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Ⅳ．研究成果の刊行物・別刷

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Detecting signs of dysphagia in patients with Alzheimer's disease with oral feeding in daily life

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Aim: It is important to understand dysphagia in patients with dementia, as it is associated with malnutrition and aspiration pneumonia. Particularly in patients with Alzheimer's disease (AD), mortality from pneumonia is high and accounts for 70% of the causes of death. However, the standard swallowing tests are often difficult to use for patients with dementia, and methods to assess daily swallowing function are required. Therefore, the purpose of the present study was to identify signs of dysphagia in AD patients in daily life.

Methods: A total of 155 AD patients underwent evaluation of their swallowing function (modified water swallowing test), oral status (residual teeth, occlusal contacts), oral functions (lips function, tongue function, rinsing and gargling ability), vital functions (Barthel Index, Vitality Index), nutritional status (serum albumin, body mass index), cognitive function and neurological signs (Mini-Mental State Examination, Clinical Dementia Rating, limb contractures), and diet-related assessments (storing food in the mouth, stuffing food into the mouth, appetite, caloric intake).

Results: The severity of AD was significantly associated with swallowing function ($P < 0.001$). According to logistic regression analysis, the factor most significantly associated with dysphagia was "rinsing ability" ($P = 0.001$, odds ratio 4.8, 95% confidence interval 1.9–12.1).

Conclusion: The factors that affect swallowing function in AD patients were examined. The swallowing function of severe AD patients was poor, and an association between AD and dysphagia was shown. Defective rinsing ability was identified as a risk factor for dysphagia. Therefore, observation of daily rinsing ability appears to be useful to identify signs of dysphagia in AD patients. **Geriatr Gerontol Int 2013; ••: ••–••.**

Keywords: Alzheimer's disease, dementia, dysphagia, modified water swallowing test, rinsing ability.

Introduction

Japan is an aging society; 23.1% of the population is now aged over 65 years,[1] and that percentage is increasing. It has been inferred that the number of people with dementia will increase, because the incidence of dementia increases with age. Furthermore, the number of dementia patients is expected to rise to 3 450 000 in 2015 and will continue to increase.[2] The swallowing function is important, because it is related to nutritional status and aspiration pneumonia. In Alzheimer's disease (AD) patients, pneumonia accounts for 70% of the causes of death.[3] The mortality caused by pneumonia in AD patients is particularly high when compared with subjects without dementia.[4] Thus, it is necessary to detect the signs of dysphagia in AD patients, and to deal with it early. Videofluorography (VF) and videoendoscopy (VE) are standard methods used to examine swallowing function. However, there are many cases in which those tests are difficult for AD patients to undergo because of the behavioral and psychological symptoms of dementia (BPSD). The role of VF in advanced AD has not been established, but dysphagia can be optimally managed in most cases using a multimodal approach based on a thorough history and meal-time assessment.[5]

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Table 1 Summary of participants according to Clinical Dementia Rating

	CDR1	CDR2	CDR3	Total
Men/women (*n*)	4/22	15/53	7/54	26/129
Average age (years)	81.77 ± 8.83	84.78 ± 6.92	86.51 ± 7.27	84.95 ± 7.53

CDR, Clinical Dementia Rating.

The present study focused on oral functions that can be easily observed in daily life, and their relationships with dysphagia were examined. The purpose of the present study was to determine how to identify signs of dysphagia in AD patients in daily life.

Methods

Participants

A total of 1666 elderly patients (aged over 65 years) with dementia were investigated. They were patients who were in hospitals or were residents of nursing homes or group homes. The participants of the present study were restricted to 422 patients who were diagnosed with AD by a neurologist. The diagnoses were carried out in accordance with the criteria issued by the National Institute of Neurological and Communicative Disorders and Stroke, and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA),[6] and the Hachinski ischemic score[7] did not exceed 4 for any patient in the study. A total of 158 of the 422 patients were able to try the modified water swallowing test (MWST). Finally, 155 participants were selected who had basic information about age, sex and severity of AD. The severity of AD was classified into mild (CDR1), moderate (CDR2) and severe (CDR3) by the Clinical Dementia Rating (CDR).[8] The participants included 29 men and 126 women, with an average age of 84.95 ± 7.53 years. The sex and average age of participants are summarized according to CDR in Table 1. Informed consent was obtained from each patient or their agent before the survey. They were fully informed about the purpose, nature and potential risks of the experiments, that participation was voluntary, and that they would not be placed at any disadvantage if they refused to participate in the study or withdrew from it before its completion. For all patients, their dates and names were recorded as numbers to prevent the identification of individuals. The present study was carried out with the approval of the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology (Ethical Clearance Number 44 [26 November 2010]).

Study design

The investigation was carried out from January to February 2011. The survey items are shown in Table 2. The swallowing test, oral status and oral function tests were carried out by dentists or dental hygienists, and a neurologist examined cognitive function and nutritional status. Nurses and care persons in charge evaluated basic information, neurological signs, vital functions and diet-related assessments. Likewise, rinsing and gargling were carried out to obtain information about the patients' performance in daily life. Furthermore, patients who could not answer questions, follow instructions and finish the test were excluded from the analysis.

Table 2 Survey items

	Survey items
Swallowing function	Modified water swallowing test
Oral status	Residual teeth
	Occlusal contacts
Oral functions	Lips function
	Tongue function
	Rinsing ability
	Gargling ability
Basic information and Vital functions	Age and Sex
	Barthel index (BI)
	Vitality index (VI)
Cognitive function and neurological signs	Mini-Mental State Examination
	Clinical Dementia Rating
	Limb contractures
Nutritional status	Serum albumin
	Body mass index
Diet-related assessments	Storing food in the mouth
	Stuffing food into the mouth
	Appetite
	Caloric intake

Swallowing function

Based on a common method,[9] a MWST was carried out; 3 mL of cold water were poured into the floor of the mouth with a 5 mL syringe, after which the participant was instructed to swallow, and their swallowing was scored as shown in Table 3. If the score was equal to or

Table 3 Modified water swallowing test score

Score 1	Inability to swallow with choking and/or breathing changes
Score 2	Swallowing occurred, but with breathing changes
Score 3	Swallowing occurred with no breathing changes, but with choking and/or wet hoarseness
Score 4	Swallowed successfully with no choking or wet hoarseness
Score 5	Furthermore to Score 4, additional deglutition (dry swallowing) occurred more than twice within 30 s

above 4 (score 4 or score 5), the test was repeated twice, and the lowest score was used as the test score. A score of 3 or less was defined as dysphagia.

Oral status

1 Residual teeth. Whether residual teeth were present or not was assessed.
2 Occlusal contacts. Regardless of prostheses, such as bridges and dentures, participants who could maintain the height of the bite were defined as having the "presence" of occlusal contacts, whereas those who could not do that were defined as having the "absence" of occlusal contacts.

Oral functions

1 Lips function. Participants who could not close their lips completely were defined as "worse". Good function was defined as "better".
2 Tongue function. The participants were asked to stick out their tongues. If the participant's proglossis could pass beyond the dental arch, it was defined as "better", whereas those who could not do so were defined as "worse".
3 Rinsing ability. Participants who could rinse rhythmically sequentially without leaking water were defined as "better" function, whereas those who could not were defined as "worse".
4 Gargling ability. Participants put water into their mouth, looked upward and gargled. If participants cleared it with no cough, they were defined as "better"; if not, they were defined as "worse".

Basic information and vital function tests

1 Age and sex.
2 Barthel Index (BI).[10]
3 Vitality Index (VI).[11]

The nurse in charge or the care provider recorded the patient's age and sex on the questionnaire. Vital function tests were carried out using the BI and the VI.

Cognitive function and neurological signs

1 Mini-Mental State Examination (MMSE).[12] Cognitive function was examined using the MMSE.
2 Clinical Dementia Rating (CDR).[8] Using the five scales of the CDR, the severity of AD was rated as follows: absent (0); questionable (0.5); mild (1); moderate (2); or severe (3). Participants given a rating of CDR 0 or CDR 0.5 were not included in the present study.
3 Neurological signs. Each patient was examined for the presence of limb contractures.

Nutrition status

1 Serum albumin. Recent data (within 3 months) were obtained from nursing and care records.
2 Body mass index (BMI). The most recent data (within 3 months) were obtained from nursing and care records.

Diet-related assessments

1 Storing food in the mouth. Patients who could not continue proper mastication and send food into the pharynx, which results in storing food in the oral cavity, were classified as storing food. This was evaluated as storing being "absent" or "present".
2 Stuffing food into the mouth. Patients who took food into their mouth by themselves without stopping, even when their mouth was already full, were classified as stuffing food into their mouth. This was evaluated as stuffing being "absent" or "present". The words "storing food" and "stuffing food" were defined by us.
3 Appetite. Participants with "no appetite" were defined as those who were indifferent to their diet, resisted meals, and rejected meals, at least half of the time.
4 Caloric intake. Whether or not participants could maintain an average caloric intake of at least 80% was evaluated.

Statistical analyses

Statistical analyses were carried out using SPSS version 17 (SPSS, Chicago, IL, USA). The evaluation of continuous quantitative data, such as age, cognitive assessments, vital functions tests and nutritional status, was carried out using the Mann–Whitney *U*-test. Qualitative data, such as swallowing function, oral status, oral functions and diet-related assessments, were analyzed using the χ^2-test. Parameters showing a significant difference were further investigated by multivariate analysis using

Table 4 Associations between the severity of Alzheimer's disease and items surveyed

Items		Mild (CDR1 [n = 26]) & moderate (CDR2 [n = 68]) (mean ± SD)	Severe (CDR3) (n = 61) (mean ± SD)	Mann–Whitney U-test P-value
Age (years)		83.9 ± 7.6	86.5 ± 7.3	$P = 0.026$
MMSE		14.1 ± 5.9	5.9 ± 6.7	$P = 0.002$
Barthel Index		43.1 ± 31.5	11.9 ± 18.3	$P < 0.001$
Vitality Index		6.3 ± 2.3	3.0 ± 2.4	$P < 0.001$
BMI (kg/m^2)		21.0 ± 3.2	17.6 ± 2.4	$P < 0.001$
Albumin (g/dL)		3.5 ± 0.4	3.4 ± 0.4	$P = 0.201$
Items		Mild & moderate % (n)	Severe % (n)	χ^2-test P-value
Dysphagia	Absence	87.2 (82)	59.0 (36)	$P < 0.001$
	Presence	12.8 (12)	41.0 (25)	
Residual teeth	Presence	48.9 (46)	56.7 (34)	$P = 0.409$
	Absence	51.1(48)	43.3 (26)	
Occlusal contacts	Presence	73.1 (68)	45.9 (28)	$P = 0.001$
	Absence	26.9 (25)	54.1 (33)	
Lips function	Better	74.7 (68)	74.0 (37)	$P = 1.000$
	Worse	25.2 (23)	26.0 (13)	
Tongue function	Better	85.9 (79)	66.0 (33)	$P = 0.009$
	Worse	14.1 (13)	34.0 (17)	
Rinsing ability	Better	82.2 (74)	40.0 (22)	$P < 0.001$
	Worse	17.8 (16)	60.0 (33)	
Gargling ability	Better	48.1 (39)	18.0 (9)	$P = 0.001$
	Worse	51.9 (42)	82.0 (41)	
Limb contractures	Absence	74.1 (63)	40.0 (22)	$P < 0.001$
	Presence	25.9 (22)	60.0 (33)	
Storing food	Absence	89.1 (82)	73.9 (34)	$P = 0.027$
	Presence	10.9 (10)	26.1 (12)	
Stuffing food	Absence	82.6 (76)	95.7 (44)	$P = 0.034$
	Presence	17.4 (16)	4.3 (2)	
Appetite	Presence	85.1 (80)	85.2 (52)	$P = 1.000$
	Absence	14.9 (14)	14.8 (9)	
Caloric intake	Better	82.4 (75)	86.5 (45)	$P = 0.639$
	Worse	17.6 (16)	13.5 (7)	

Upper section: Means of basic data by the severity of Alzheimer's disease (AD) and results of the Mann–Whitney U-test. Lower section: Number and frequency of each item by the severity of AD, and results of the χ^2-test. For the purpose of this analysis, mild and moderate AD patients were combined. BMI, body mass index; CDR, Clinical Dementia Rating; MMSE, Mini-Mental State Examination.

logistic regression analysis. Statistical significance was defined as $P < 0.05$.

Results

The associations between the severity of AD and the items investigated were examined (Table 4). The severity of AD was associated with age ($P = 0.026$), MMSE ($P = 0.002$), BI ($P < 0.001$), VI ($P < 0.001$), BMI ($P < 0.001$), dysphagia ($P < 0.001$), occlusal contacts ($P < 0.001$), tongue function ($P = 0.009$), rinsing ability ($P < 0.001$), gargling ability ($P = 0.001$), limb contractures ($P < 0.001$), storing food ($P = 0.027$) and stuffing food ($P = 0.034$). A total of 25 of 61 (41.0%) severe AD patients had dysphagia. Stuffing food into the mouth was significantly more common in mild and moderate AD patients than in severe AD patients.

On examination of the associations between dysphagia and the investigated items (proven association with

Table 5 Examinations of associations between various items and dysphagia

Items		Normal % (*n*)	Dysphagia % (*n*)	Univariate Relative risk OR (95% CI)	*P*	Multivariate Relative risk †OR (95% CI)	*P*
Occlusal contacts	Presence	70.3 (83)	37.8 (14)	3.8	0.001		
	Absence	29.7 (35)	62.2 (23)	(1.8–8.3)			
Tongue function	Better	84.1 (95)	58.6 (17)	3.7	0.004		
	Worse	15.9 (18)	41.4 (12)	(1.5–9.1)			
Rinsing ability	Better	76.8 (86)	30.3 (10)	7.6	<0.001	4.8	0.001
	Worse	23.2 (26)	69.7 (23)	(3.2–18.0)		(1.9–12.1)	
Gargling ability	Better	43.4 (43)	15.6 (5)	4.1	0.007		
	Worse	56.6 (56)	84.4 (27)	(1.5–11.7)			
Limb contractures	Absence	69.8 (74)	32.4 (11)	4.8	<0.001		
	Presence	30.2 (32)	67.6 (23)	(2.1–11.1)			
Storing food	Absence	85.1 (97)	79.2 (19)	1.5	0.474		
	Presence	14.9 (17)	20.8 (5)	(0.5–4.6)			
Stuffing food	Absence	86.8 (99)	87.5 (21)	0.9	0.931		
	Presence	13.2 (15)	12.5 (3)	(0.2–3.6)			

Left side: The frequency and number of each item by swallowing function. Right side: Associations between dysphagia and each item (univariate and multivariate analysis). †The odds ratio was adjusted by age, sex and Clinical Dementia Rating.

AD in Table 4), significant differences were found in occlusal contacts ($P = 0.001$), tongue function ($P = 0.004$), rinsing ability ($P < 0.001$), gargling ability ($P = 0.007$) and limb contractures ($P < 0.001$) (Table 5). There were 94 participants with mild and moderate AD, and 61 participants with severe AD. However, the number of participants was different for each test, as it was difficult for severe AD patients to complete some of the tests, especially gargling ability, lip function and tongue function.

Signs of dysphagia were analyzed by logistic regression analysis (Table 5). Five factors (occlusal contacts, tongue function, rinsing ability, gargling ability and limb contractures) were identified by univariate analysis ($P \leq 0.25$). These items were defined as independent variables, and dysphagia was the dependent variable in the logistic regression analysis using the variable increase method (the likelihood method). Three items (sex, age and severity of AD) might affect dysphagia, so the odds ratio was adjusted by these items. By logistic regression analysis, rinsing ability was significantly associated with dysphagia ($P = 0.001$, crude odds ratio 5.730, 95% confidence interval 2.0–15.9, adjusted odds ratio 4.776, 95% confidence interval 1.9–12.1).

Discussion

There have been few reports on oral functions in patients with dementia,[13,14] but it is important to confirm oral functions when examining for dysphagia. When examining for the signs of dysphagia, the state of the teeth and tongue dysfunction need to be noted, and salivary leakage from the lips, decreased muscle strength, and decreased jaw and soft palate movements might be observed.[15] Sumi *et al.* reported that there was a relationship between gargling function and cognitive function.[16] In our study, it was shown that occlusal contacts were lost in patients with severe AD, and there were significant differences in tongue function, and rinsing and gargling abilities became worse in patients with severe AD. There have been no previous reports investigating oral status and functions, especially with AD patients. One study reported that there were no significant differences in the number of remaining teeth.[13] A previous study reported a positive relationship between dementia and having few teeth;[17] however, the present participants were restricted for AD. So there were differences between participants. To summarize the present study and earlier research, the number of remaining teeth has not unraveled its relationship with dementia or AD yet, so further research is required. Also, regarding occlusal contacts, it is associated with AD severity in the present study. We found that tongue function, rinsing ability and gargling ability were associated with the severity of AD. It is interesting to note that not only the oral status, but also functional changes occur according to the severity of AD.

In the present study, a MWST was used to evaluate swallowing function. The water swallowing test is commonly used as a screening test for dysphagia. There are various methods used, with volumes of water ranging from 3–100 mL.[9,18,19] The MWST has often been used because it has 70% sensitivity and 88% specificity,[9] and

it is safe because of the small volume (3 mL) used. Overall, 41.0% of patients with severe AD were found to have dysphagia. It was reported earlier in a study using video fluorography that 44.4% of severe AD patients have dysphagia.[20] The nature of MWST and video fluorography are different, but in this case the water swallowing test appears to give appropriate results.

The cause of dysphagia in AD patients is considered to be cerebrocortical atrophy. In AD, the functional decline of the brain cortex region has been reported.[21] Martin and Sessle,[22] reviewed the association between the brain cortex and swallowing, and concluded that the brain cortex is in charge of the initiation and modification of swallowing and sensorimotor integration. A lesion of the left brain cortex was associated with deficits of the preparatory and oral stages of swallowing (coordinating oral movements and apraxia).[22] Based on the foregoing, one can infer that the cerebrocortical atrophy of AD patients affects the preparatory and oral stages of swallowing. This is in agreement with the characteristic prolongation of the preparatory and oral stages in AD. In the present study, storing food in the mouth and tongue dysfunction were significantly more frequent with severe AD, as could be expected.

Furthermore, the present study examined factors that affect dysphagia in AD patients; rinsing ability was identified to be strongly associated with dysphagia. In the clinical setting, the importance of the function of rinsing has been recognized, but no previous report has examined its importance in relation to dysphagia. Arai *et al.* mentioned the relationship between self-feeding and rinsing, and noted that rinsing requires many difficult functions, including liquid and equipment management, pharyngeal functions, oral pressure control and spit control skills.[23] Likewise, functional changes in the cortical control of swallowing are evident in early AD, and changes in the cortical control of swallowing might begin long before dysphagia becomes apparent.[21] Therefore, early screening seems to be possible by assessing rinsing ability. The present study was carried out for AD patients. Severe AD patients sometimes could not complete the tests, because it is difficult for them to understand what the investigator said. Thus, it is a limitation of this survey for AD.

In patients with dementia, the results of detailed examination, such as video endoscopy or video fluoroscopy, do not always reflect daily functions. Therefore, routine daily mealtime habits, swallowing water and rinsing can be important sources of information to detect dysphagia. The factors affecting the swallowing function of AD patients were examined. Swallowing function was shown to deteriorate significantly with the increasing severity of AD, and an association between AD and dysphagia was shows. It was found that difficulty with rinsing is a sign of dysphagia. Therefore, it is useful to routinely observe rinsing ability to detect dysphagia in AD patients.

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Disclosure statement

The authors declare no conflict of interest.

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Gerodontology

Original article

Prevalence and factors associated with xerostomia and hyposalivation among community-dwelling older people in Japan

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Prevalence and factors associated with xerostomia and hyposalivation among community-dwelling older people in Japan

Objective: This study investigated the prevalence and factors associated with xerostomia and hyposalivation among community-dwelling older people.
Background: Xerostomia and hyposalivation are common symptoms in the older population.
Materials and methods: This study included with 894 community-dwelling, Japanese older people (355 men, 539 women; age 65–84 years) who participated in a comprehensive geriatric health examination, which included questionnaires and interviews regarding medical history, medications, Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC), depressive condition. The Zung Self-Rating Depression Scale (SDS) was used to evaluate depression. Resting salivary flow rate was evaluated by the modified cotton roll method.
Results: In this study, 34.8% of the participants (mean age, 73.5 ± 5.0 years) complained about xerostomia, while the prevalence of hyposalivation was 11.5%. Multiple regression analysis revealed hypnotics use [odds ratio (OR) = 1.71, 95% confidence interval (CI) = 1.13–2.61], SDS (OR = 1.05, CI = 1.04–1.07) and TMIG-IC total points (OR = 0.87, CI = 0.76–0.99) to be significantly associated with xerostomia. In contrast, female gender (OR = 2.59, CI = 1.55–4.31) and the use of agents affecting digestive organs (OR = 1.78, CI = 1.11–2.86) were associated with hyposalivation.
Conclusion: Our findings showed that the prevalence of xerostomia and hyposalivation were approximately 1 in 3 and 1 in 10 respectively. The factors associated with psychological factors and high-level functional competence, while hyposalivation was associated with medications and gender, as well as systemic and/or metabolic differences. It is important to consider these multidimensional factors associated with xerostomia and hyposalivation.

Keywords: dry mouth, saliva, epidemiology, general condition.

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Introduction

Xerostomia and hyposalivation are common symptoms in the older population[1–8]. Xerostomia and hyposalivation are two separate entities: xerostomia denotes the subjective feeling of oral dryness, while hyposalivation denotes an objective symptom of decreased salivary flow rate[9]. Previous studies suggested that not all people who have hyposalivation report xerostomia, that is, people who report xerostomia may have normal or high salivary flow[1,10,11]. It is important to establish the current status of xerostomia and hyposalivation comprehensively in potentially frail older patients exhibiting these symptoms. However, most population-based studies have only investigated the prevalence of xerostomia, and only a few studies have investigated the prevalence of both xerostomia and hyposalivation within the same older populations[12].

These symptoms may impair speaking, chewing, tasting and swallowing[2,13], and may also affect

quality of life[3,5,14], and social role[6]. Individuals who complain about xerostomia with a low or altered salivary flow may be at a higher risk of dental caries, gingivitis, erosion and ulceration of mucosal tissues, oral candidiasis, dysgeusia and dysphagia[10,15]. Oral dysfunction may have a negative impact on general well-being and social relationships[6]; therefore, it is paramount for older people to maintain their oral health[16,17]. With the rapidly ageing society, maintenance of a functional level of competence has become an important issue, and is regarded as a critical aspect among older people in order to go about their everyday lives independently[18]. However, previous studies on the prevalence of xerostomia and hyposalivation, and the relationship with general health status or higher level functional capacity among community-dwelling older people, is limited.

It is considered that the most frequent cause of xerostomia is medication[1,11,19,20]. Sreebny and Schwartz reported that 80% of the most commonly prescribed medications cause xerostomia, and more than 400 medications are associated with hyposalivation as an adverse effect[21]. Older people are more likely to take medications and are thus more vulnerable to their side effects compared to other generations[11,19]. It is well known that antidepressants and depressive symptoms are risk factors for xerostomia and hyposalivation[11,21,22], but the risk ratio of these factors among the Japanese community-dwelling older populations is not well known.

The aim of this study was to investigate the prevalence and the factors associated with xerostomia and hyposalivation among community-dwelling older people in Japan.

Materials and methods

The study population comprised 894 community-dwelling older people (355 men, 539 women; age 65–84 years) who were invited to undergo a comprehensive geriatric health examination by the Tokyo Metropolitan Institute of Gerontology. The mean age of the participants was 73.5 ± 5.0 years. The present examination was conducted for 11 consecutive days in the Itabashi Ward located in the north of Tokyo in October 2011.

The participants were asked to answer the dichotomous yes-no question 'Does your mouth feel dry?' in order to assess their subjective feelings of oral dryness[23,24].

In order to determine hyposalivation, only the resting salivary flow rate was measured, since this is likely to be more important in protecting dentition[25]. Resting saliva was collected using the modified cotton roll method[3,19,26]. A pre-weighed cotton roll was placed under the tongue, and the participants were instructed to close their mouth for 30 s, after which the cotton roll was removed. The amount of saliva absorbed by the cotton was then measured using an electronic scale. The measurement was carried out once for each participant. This method is non-invasive and easy-to-use, reducing the burden for older individuals. Participants whose resting saliva was <0.1 g were categorised in the hyposalivation group. This cut-off value was based on the previous study including older patients with subjective oral dryness by Takahashi et al.[26].

The Zung Self-Rating Depression Scale (SDS), one of the most widely used instruments for assessing the intensity of depression[27,28] was conducted. The Japanese version of the SDS is a self-reporting, 20-question instrument that assesses the psychological and somatic symptoms of depression. Ten questions are positively worded, and 10 are negatively worded. Each question is scored on the following 4-point scale: 1, a little of the time; 2, some of the time; 3, a good part of the time; 4, most of the time. To obtain the total score, the positive items are reversed, and the items are then summed[29].

The questionnaire included the following variables: common systemic disease which were investigated in a comprehensive geriatric health research survey among Japanese community-dwelling older people (defined as a history of hypertension, heart disease, stroke, diabetes mellitus, osteoporosis or bronchial asthma)[6,30,31], common xerostomic medication (antihypertensive, anti-inflammatory drugs/analgesics, steroids, drugs for the treatment of osteoporosis, anxiolytics, hypnotics or agents affecting digestive organs) according to previous reports[12,19,21] and smoking habit.

We assessed higher level functional competence using the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC)[32]. Functional capacity contains two major components: 'Basic activity of daily living' and 'Higher level functional competence'[18]. The TMIG-IC defines higher level functional competence as the ability to prepare meals, manage money and take medications[32] This index consists of the following three subscales: instrumental self-maintenance (five items), intellectual activity (four items) and social role (four items). A high score reflects a higher functional level of competence. This index of competence has been verified to have high reliability and validity and is widely accepted and used in Japan[31,33,34].

This study was approved by the Ethics Board of the Tokyo Metropolitan Institute of Gerontology (Issue#23-1235 in 2011). Signed informed consent was obtained from each participant.

The chi-square test was used for categorical variables; Student's *t*-test and the Mann–Whitney *U*-test for continuous variables were used, to examine characteristics of the xerostomia group and the hyposalivation group respectively.

Multiple logistic regression analysis (forced entry analysis) was performed to identify factors associated with xerostomia and hyposalivation. The dependent variables comprised the presence or absence of xerostomia and hyposalivation, while variables that resulted in a *p*-value of <0.2 in the univariate analysis were determined as dependent variables. Prior to multiple logistic regression analysis, the dependent variables for which the correlation coefficient of was >0.8 were deleted in order to avoid multicollinearity. All statistical analyses were carried out using SPSS Statistics Ver. 19.0J software for Windows (IBM, Tokyo, Japan). The level of significance was set at $p < 0.05$.

Results

Approximately, one-third (34.8%) of the participants were classified as having xerostomia, while 11.5% of them were classified as having hyposalivation (Table 1). Moreover, 4.8% of the participants were categorised in the hyposalivation and xerostomia groups, and 58.5% of them were categorised in the normal group. Importantly, 30% of participants complained about xerostomia with normal salivary flow, whereas 6.7% of them were classified in the hyposalivation group without xerostomia, which means that subjective and objective evaluation were not necessarily in accordance.

The participants with xerostomia were more likely to have symptoms of osteoporosis; take medications such as anxiolytics, hypnotic drugs or agents that affect the digestive organs; have a smoking habit, be functionally dependent; and to have a high SDS score compared to non-xerostomia individuals (Table 2).

On the other hand, participants with hyposalivation were more likely to be females and to take anxiolytic drugs compared to the normal group (Table 3).

According to multiple logistic regression analysis, the use of hypnotics [odds ratio (OR) = 1.71, 95% confidence intervals (CI) = 1.13–2.61), SDS (OR = 1.05, CI = 1.04–1.07), the presence of a smoking habit (OR = 1.69, CI = 1.03–2.77) and TMIG-IC total points (OR = 0.87, CI = 0.76–0.99) were significantly associated with xerostomia (Table 4).

However, female gender (OR = 2.59, CI = 1.55–4.31) and the use of agents affecting digestive organs (OR = 1.78, CI = 1.11–2.86) were associated with hyposalivation (Table 5). Therefore, xerostomia and hyposalivation were each associated with different factors.

Table 1 Prevalence of xerostomia and hyposalivation.

	Salivary gland secretion					
	Low		*Normal*		*Total*	
	n	%	*n*	*Total*	*n*	%
Xerostomia						
Yes	43	4.8	268	30	311	34.8
No	60	6.7	523	58.5	583	65.2
Total	103	11.5	791	88.5	894	100

Discussion

This cross-sectional study was conducted in a community-dwelling, older Japanese population, to investigate the prevalence of xerostomia and hyposalivation, and the factors associated with these conditions. Our findings revealed that 34.8% of the participants complained of xerostomia, 11.5% had hyposalivation, and 4.8% of the participants had both xerostomia and hyposalivation. In other words, approximately 40% of older participants in the present study had xerostomia and/or hyposalivation.

According to the review by Hopcraft *et al.*[12], the prevalence of xerostomia in population based studies ranges from 10 to 46%, and our results were in line with these previous reports. Population studies conducted on both xerostomia and hyposalivation within the same sample in older people revealed that the prevalence of both symptoms were 3.3–5.7%. The results of this study were similar to previous reports[14,25,35].

Our findings suggested that hyposalivation can exist in people who have no complaint of xerostomia, while people with sufficient salivary secretion can have xerostomia. Thus, in order to detect older individuals potentially suffering from xerostomia and hyposalivation, we suggest the importance of both subjective and objective assessments of dry mouth symptoms.

Multiple logistic regression analysis revealed a significant association between taking medications and xerostomia or hyposalivation rather than their

Table 2 Comparison of characteristics of xerostomic and non-xerostomia groups.

	Xerostomia			*Non-xerostomia*			
Variable	*Mean ± SD*	*n*	*%*	*Mean ± SD*	*n*	*%*	*p-Value*
Age (year)	73.9 ± 5.2			73.3 ± 4.9			0.056[a]
Gender							
Male		119	38.3		236	40.5	0.284[b]
Female		192	61.7		347	59.5	
Presence of systemic disease (% present)							
Hypertension		145	46.6		264	45.2	0.377[b]
Heart disease		46	14.8		97	16.6	0.268[b]
Stroke		18	5.8		31	5.3	0.439[b]
Diabetes mellitus		36	11.6		70	12.0	0.471[b]
Osteoporosis		58	18.7		74	12.7	0.011[b]
Presence of medication (% present)							
Antihypertensive		133	43.0		252	43.4	0.498[b]
Anti-inflammatory drugs/analgesics		38	12.2		48	8.2	0.036[b]
Steroids		7	2.3		17	2.9	0.360[b]
Drug for the treatment of osteoporosis		47	15.1		57	9.8	0.013[b]
Axiolytics		30	9.6		35	6.0	0.033[b]
Hypnotics		66	21.3		61	10.5	<0.001[c]
Agents affecting digestive organs		103	33.2		136	23.3	0.001[b]
Smoking habit (% yes)		43	13.9		49	8.4	0.008[b]
SDS (points)	37.8 ± 9.3			32.6 ± 8.4			<0.001[c]
TMIG-IC total points	12.1 ± 1.8			12.6 ± 1.0			<0.001[c]

SDS, Zung Self-rated Depression Scale; TMIG-IC, Tokyo Metropolitan Institute of Gerontology Index of Competence; SD, standard deviation.
[a]Student's *t*-test.
[b]χ^2 test.
[c]Mann–Whitney U test.

association with a systemic disease per se. In accordance with previous studies, medications are one of the important factors contributing to both xerostomia and hyposalivation. Schubert and Izutsu[36] suggested that neural control of salivation is extremely complex, and pharmacological agents can mimic or antagonize numerous regulatory aspects of salivation, thus affecting both salivary flow and composition. Side effects also tend to occur more readily in older people than in younger people. Potential reasons for this being that in older people, drug activity is stronger as a result of decreased levels of serum albumin, and the plasma half-life of drugs is longer owing to delayed drug elimination as a result of decreased renal function and slower metabolism[19]. To manage drug-induced hyposalivation and xerostomia, it is necessary to acquire a thorough medical and drug history[21]. In clinical practice, a medication notebook provided by pharmacies might be useful to gather accurate information.

The results of multiple regression analysis in the present study show that the factors associated with xerostomia are different from those associated with hyposalivation. It is important for health care providers to consider these multidimensional factors among older people with xerostomia and hyposalivation.

This study showed that more depressed persons, as assessed by the SDS, are more likely to suffer from xerostomia while there was no association between the SDS score and hyposalivation. Some previous studies have suggested an association between xerostomia and depressive conditions[37–39], but the participants of these studies were relatively younger, and few studies have evaluated depressive conditions for the healthy general older population using a self-rating depression scale so far. The evaluated depressive condition does not mean clinical depression. We should state that some of the participants of the present study might have been using antidepressants, which possibly cause xerostomia. This study, however, did not find any association between the SDS and hyposalivation. This suggests that the association of SDS with xerostomia is not necessarily caused only by antidepressants. Our findings suggest that a depressive condition may be an important factor in older individuals with