained from all study patients.

Conflict of interest

The authors have no conflicts of interest to declare.

Funding

The authors have no sponsors to disclose.

Author contributions

M.I., Y.Y., H.H., Y.I. and K.T. conceived and designed the research, reviewed data; S.O. and M.A. made critical revision of the manuscript; M.I. and M.I. collected data, performed the statistical analysis and drafted the manuscript. All authors had reviewed the manuscript.

Data availability

The datasets used during the current study are available from the corresponding autho on reasonable request.

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Tables

Table 1. Patient characteristics

	Total (n=111)	Robust (n=66)	Pre-frailty (n=33)	Frailty (n=12)	p
Sex (male), n (%)	72 (64.9%)	49 (74.2%)	18 (54.5%)	5 (41.7%)	0.032
Age (y.o.), mean±SD	79.7±3.8	78.8±3.1	80.7±4.4	82.3±3.5	0.004
BMI, mean±SD	23.2±3.8	22.8±3.8	23.9±4.2	23.3±2.5	0.336
Duration of diabetes (years), mean±SD	20.4±11.1	19.7±10.5	19.5±10.6	26.4±14.5	0.182
≤20 years, n (%)	57 (51.4%)	35 (53.0%)	19 (57.6%)	3 (25.0%)	0.131
>20 years, n (%)	54 (48.6%)	31 (47.0%)	14 (42.4%)	9 (75.0%)	
HbA1c (%), mean±SD	7.1±0.7	7.1±0.6	7.3±0.9	7.2±0.6	0.615
Frailty score, mean±SD	0.8±1.1	0±0	1.5±0.5	3.3±0.5	<0.001
OFI-8 score, mean±SD	3.9±2.0	3.3±1.8	4.4±1.8	5.8±2.4	<0.001
Score <4, n (%)	52 (46.8%)	39 (59.1%)	11 (33.3%)	2 (16.7%)	0.003
Score ≥4, n (%)	59 (53.2%)	27 (40.9%)	22 (66.7%)	10 (83.3%)	
DASC-8, mean±SD	10.2±3.0	9.2±1.3	11.1±3.7	13.6±4.4	<0.001
Category I, n (%)	80 (72.1%)	57 (86.4%)	19 (57.6%)	4 (33.3%)	-
Category II, n (%)	25 (22.5%)	9 (13.6%)	11 (33.3%)	5 (41.7%)	
Category III, n (%)	6 (5.4%)	0	3 (9.1%)	3 (25.0%)	

DASC-8: the dementia assessment sheet for community-based integrated care system-8 items, OFI-8 score: oral frailty index-8

Table 2. Factors influencing pre-frailty, frailty, and oral frailty score

Factors influencing pre-frailty, model: p<0.0001				
Variables	Estimate	S.E.	Chi-square	p
Sex (male)	-0.39	0.25	2.43	0.119
Age	0.08	0.07	1.33	0.248
OFI-8 score	0.28	0.12	5.04	0.024
DASC-8 score	0.38	0.13	8.57	0.003
BMI	0.13	0.06	4.67	0.030
Factors influencing frailty, model: p<0.0001				
Variables	Estimate	S.E.	Chi-square	p
OFI-8 score	0.44	0.17	6.41	0.011
DASC-8	0.24	0.08	7.52	0.006
Factors influencing OFI-8 score, model: p=0.0011				
Variables	Estimate	S.E.	t value	p
Sex (male)	-0.25	0.18	-1.4	0.164
Age	0.05	0.04	1.23	0.221
Duration of diabetes	0.03	0.01	2.28	0.024
HbA1c	-0.36	0.24	-1.52	0.132
Frailty score	0.60	0.16	3.57	<0.001

DASC-8: the dementia assessment sheet for community-based integrated care system-8 items, OFI-8: oral frailty index-8

Figures

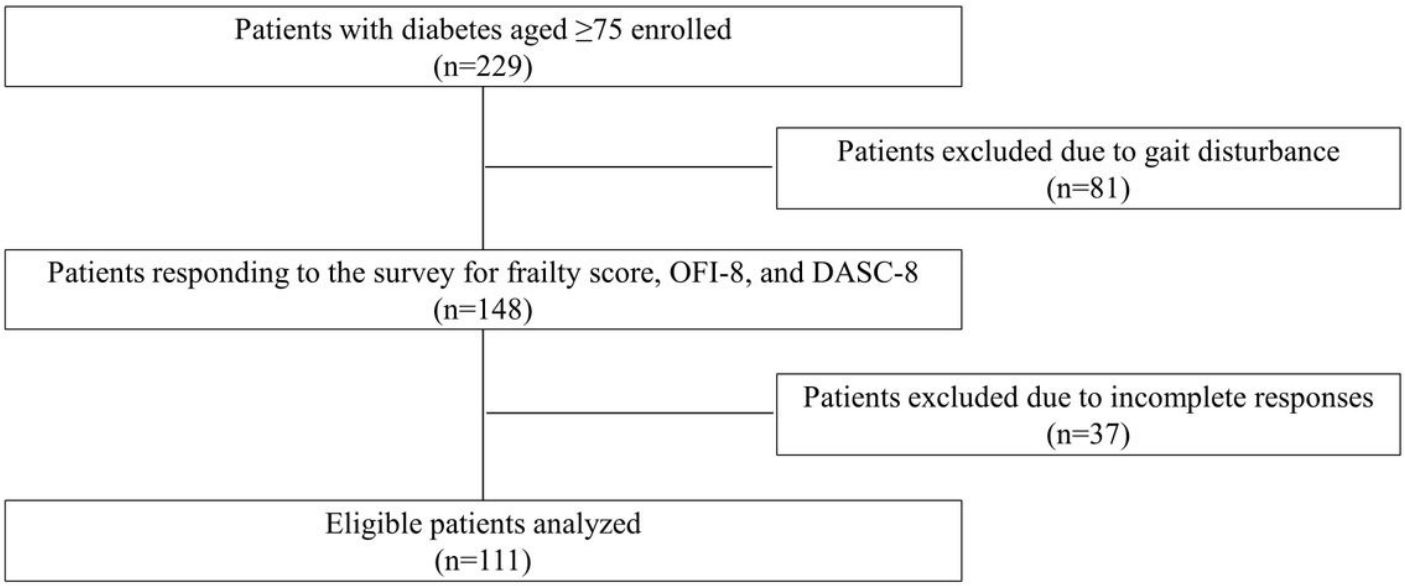

Figure 1

Patient inclusion/exclusion flowchart DASC-8: the dementia assessment sheet for community-based integrated care system-8 items, OFI-8: oral frailty index-8

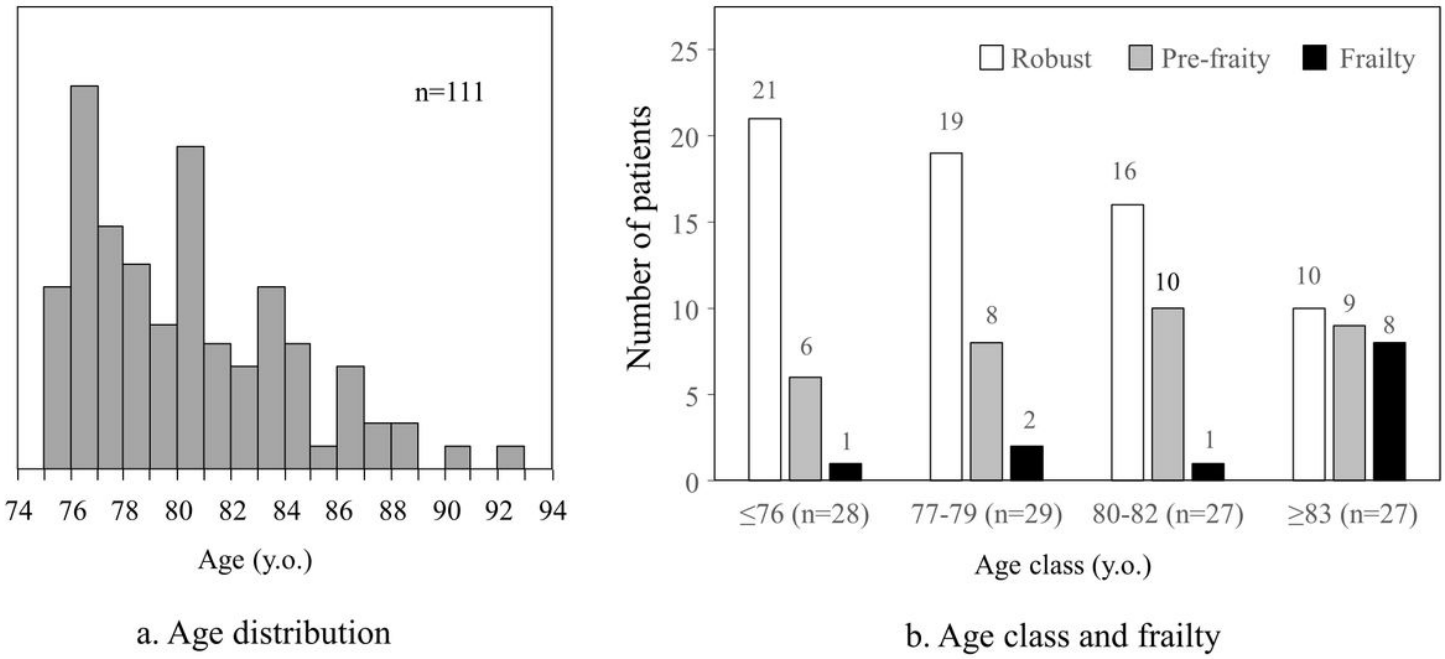

Figure 2

Age distribution and rates of frailty

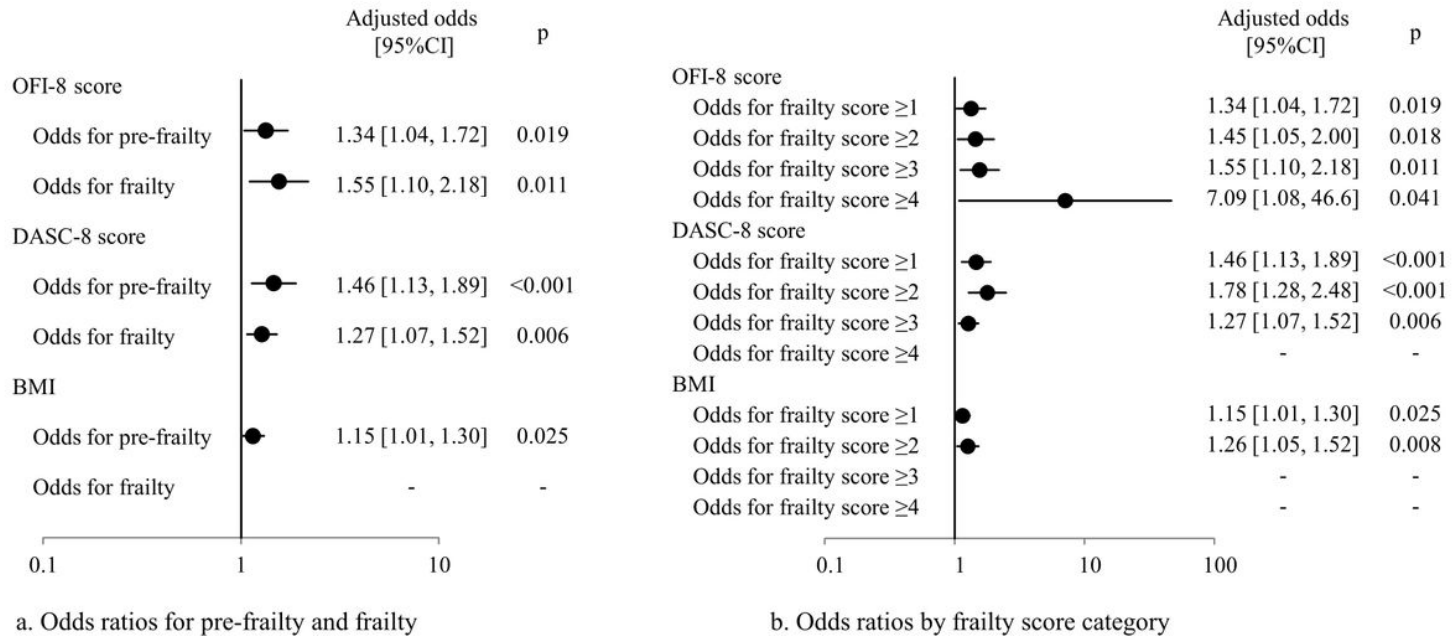

Figure 3

Adjusted odds ratios for frailty DASC-8: the dementia assessment sheet for community-based integrated care system-8 items, OFI-8: oral frailty index-8

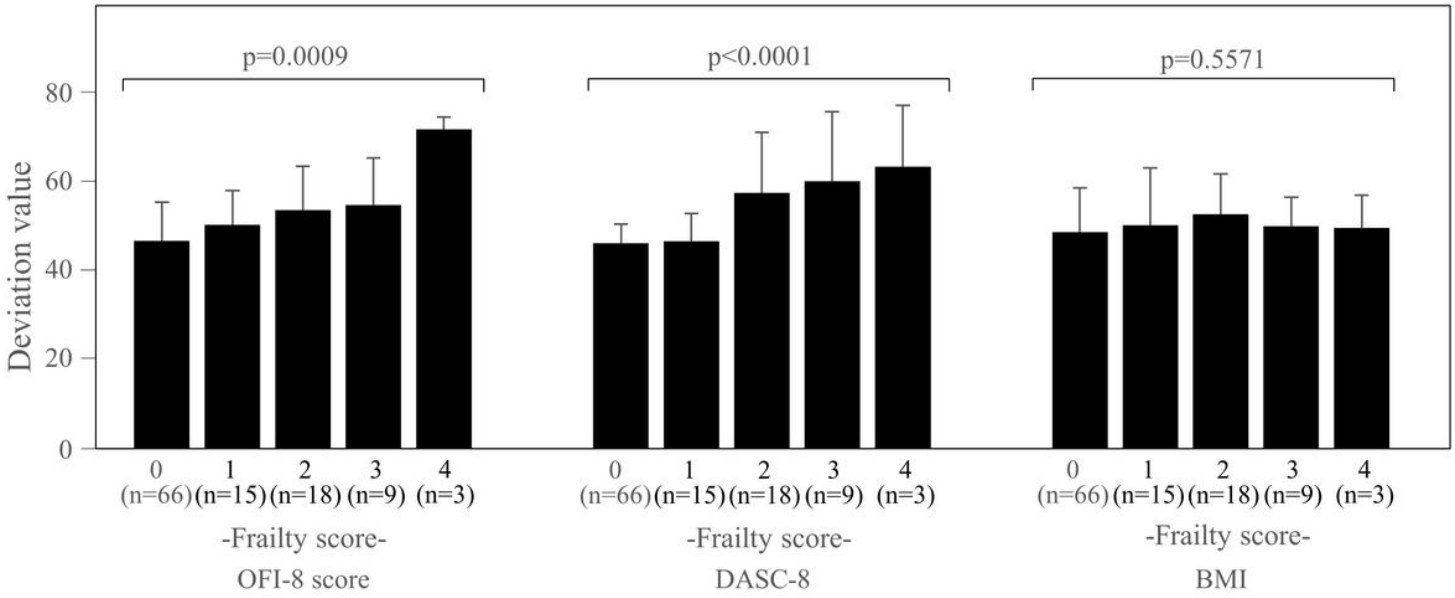

Figure 4

Frailty scores and deviation values for OFI-8, DASC-8, and BMI

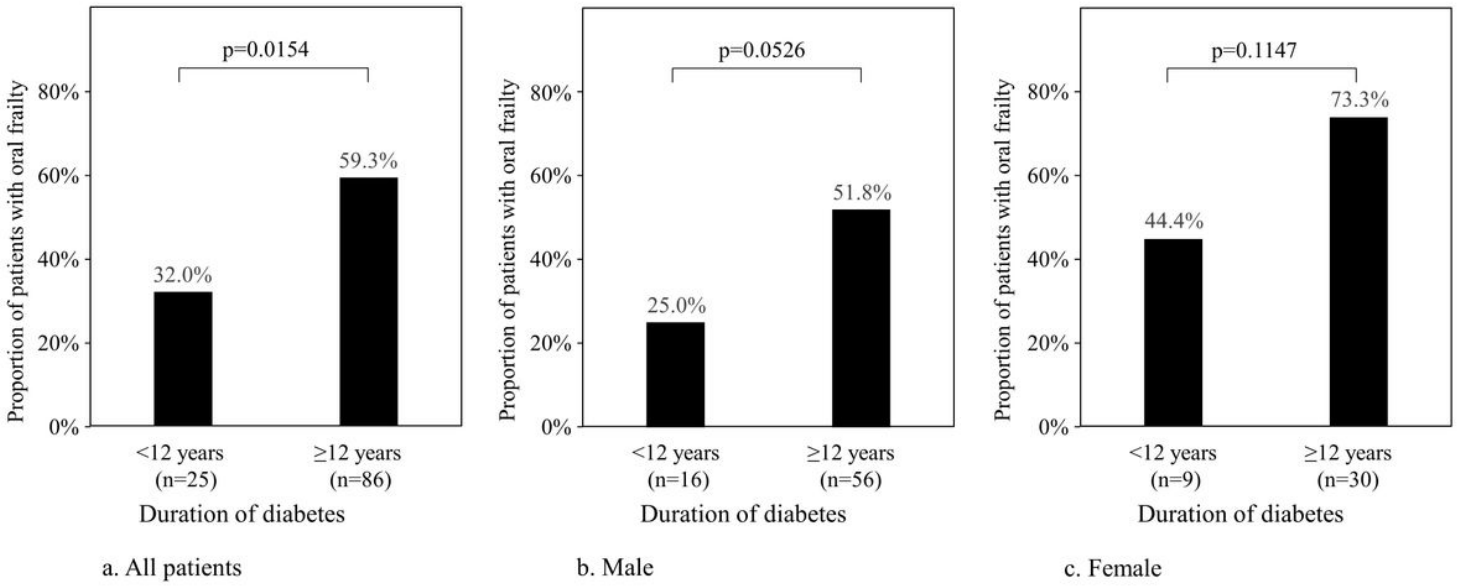

Figure 5

Duration of diabetes and proportion of patients with oral frailty Oral frailty was defined as an oral frailty score ≥4