Table 2
Univariate analysis of subjects' demographics.

		Asphyxiation (n = 51)	No asphyxiation (n = 386)	Relative risk (95% CI)	p value
Sex	Male	10	100	1.43 (0.69–2.97)	0.21
	Female	41	286		
Self feeding	Independent	41	209	3.47 (1.69–7.13)	<0.001
	Dependent	10	177		
ADL	Maintained	34	312	2.11 (1.12–3.98)	0.02
	Decreased	17	74		
Cognitive function	Maintained	28	117	2.80 (1.55–5.06)	<0.001
	Decreased	23	269		
Tongue coating	Yes	20	135	1.20 (0.66–2.19)	0.55
	No	31	251		
Food residue	Yes	20	157	0.93 (0.51–1.69)	0.32
	No	31	222		
Xerostomia	Yes	15	132	0.80 (0.42–1.52)	0.44
	No	36	254		
Occlusal support	Natural occlusal support	5	83		
	Denture occlusal support	16	153		0.02
	Occlusal support disruption	30	150		
Swallowing disorder	Yes	27	124	2.38 (1.32–4.29)	0.03
	No	24	262		
Previous stroke	Yes	19	212	0.72 (0.40–1.32)	0.18
	No	32	174		
Drug administration	Yes	16	110	1.15 (0.61–2.16)	0.39
	No	35	276		

3. Results

3.1. Incidence of asphyxiation

Fifty-one subjects suffered asphyxiation due to food (10 men and 41 women; mean age, 85.6 ± 7.1 years). The annual incidence of asphyxiation accidents was 4.7%. Four subjects had two or more episodes of asphyxiation during the period (four times: one subject, three times: two subjects, two times: one subject). Death caused by asphyxiation occurred in two subjects.

The food causing asphyxiation was fruit in seven subjects, vegetables in four, meat in four, fish in four, rice in three, bread in one, and others in six. There were 29 unclear cases where several foods were involved. There could be multiple causes in those subjects. After the onset of asphyxiation, 13 subjects (25.5%) were transferred to an emergency clinic or hospitalized, but two of them died in hospital within 24 h.

3.2. Risk factors

Factors showing a significant relationship with the onset of asphyxiation were self-feeding [$p < 0.001$, relative risk = 3.47 (1.691–7.131)], ADL [$p = 0.02$, relative risk = 2.11 (1.12–3.98)], and cognitive function [$p < 0.001$, relative risk = 2.80 (1.55–5.06)]. Among 180 subjects who had lost occlusal support with their natural teeth and did not regain occlusion, 30 subjects (16.7%) suffered asphyxiation. However, among 169 subjects whose occlusal support was restored with dentures, 16 subjects (9.5%) suffered asphyxiation, and among 88 subjects with occlusal support with their natural teeth, 5 subjects (5.7%) suffered asphyxiation. The incidence of asphyxiation showed a significant difference ($p = 0.016$) among the three groups (Table 2) (Fig. 1).

3.3. Survey of diagnosis

The presence or absence of general conditions that might have affected swallowing function was determined, and found out that none of them had affected swallowing function (Table 3).

3.4. Results of logistic analysis

Risk factors were screened by logistic analysis of variance using the presence or absence of a history of asphyxiation as a dependent variable and the presence of significant factors in univariate analysis as an independent variable. The stepwise method (backward elimination method) was used for variable selection. As a result, "self-feeding" ($p < 0.001$, relative risk = 3.11, 95% CI:

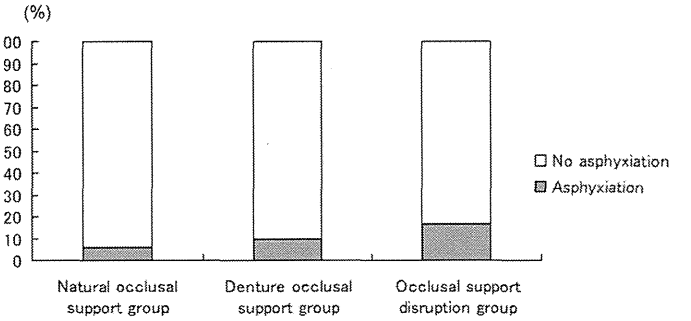

Fig. 1. Relationship between dental status and incidence of asphyxiation. Among 171 subjects who had lost occlusal support with their natural teeth and did not regain occlusion with dentures, 30 subjects (17.5%) suffered asphyxiation. Among 215 subjects whose occlusal support was restored by means of dentures, 21 subjects (9.8%) suffered asphyxiation. Among 113 subjects with occlusal support with their natural teeth, 5 subjects (4.4%) suffered asphyxiation ($p = 0.016$, chi-squared test).

Please cite this article in press as: Kikutani, T., et al., Tooth loss as risk factor for foreign-body asphyxiation in nursing-home patients. Arch. Gerontol. Geriatr. (2012), doi:10.1016/j.archger.2012.01.010

Table 3
Univariate analysis of subjects' general conditions.

		Asphyxiation ($n = 51$)	No asphyxiation ($n = 386$)	Relative risk (95% CI)	p value
Cerebrovascular disease	Yes	19	212	0.72 (0.40–1.32)	0.180
	No	32	174		
Neuromuscular disease	Yes	5	25	1.57 (0.57–4.30)	0.264
	No	46	361		
Cardiac disease	Yes	4	48	0.60 (0.21–1.74)	0.242
	No	47	338		
Respiratory disease	Yes	4	18	1.74 (0.57–5.36)	0.247
	No	47	368		
Diabetes	Yes	1	5	1.52 (0.17–13.31)	0.527
	No	50	381		
Bone and joint disease	Yes	16	97	1.36 (0.72–2.57)	0.395
	No	35	289		

1.50–6.44) and "occlusal support" ($p = 0.01$, relative risk = 1.75, 95% CI: 1.12–2.73) were selected as significant explanatory variables (Table 4).

4. Discussion

The annual incidence per capita of asphyxiation accidents in the present study was 4.7 per 1000 population in Japan; this is lower than the results from previous research carried out at day-care facilities for elderly people (Takahashi et al., 1994). The incidence of asphyxiation among elderly people in care facilities for the aged was clearly higher than that of elderly people living at home. The elderly people in care facilities appeared to be frailer than those who received care at home. Although the frequency was generally low, accidents were often fatal. Our results show that many individuals were hospitalized after asphyxiation accidents and some of them died. Among the subjects with asphyxiation, approximately 8% had several asphyxiation episodes during the study period, which is four times higher than that reported previously (Suda et al., 2008). Those who suffered several asphyxiation accidents were considered to be at higher risk of death.

We demonstrated that factors related to asphyxiation accidents include self-feeding, ADL, cognitive function, occlusal support of molars, and swallowing disorders. Of these, there was a strong correlation between occlusal support of molars and the incidence of asphyxiation. Many elderly people lose their teeth because of dental caries or periodontal disease, and many of those in the present study had lost occlusal support with their natural teeth. This may lead to reduced chewing ability in elderly people (Hatch et al., 2001). However, the rate of use of dentures, especially among frail individuals, is known to be low. The ability to use dentures is reduced by impaired cognitive function, apraxia, and spatial cognition disorders and is known to be affected by a decrease in ADL (Carter and Jancar, 1984).

We demonstrated that cognitive function is one of the risk factors for asphyxiation. In elderly people with reduced cognitive function requiring nursing care, it has been reported that swallowing without chewing as well as cramming food into the mouth often occurs (Samuels and Chadwick, 2006). These people have also been reported to show symptoms of fast-eating syndrome (Bazemore et al., 1991). In fact, many elderly people with dementia die because of accidental swallowing or asphyxiation (Brunnström and Englund, 2009). In comparison with patients with cerebrovascular dementia, patients with frontotemporal dementia are known to have abnormal eating habits, including cramming food and eating fast (Bathgate et al., 2001), which makes it necessary to take measures to prevent asphyxiation in accordance with the type of dementia.

It is interesting that the incidence of asphyxiation showed a strong association with the ability to self-feed. The ability to understand the use of eating utensils, a sufficient range of arm motion, and coordination of both arms and oral function are necessary for self-feeding. Good management of self-feeding ability is an important factor in maintaining quality of life of the elderly. According to Volicer et al. (1987), (50)% of patients with Alzheimer disease lose the ability to self-feed within 8 years after diagnosis. Apraxia and spatial-cognitive disorders cause problems in self-feeding ability. Many diseases associated with dementia are considered to impair self-feeding ability. To improve or maintain self-feeding ability, it is necessary to undertake very complex measures based on an understanding of one's own chewing function and swallowing function, and on selection of food in accordance with those functions. If selection of food is necessary, reprocessing of food could be undertaken such as by subdividing, cutting or mixing, to make the food match the functions mentioned above. Every individual must consider the pace of eating by coordinating the amount of food in each bite to prevent accidents.

The results of this study suggest that absence of occlusal support is a risk factor for asphyxiation. Individuals who had lost occlusal support with their natural teeth showed a higher risk of asphyxiation than those with occlusal support. These results suggest that restoration of occlusal support with dentures might be an effective procedure to prevent asphyxiation. If dentists undertook measures based on continuous dental management for frail elderly people, more people might become able to wear dentures (Kawana et al., 2010). Prevention of dental caries and periodontal diseases that cause tooth loss is, of course, essential to prevent loss of occlusal support, and should be included in the management plan. Maintenance of occlusal support for frail elderly people by means of continuous management by dentists is also effective to prevent asphyxiation.

To further prevent asphyxiation and eat safely in elderly people with little ability to control the speed and amount of food, it is important to assist such people while taking food, rather than encourage them to improve their self-feeding ability.

Table 4
Independent predictors of asphyxiation.

	Coefficient (±S.E.)	p value	Relative risk	95% CI	
				Lower	Upper
Self feeding	1.13 (±0.37)	<0.001	3.11	1.50	6.44
Occlusal support	0.56 (±0.23)	0.01	1.75	1.12	2.73

S.E.: standard error.

Conflict of interest statement

None.

Acknowledgments

This study was supported by a Grant-in-Aid (20-17) and a Research Grant for Longevity Science (21-2) from of the Ministry of Health, Labour and Welfare, Japan (2009).

The authors thank all the patients and caregivers, and the nurses who participated in the study.

References

Bathgate, D., Snowden, J.S., Varma, A., Blackshaw, A., Neary, D., 2001. Behaviour in frontotemporal dementia, Alzheimer's disease and vascular dementia. Acta Neurol. Scand. 103, 367–378.

Bazemore, P.H., Tonkonogy, J., Ananth, R., 1991. Dysphagia in psychiatric patients: clinical and videofluoroscopic study. Dysphagia 6, 2–5.

Brunnström, H.R., Englund, E.M., 2009. Cause of death in patients with dementia disorders. Eur. J. Neurol. 16, 488–492.

Carl, L.L., Johnson, P.R., 2006. Drugs and Dysphagia: How Medications Can Affect Eating and Swallowing. Pro-Ed, Austin, TX.

Carter, G., Jancar, J., 1984. Sudden deaths in the mentally handicapped. Psychol. Med. 14, 691–695.

Eichner, K., 1955. Über eine Gruppeneinteilung der Lunckengebisse für die Prothetic. Dtsch. Zahnarztl. Z. 10, 1831–1834 (in German).

Ekberg, O., Feinberg, M., 1992. Clinical and demographic data in 75 patients with near-fatal choking episodes. Dysphagia 7, 205–208.

Feinberg, M.J., Ekberg, O., Segall, L., Tully, J., 1992. Deglutition in elderly patients with dementia: findings of videofluorographic evaluation and impact on staging and management. Radiology 183, 811–814.

Finestone, H.M., Fisher, J., Greene-Finestone, L.S., Teasell, R.W., Craig, I.D., 1998. Sudden death in the dysphagic stroke patient—a case of airway obstruction caused by a food bolus: a brief report. Am. J. Phys. Med. Rehabil. 77, 550–552.

Fioritti, A., Giaccotto, L., Melega, V., 1997. Choking incidents among psychiatric patients: retrospective analysis of thirty-one cases from the west Bologna psychiatric wards. Can. J. Psychiatry 42, 515–520.

Haddon Jr., W., 1980. Advances in the epidemiology of injuries as a basis for public policy. Public Health Rep. 95, 411–421.

Hatch, J.P., Shinkai, R.S., Sakai, S., Rugh, J.D., Paunovich, E.D., 2001. Determinants of masticatory performance in dentate adults. Arch. Oral Biol. 46, 641–648.

Hirakawa, Y., Kuzuya, M., Enoki, H., Hasegawa, J., Iguch, A., 2008. Caregiver burden among Japanese informal caregivers of cognitively impaired elderly in community settings. Arch. Gerontol. Geriatr. 46, 367–374.

Ichikawa, M., Marui, E., 2000. Mortality of unintentional injuries in childhood and later adulthood in Japan: 1968–1997. Jpn. J. Health Hum. Ecol. 66, 126–136.11.

Kakinoki, Y., Nishihara, T., Arita, M., Shibuya, K., Ishikawa, M., 2004. Usefulness of new wetness tester for diagnosis of dry mouth in disabled patients. Gerodontology 21, 229–231.

Kawana, H., Kikutani, T., Takahashi, N., Hirabayashi, M., Tashiro, H., Fukui, T., Tamura, F., 2010. Effect of continuous management of oral function in the nursing home for denture-wearing elderly under long-term care. J. Gerodont. 25, 3–10 (in Japanese).

Mahoney, F.I., Barthel, D.W., 1965. Functional evaluation: the Barthel index. Md. State Med. J. 14, 61–65.

Minakuchi, S., Takaoka, S., Ito, J., Shimoyama, K., Uematsu, H., 2006. Factors affecting denture use in some institutionalized elderly people. Spec. Care Dentist 26, 101–105.

Ministry of Health, Labour and Welfare of Japan, 2011. Activity of Daily Living Independence of Demented Elderly. Available at: http://www.mhlw.go.jp:80/topics/kaigo/kentou/15kourei/sankou4.html (accessed on May 29, 2011, in Japanese).

Miyazaki, H., Sakao, S., Katoh, Y., Takehara, T., 1995. Correlation between volatile sulphur compounds and certain oral health measurements in the general population. J. Periodontol. 66, 679–684.

NANDA International, 2003. NANDA Nursing Diagnosis: Definitions and Classification 2003–2004. North American Nursing Diagnosis Association, Philadelphia, p. 256.

Ono, T., Kumakura, I., Arimoto, M., Hori, K., Dong, J., Iwata, H., Nokubi, T., Tsuga, K., Akagawa, Y., 2007. Influence of bite force and tongue pressure on oro-pharyngeal residue in the elderly. Gerodontology 24, 143–150.

Samuels, R., Chadwick, D.D., 2006. Predictors of asphyxiation risk in adults with intellectual disabilities and dysphagia. J. Intellect. Disabil. Res. 50, 362–370.21.

Suda, M., Kikutani, T., Tamura, F., Yoneyama, T., 2008. Associated factors for suffocation accidents in the disabled elderly at home. J. Gerodont. 23, 3–11 (in Japanese).

Takahashi, K., Groher, M.E., Michi, K., 1994. Methodology for detecting swallowing sounds. Dysphagia 9, 54–62.

Volicer, L., Seltzer, B., Rheaume, Y., Fabiszewski, K., Herz, L., Shapiro, R., Innis, P., 1987. Progression of Alzheimer-type dementia in institutionalized patients: a cross-sectional study. J. Appl. Gerontol. 6, 83–94.

Please cite this article in press as: Kikutani, T., et al., Tooth loss as risk factor for foreign-body asphyxiation in nursing-home patients. Arch. Gerontol. Geriatr. (2012), doi:10.1016/j.archger.2012.01.010

Geriatr Gerontol Int 2013; **13:** 50–54

ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Relationship between nutrition status and dental occlusion in community-dwelling frail elderly people

Takeshi Kikutani,[1] Mitsuyoshi Yoshida,[4] Hiromi Enoki,[5] Yoshihisa Yamashita,[6] Sumio Akifusa,[7] Yoshihiro Shimazaki,[6] Hirohiko Hirano[2] and Fumio Tamura[3]

[1]Division of Oral Rehabilitation, the Nippon Dental University Graduate School of Life Dentistry, [2]Research Team for Promoting Independence of the Elderly, Tokyo Metropolitan Institute of Gerontology, [3]Rehabilitation Clinic for Speech and Swallowing Disorders, The Nippon Dental University School of Life Dentistry at Tokyo, Dental Hospital, Tokyo, [4]Dental Department, Hiroshima City General Rehabilitation Center, Hiroshima, [5]Department of Health and Medical science, Aichi Shukutoku University, Aichi, [6]Section of Preventive and Public Health Dentistry, Division of Oral Health, Growth and Development, Kyushu University Faculty of Dental Science, and [7]Department of Health Management, School of Oral Health Sciences, Kyushu Dental College, Fukuoka, Japan

Aim: This study aimed to determine the risk of malnutrition in some communities where the frail elderly receive public long-term care insurance. We also clarified the dental problems in those at risk of malnutrition.

Methods: A total of 716 frail elderly who lived in eight cities in Japan (240 males and 476 females with a mean age of 83.2 ± 8.6 years) were divided into three groups according to Mini Nutritional Assessment short form results: well nourished, at risk of malnutrition and malnourished. They were also divided into three groups in terms of remaining teeth occlusion and denture occlusion: group A, natural dentition with adequate function; group B, partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws; and group C, functionally inadequate occlusion with no dentures. The relationship between nutrition status and dental occlusion was evaluated using logistic regression analysis with sex, age, activities of daily living and cognitive function as covariates.

Results: The number of participants in each of the groups was as follows: 251 well nourished, 370 at risk of malnutrition and 95 malnourished. When they were divided into just two groups, (i) well nourished and (ii) at risk of malnutrition plus malnourished, in order to study malnutrition risk factors, there were significant relationships between their nutritious status and sex, Barthel index, and occlusion.

Conclusion: This large-scale cross-sectional survey showed that loss of natural teeth occlusion was a risk factor for malnutrition among community-dwelling frail elderly. **Geriatr Gerontol Int 2013; 13: 50–54.**

Keywords: frail elderly people, Mini Nutritional Assessment short form, nutrition, occlusion.

Introduction

The intake of nutrients from daily meals is the foundation of life. Low nutrition decreases the immunological defenses, reduces physical functions, and can be a direct or indirect cause of morbidity and mortality among the elderly.[1,2] It has been reported that 1–15% of outpatients and 15–60% of the institutionalized elderly suffer from protein-energy malnutrition (PEM),[3] suggesting that the condition of elderly at risk of malnutrition should be investigated and improved without delay.

Several screening methods are available for determining malnutrition, but the use of a questionnaire is a simpler and more convenient method for a large-scale survey.[4] Especially, The Mini Nutritional Assessment short form (MNA-SF) has been highly utilized worldwide, and its sensitivity and specificity have already been shown.[5,6]

The present study evaluated the malnutrition risk for community-dwelling frail elderly receiving public long-term homecare insurance in Japan using the MNA-SF to determine whether dental occlusion might influence the risk of malnutrition.

Methods

The participants were 716 elderly individuals living at home and receiving public long-term care insurance services (240 males and 476 females with a mean age of

Accepted for publication 16 February 2012.

Correspondence: Dr Mitsuyoshi Yoshida DDS PhD, Dental Department, Hiroshima City General Rehabilitation Center, Tomo-minami 1-39-1, Asaminami-ku, Hiroshima 731-3168, Japan. Email: mitsu@hiroshima-u.ac.jp

 doi: 10.1111/j.1447-0594.2012.00855.x

83.2 ± 8.6 years) in eight prefectures in Japan (Tokyo, Fukushima, Kanagawa, Yamanashi, Shizuoka, Niigata, Fukuoka and Okinawa). Their malnutrition risk was evaluated using the MNA-SF, and also age, sex and underlying medical problems using the Charlson index[7] were determined. In addition, activities of daily living (ADL) and cognitive function were evaluated using the Barthel index[8] and the Clinical Dementia Rating,[9] respectively, based on information from caregivers or care managers. This evaluation also determined one of the living environment factors, whether or not living alone.

The participants received oral examinations by a dentist or dental hygienist at home or at the day care facility they usually used, and molar occlusion was classified into the following three groups according to edentulous condition and denture-wearing status:

- Group A, natural dentition with adequate function
- Group B, partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws
- Group C, functionally inadequate occlusion with no dentures

Swallowing function was evaluated using a stethoscope to determine whether cervical auscultation of swallowing sounds was normal or abnormal.[10] Before the examination, the dentist and dental hygienist in charge were instructed about the cervical auscultation method.

The participants were divided into three groups according to the result of the MNA-SF: (i) well-nourished; (ii) at risk of malnutrition; and (iii) malnourished. The relationship between participants' general condition and oral status was analyzed using the χ^2-test and one-way ANOVA. In addition, participants were also divided into two groups: (i) well-nourished; and (ii) at risk of malnutrition or malnourished. Logistic regression analysis was carried out to study the significant risk factors influencing malnutrition. Participants were also divided into two groups according to whether they were: (i) well-nourished *plus* those at risk of malnutrition; and (ii) malnourished. Logistic regression analysis was carried out to clarify the characteristics of malnourished subjects. PASW Statistics 18 (IBM, Tokyo, Japan) was used for statistical analysis with the significance level set at 95%.

Results

The MNA-SF showed the following: 251 individuals (94 males and 157 females) were well nourished, 370 (120 males and 250 females) were at risk of malnutrition and 95 (26 males and 69 females) were malnourished. Table 1 shows the general condition of participants, number of missing teeth and number of remaining teeth roots among those without occlusion according to nutrition group. The number of participants who lived alone by nutrition group was 30 in the well-nourished group (17.9%), 29 in the at risk of malnutrition group (14.0%) and 16 in the malnourished group (28.6%; $P < 0.05$).

The number of participants by occlusal relationship was 174 in group A (80 males and 94 females with a mean age of 78.7 ± 9.0 years), 421 in group B (120 males and 301 females with a mean age of 84.6 ± 8.0 years) and 121 in group C (40 males and 81 females with a mean age of 84.9 ± 7.7 years), which indicated that there was a significant correlation between occlusal relationship and nutrition status ($P < 0.05$; Fig. 1).

Cervical auscultation showed that the 516 participants exhibited normal swallowing sounds (151 males and 365 females with a mean age of 82.8 ± 8.4 years) and 200 had abnormal swallowing sounds (89 males and 111 females with a mean age of 84.0 ± 9.0 years). There was a significant relationship between normal swallowing sounds and nutrition status ($P < 0.05$, Fig. 2).

The results of the logistic regression analysis showed a significant relationship between malnutrition risk and sex, Barthel index, and occlusal relationship (Table 2).

Table 1 General condition and the number of missing teeth by nutrition group

	Well nourished	At risk of malnutrition	Malnourished
Age	81.9 ± 8.6	83.9 ± 8.3*	83.8 ± 9.3
Charlson index	1.4 ± 1.5	1.6 ± 1.4	1.8 ± 1.4**
Barthel index	77.1 ± 20.8	57.2 ± 27.8*	34.3 ± 28.6**,***
Clinical dementia rating	0.8 ± 0.9	1.2 ± 1.0*	1.4 ± 1.1**
No. missing teeth	20.2 ± 10.6	22.4 ± 9.8*	21.2 ± 9.6
No. remaining teeth root	0.9 ± 2.2	1.7 ± 3.3*	2.3 ± 4.0**
No. occlusal group (group A/B/C)	80/145/26	66/232/72	28/44/23†
No. swallowing sounds (normal/abnormal)	208/43	262/108	46/49†

One-way ANOVA and Games-Howell pairwise comparison test were used for parametric variables. *$P < 0.05$, well-nourished versus at risk of malnutrition; **$P < 0.05$, well nourished versus malnourished; ***$P < 0.05$, at risk of malnutrition versus malnourished. †The χ^2-test was used for non-parametric variables (<0.05).

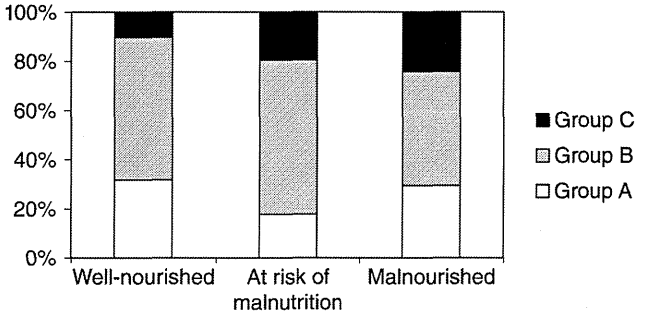

Figure 1 Relationship between nutrition and occlusion (χ^2-test, $P < 0.05$). Group A: natural dentition with adequate function. Group B: partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws. Group C: functionally inadequate occlusion with no dentures.

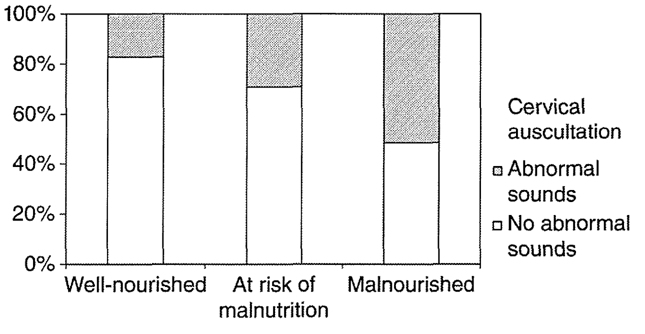

Figure 2 Relationship between nutrition and abnormal swallowing sounds detected by cervical auscultation (χ^2-test, $P < 0.05$).

A significant relationship was also observed between malnutrition and Barthel index, abnormal swallowing sounds by cervical auscultation, and living alone (Table 3).

Discussion

The results of the present study showed that the number of frail elderly with malnutrition was 13.3% (95), which is nearly in agreement with the results of a previous study carried out in Japan.[11] Furthermore, the number of the participants at risk of malnutrition, including those in the at risk of malnutrition and malnourished groups was 64.9% (465), which surprisingly exceeded 50% of the participants. This result shows that improvement in the nutrition status of frail elderly living in home care needs to be urgently addressed.

The Barthel index was the significant factor documenting both malnutrition risk and malnourishment in the present study. Many researchers agree that there is a relationship between physical function and nutrition status.[12] It might be concluded that individuals whose daily activity is limited tend to avoid shopping for food items, resulting in nutritional disturbance.

In addition to the Barthel index, sex was found to be a significant factor influencing malnutrition risk. The present study showed that older females had a 1.845-fold greater malnutrition risk than older males (95% CI 1.121–3.036), which agreed with the results of a previous study that showed that older females were more likely to develop nutritional disturbance, both obesity and malnutrition.[13]

Furthermore, occlusal status was significantly related to malnutrition risk. The group C individuals (functionally inadequate occlusion with no dentures) had a 3.189-fold greater malnutrition risk than group A (natural dentition with adequate function; 95% CI 1.437–7.080). Chewing efficiency, for example, the rate of breakdown of food during mastication, is clearly correlated with features of the dentition, such as number of posterior teeth and occlusal relationships.[14] The most pronounced difference in intake involves hard-to-chew foods, such as vegetables and some fruits, therefore tooth loss affects elements of nutritional intake, such as dietary fiber and vitamins.[15] These micronutrients are the key element in maintaining good nutrition, which suggests that lack of such food might result in greater malnutrition risk.

In addition, group B (partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws) had a 1.704-fold greater malnutrition risk than group A (95% CI 1.013–2.864). Previous studies have shown that individuals who have lost natural molar contacts consume lesser amounts of hard-to-chew foods, such as vegetables and fruits, even though they use their dentures during food intake.[16] Our findings in the present study support the view that denture use is not sufficient to compensate for natural teeth. Recently, Bradbury *et al.* showed that food instruction encourages an increase in the consumption of vitamins and minerals among new denture wearers.[17] In general, denture treatment has not usually included in such dietary intervention. Future studies will be required to identify the effect of dietary intervention on the prevention of malnutrition in denture users.

In contrast, there was no significant relationship between malnourishment and occlusion in frail elderly participants. There were significant relationships between malnutrition and Barthel index, abnormal swallowing sounds detected by cervical auscultation, and living alone. These results suggest that malnourished elderly have already developed dysphagia resulting in dietary modification;[18] therefore, their malnutrition might be less influenced by a proper occlusal relationship. A vicious cycle, in which decreased ability to

Table 2 Items significantly involved in malnutrition risk

	B	Standard deviation	Wald	*P*-value	Exp (B)	95% Confidence interval	
Sex	0.612	0.254	5.803	0.016	1.845	1.121	3.036
Age	−0.001	0.015	0.006	0.939	0.999	0.971	1.028
Charlson index	0.089	0.082	1.168	0.280	1.093	0.930	1.284
Barthel index	−0.036	0.005	43.381	0.000	0.965	0.955	0.975
Clinical Dementia Rating	0.156	0.140	1.251	0.263	1.169	0.889	1.537
Swallowing sounds	0.482	0.297	2.627	0.105	1.619	0.904	2.900
Occlusal relationship (a) group A *vs* group B	0.533	0.265	4.039	0.044	1.704	1.013	2.864
Occlusal relationship (b) group A *vs* group C	1.160	0.407	8.125	0.004	3.189	1.437	7.080
Living alone	0.353	0.301	1.380	0.240	1.424	0.790	2.567
Constant	1.701	1.265	1.807	0.179	5.479		

The participants were divided into two groups according to their nutrition status: (i) a well-nourished group; and (ii) a group that included those at risk of malnutrition and malnourished. Group A, natural dentition with adequate function; group B, partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws; group C, functionally inadequate occlusion with no dentures.

Table 3 Items significantly involved in malnutrition

	B	Standard deviation	Wald	*P*-value	Exp (B)	95% Confidence interval	
Sex	0.613	0.388	2.501	0.114	1.846	0.864	3.947
Age	−0.002	0.021	0.007	0.933	0.998	0.958	1.040
Charlson Index	0.014	0.104	0.019	0.891	1.014	0.827	1.244
Barthel Index	−0.035	0.007	27.940	0.000	0.966	0.953	0.978
Clinical Dementia Rating	−0.072	0.178	0.165	0.685	0.930	0.657	1.318
Swallowing sounds	1.060	0.340	9.684	0.002	2.885	1.480	5.623
Occlusal relationship (a) group A *vs* group B	−0.453	0.391	1.343	0.246	0.636	0.295	1.368
Occlusal relationship (b) group A *vs* group C	−0.485	0.520	0.871	0.351	0.616	0.222	1.705
Living alone	1.461	0.403	13.143	0.000	4.312	1.957	9.502
Constant	−0.746	1.777	0.176	0.674	0.474		

Participants were divided into two groups according to their nutritious status: (i) a group of well-nourished individuals and those at risk of malnutrition; and (ii) a group of malnourished individuals. Group A, natural dentition with adequate function; group B, partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws; group C, functionally inadequate occlusion with no dentures.

swallow food could accelerate malnutrition, was also considered. Elderly people who live alone are less likely to follow through with dietary modification,[19] and it might lead to malnutrition regardless of occlusal status.

In conclusion, the present study, as well as previous studies, has shown that retaining the natural teeth plays an important role in the prevention of nutritional disturbance, and that early dental treatment in the elderly is important to protect their teeth and occlusion. Dieticians, as well as other care staff, should monitor oral conditions, such as remaining teeth and occlusion, in the elderly in order to prevent malnutrition. We also suggest that all dentists enhance their skills and knowledge in the fields of swallowing function and nutritional guidance.

Acknowledgments

This study was supported by the Ministry of Health, Labour and Welfare.

References

1 Lesourd B. Nutrition: a major factor influencing immunity in the elderly. *J Nutr Health Aging* 2004; **8**: 28–37.
2 Landi F, Zuccala G, Gambassi G *et al.* Body mass index and mortality among older people living in the community. *J Am Geriatr Soc* 1999; **47**: 1072–1076.
3 Guigoz Y, Lauque S, Vellas BJ. Identifying the elderly at risk for malnutrition. The mini nutritional assessment. *Clin Geriatr Med* 2002; **18**: 737–757.
4 Phillips MB, Foley AL, Barnard R, Isenring EA, Miller MD. Nutritional screening in community-dwelling older adults: a systematic literature review. *Asia Pac J Clin Nutr* 2010; **19**: 440–449.
5 Vellas B, Villars H, Abellan G *et al.* Overview of the MNA– Its history and challenges. *J Nutr Health Aging* 2006; **10**: 456–463.
6 Kaiser MJ, Bauer JM, Ramsch C *et al.* MNA-International Group. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. *J Nutr Health Aging* 2009; **13**: 782–788.
7 Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987; **40**: 373–383.
8 Mahoney FI, Barthel DW. Functional evaluation; the Barthel index. *Md State Med J* 1965; **14**: 61–65.
9 Morris JC. The Clinical Dementia Rating (CDR): current version and scoring rules. *Neurology* 1993; **43**: 2412–2414.
10 Takahashi K, Groher ME, Michi K. Methodology for detecting swallowing sounds. *Dysphagia* 1994; **9**: 54–62.
11 Izawa S, Kuzuya M, Okada K *et al.* The nutritional status of frail elderly with care needs according to the mini-nutritional assessment. *Clin Nutr* 2006; **25**: 962–967.
12 Mirarefin M, Sharifi F, Fakhrzadeh H *et al.* Predicting the value of the Mini Nutritional Assessment (MNA) as an indicator of functional ability in older Iranian adults (Kahrizak elderly study). *J Nutr Health Aging* 2011; **15**: 175–180.
13 Morley JE. Nutrition and the older female: a review. *J Am Coll Nutr* 1993; **12**: 337–343.
14 Carlsson GE. Masticatory efficiency: the effect of age, theloss of teeth and prosthetic rehabilitation. *Int Dent J* 1984; **34**: 93–97.
15 Yoshida M, Kikutani T, Yoshikawa M, Tsuga K, Kimura M, Akagawa Y. Correlation between dental and nutritional status in community-dwelling elderly Japanese. *Geriatr Gerontol Int* 2011; **11**: 315–319.
16 Marshall TA, Warren JJ, Hand JD, Xie XJ, Stumbo PJ. Oralhealth, nutrient intake and dietary quality in the very old. *J Am Dent Assoc* 2002; **133**: 1369–1378.
17 Bradbury J, Thomasson JM, Jepson NJA, Walls AWG, Allen PF, Moynihan PJ. Nutrition counseling increases fruit and vegetable intake in the edentulous. *J Dent Res* 2006; **85**: 463–468.
18 Garcia JM, Chambers E 4th. Managing dysphagia through diet modifications. *Am J Nurs* 2010; **110**: 26–33.
19 Ramic E, Pranjic N, Batic-Mujanovic O, Karic E, Alibasic E, Alic A. The effect of loneliness on malnutrition in elderly population. *Med Arh* 2011; **65**: 92–95.

Dysphagia
DOI 10.1007/s00455-012-9407-z

ORIGINAL ARTICLE

Tongue Thickness Relates to Nutritional Status in the Elderly

Fumiyo Tamura · Takeshi Kikutani · Takashi Tohara · Mitsuyoshi Yoshida · Ken Yaegaki

Received: 21 July 2011 / Accepted: 5 April 2012

Abstract Many elderly people under long-term care suffer from malnutrition caused by dysphagia, frequently leading to sarcopenia. Our hypothesis is that sarcopenia may compromise oral function, resulting in dysphagia. The objectives of this study were to evaluate sarcopenia of the lingual muscles by measuring the tongue thickness, and elucidate its relationship with nutritional status. We examined 104 elderly subjects (mean age $= 80.3 \pm 7.9$ years). Anthropometric data, such as triceps skinfold thickness and midarm muscle area (AMA), were obtained. The tongue thickness of the central part was determined using ultrasonography. Measurement was performed twice and the mean value was obtained. The relationship between tongue thickness and nutritional status was analyzed by Pearson's correlation coefficient and Spearman's rank correlation coefficient. AMA and age were identified by multiple-regression analysis as factors influencing tongue thickness. The results of this study suggest that malnutrition may induce sarcopenia not only in the skeletal muscles but also in the tongue.

Keywords Tongue thickness · Nutritional status · Dysphagia · Sarcopenia · Ultrasonography · Deglutition · Deglutition disorders

F. Tamura (✉) · T. Kikutani · T. Tohara
Rehabilitation Clinic for Speech and Swallowing Disorders, The Nippon Dental University School of Life Dentistry at Tokyo, Dental Hospital, 3-16, Fujimi 2-chome, Chiyoda-ku, Tokyo 102-8158, Japan
e-mail: fumita@tokyo.ndu.ac.jp

T. Tohara
e-mail: takashitohara@qa2.so-net.ne.jp

T. Kikutani
Division of Clinical Oral Rehabilitation, The Nippon Dental University Graduate School of Life Dentistry at Tokyo, 9-16, Fujimi 1-chome, Chiyoda-ku, Tokyo 102-0071, Japan
e-mail: kikutani@tokyo.ndu.ac.jp

M. Yoshida
Dental Department, Hiroshima City General Rehabilitation Center, Hiroshima, Japan

K. Yaegaki
Department of Hygiene, The Nippon Dental University School of Life Dentistry at Tokyo, Tokyo, Japan
e-mail: yaegaki-k@tky.ndu.ac.jp

The tongue plays an important role in feeding and swallowing function. Feinberg et al. [1] reported that bolus misdirection due to dysfunction and abnormality was more frequent at the oral stage alone or at both the oral and pharyngeal stages than at the pharyngeal stage alone. Dysfunction and abnormality of the tongue might also be a reason for dysphagia, since problems at the oral stage are one of the reasons for dysphagia. Many elderly people under long-term care suffer from malnutrition caused by dysphagia and frequently develop sarcopenia because of malnutrition [2]. Sarcopenia is defined as loss of muscular mass, strength, and physical performance. Sarcopenia caused by aging is also affected by the levels of anabolic hormones, which may suppress appetite or lead to a reduction of protein synthesis, resulting in worsening of the condition [3, 4] and subsequent restriction of physical activities in the elderly.

Elderly people frequently suffer from eating malfunction and malnutrition [5, 6]. Fewer occluding pairs of teeth decrease chewing function and increase chewing difficulty [7]. Therefore, chewing ability may contribute to the regulation of nutritional status in the elderly, as reported

Published online: 27 April 2012

previously [8]. Subsequently, chewing ability is associated with not only oral health status but also with the physical constitution of the elderly [8]. Low tongue pressure reflects dysphagic tongue movement and cough [9]. Moreover, a decline of oral muscle strength as well as fewer occluding teeth may cause malfunction of feeding; therefore, we presume that malnutrition may worsen in dysphagic patients. Our hypothesis is that sarcopenia may occur in the tongue as well as in other tissues. In other words, we speculated that muscle volume may relate to tongue sarcopenia rather than to body size. If so, sarcopenia of the lingual muscles would compromise oral function in the elderly. Once atrophy of the tongue occurs, people may start to develop malnutrition because of dysphagia. In most cases, the meal texture of these people becomes softer, requiring less power of tongue movement. Consequently, tongue atrophy may be promoted. The objectives of this study were to evaluate sarcopenia of the lingual muscles by measuring the tongue thickness and to elucidate its relationship with nutritional status.

Subjects and Methods

We studied 104 elderly subjects (32 men and 72 women, mean age = 80.3 ± 7.9 years). All maintained occlusal support with either natural dentition or dentures. Neither paralysis nor atrophy of the tongue was observed. The anthropometric data of triceps skinfold thickness (TSF), midarm muscle area (AMA), body weight (BW), and height (HT) were measured to evaluate nutritional status [8, 10].

Anthropometric measurements were conducted as follows: Mid-upper-arm circumference (MAC) was measured on the left arm with a tape measure. TSF was measured with Harpenden Skinfold Calipers over the triceps muscle at the midway point between the acromion and the olecranon process. AMA was calculated from MAC and TSF values based on a previously reported formula [11]. The mean of the twice-repeated measurements was taken as the true value. Tongue thickness was measured using ultrasonography (Nemio 17, SSA-550A, Toshiba Medical Systems, Tokyo, Japan). A fixation device to retain a 3.75-MHz convex probe (contact face size = 12 × 70 mm) in an appropriate position was employed to obtain accurate images, as shown in Fig. 1. To assure stable image acquisition, the probe was firmly fixed to the subject's lower jaw by wrapping a belt around the head. The subjects were asked to remain seated in an upright position. They were also instructed to swallow their saliva often and to set the tongue at the resting position. Then, ultrasonic measurements were carried out.

The measurement points were determined on the upper and lower surfaces of the lingual muscles in the center of the plane perpendicular to the Frankfurt horizontal plane in a frontal section, as shown in Fig. 2 [12]. This perpendicular plane went through the distal surfaces of the mandibular second premolars on both sides. The measurement point on the coronal plane is shown in Fig. 3. The vertical distance was measured from the surface of the mylohyoid muscle to the tongue dorsum. Figure 4 shows an image of a frontal section of the tongue on ultrasonography. Measurements were performed twice in freeze-frame when the tongue was restored to the resting position after swallowing saliva, and the mean values were obtained. To determine the reliability of the tongue thickness measurement, the two-way mixed-effects model of the intraclass correlation coefficient (ICC) (1,2) was used. The ICC values were above 0.75, indicating good reliability; values of 0.9 and

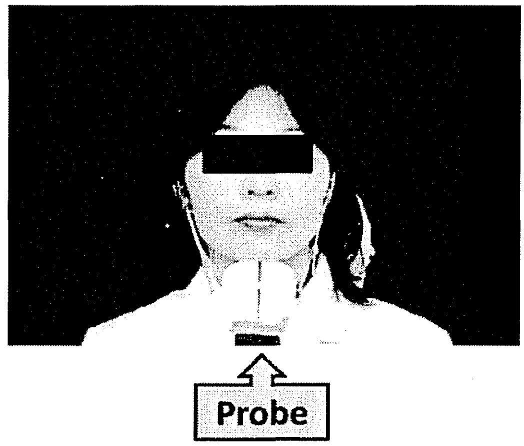

Fig. 1 Position of ultrasonic probe in frontal view

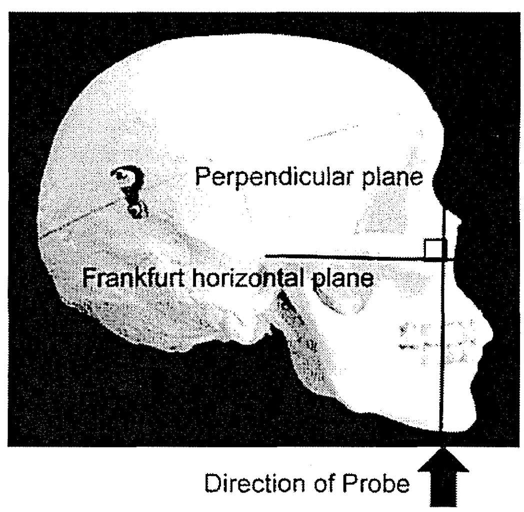

Fig. 2 Position of ultrasonic probe in lateral view. The measurement points were determined at the center of the plane perpendicular to the Frankfurt horizontal plane in a frontal section. The perpendicular plane passes through the distal surfaces of the mandibular second premolars on both sides

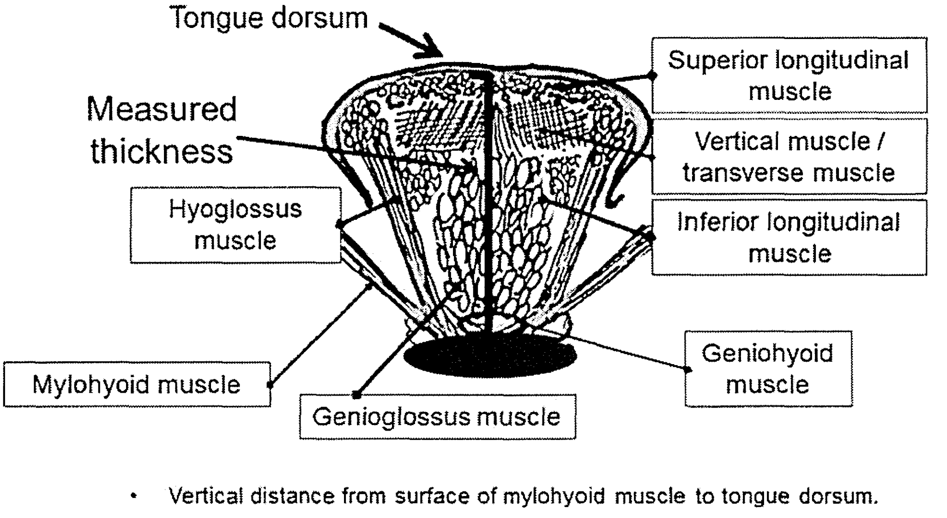

Fig. 3 Diagram of tongue. Measured thickness is the vertical distance from the surface of mylohyoid muscle to the tongue dorsum

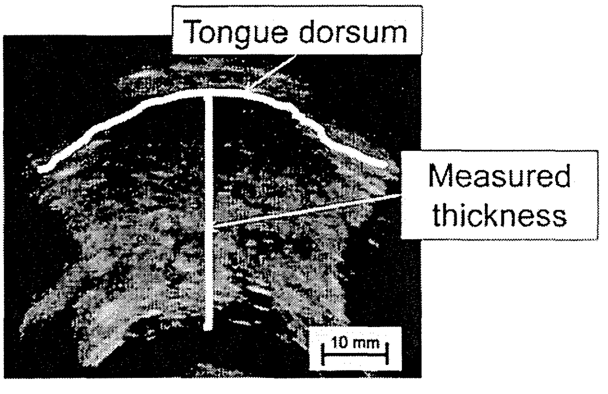

Fig. 4 Ultrasonographic image

above are reportedly even more reliable for ensuring the validity and reproducibility of clinical measurements [13]. The ICC (1,2) value for the intrarater reliability of tongue thickness measurement was 0.856 (95 % CI: 0.741–0.924).

The relationship between tongue thickness and nutritional status was analyzed using Pearson's correlation coefficient and Spearman's rank correlation coefficients using the software SPSS v16 (SPSS, Inc., Chicago, IL).

This study was approved by the Ethics Committee of The Nippon Dental University, School of Life Dentistry at Tokyo, Dental Hospital. Before starting measurements, the purpose and the protocol were explained to the subjects and/or their guardians in order to obtain their consent.

Results

Baseline Characteristics of Subjects

Table 1 gives the baseline characteristics of our subjects. TSF = 11.4 ± 4.6 mm, AMA = 34.9 ± 7.6 cm^2, HT = 151.2 ± 8.8 cm, BW = 48.9 ± 8.8 kg, and tongue thickness = 46.9 ± 5.5 mm.

Table 1 Baseline characteristics of subjects (n = 104)

	Mean	SD
Age (years)	80.3	7.9
TSF	11.4	4.6
AMA	34.9	7.6
Height (cm)	151.2	8.8
Body weight (kg)	48.9	8.8
Tongue thickness (mm)	46.9	5.5

TSF triceps skinfold thickness, *AMA* arm muscle area

Correlation Coefficients Between Tongue Thickness and Other Variables

Table 2 gives the correlation coefficients between tongue thickness and the other variables examined. Tongue thickness correlated with age ($r = -0.393$, $P < 0.001$), TSF ($r = 0.225$, $P < 0.05$), AMA ($r = 0.424$, $P < 0.001$), HT ($r = 0.312$, $P < 0.01$), and BW ($r = 0.434$, $P < 0.001$).

Table 2 Pearson's rank correlation coefficient between tongue thickness and other variables

Variables	Coefficient	*P* value
Age	−0.393	0.000
TSF	0.225	0.022
AMA	0.424	0.000
Height	0.312	0.001
Body weight	0.434	0.000

TSF triceps skinfold thickness, *AMA* arm muscle area

Table 3 Factors related to tongue thickness by stepwise multiple regression analysis

Variables	Beta	*t*	*P* value
AMA	0.231	3.412	0.001
Age	−0.188	−2.868	0.005

AMA arm muscle area

Model 1: Multiple correlation coefficient (R) = 0.424; adjusted coefficient of determination (R^2) = 0.180

Model 2: Multiple correlation coefficient (R) = 0.492; adjusted coefficient of determination (R^2) = 0.227

Stepwise Multiple Regression Analysis

Table 3 shows the results of a stepwise multiple regression analysis conducted to identify the factor most strongly influencing tongue thickness. The multiple correlation coefficient (R) was 0.492 and the adjusted coefficient of determination (R^2) was 0.227.

Discussion

Masticatory movement is governed by the coordinated functions of oral organs: teeth, jaw, cheek, lips, and tongue. Among them, the tongue plays an important role in mastication and swallowing since it transports food to the molars, initiates mastication, mixes foods with saliva, and propels a food bolus into the pharynx. Furthermore, the swallowing reflex occurs because the tongue and the soft palate close at the region of the fauces. Many elderly people under long-term care develop malnutrition because of a decline in masticatory and swallowing functions as described above. Improvement in swallowing is considered the most effective way to treat dysphagia because oral dysfunction is also strongly associated with dysphagia [1]. Therefore, evaluating tongue dysfunction or abnormality may be an essential diagnostic procedure for dysphagia. There are many methods for evaluating tongue function, i.e., measuring the strength [14–17] and speed and location of movement [18]. The strength of the tongue has been evaluated by measuring the maximum tongue pressure against the palate [14, 15]. There are some reports that tongue function in the elderly declines with age [14, 15, 19, 20]. However, the effects of malnutrition on tongue volume in the elderly are still unknown. In our study we used ultrasonography to measure tongue thickness. Ultrasonography is widely used for functional analysis of dysphagia and is also reported to be very practical for anatomical analysis [21]. Furthermore, ultrasonography has enormous potential for visualizing the tongue in clinical research because it is noninvasive and it is easy to perform repeated examinations.

The age-associated loss of both muscle mass and strength, termed sarcopenia, is highly relevant to nursing home residents [22]. It was reported that tongue sarcopenia was observed more frequently in aged rats than in control rats [23, 24]. However, the relationship between tongue sarcopenia and aging in humans is obscure. The absence of occlusal support affects tongue movement and oral function [14, 25, 26]. In this study we employed subjects with posterior occlusal dentition of their natural teeth or dentures to eliminate confounding variables.

It has been suggested that TSF and AMA correlate with nutritional status [8, 10]. TSF represents fat volume and AMA the muscle volume of the upper arm. Since there was a significant association between tongue thickness and nutritional status, tongue muscle volume may also be related to nutritional status.

Furthermore, it was suggested that sarcopenia may develop not only in skeletal muscles but also in the tongue. Hence, dysphagia, tongue disuse syndrome, or malnutrition may affect tongue thickness, with subsequent worsening of malnutrition. Moreover, Saito et al. [27] reported that in rats, the structures of tongue muscles (genioglossus and geniohyoid) may be affected by fat deposition in myofibers. Determination of the fat fraction may be required in our future studies on tongue sarcopenia [28].

It was suspected that tongue thickness correlates with mandibular length. In this regard, an animal study [29] showed the relationship between tongue thickness and mandibular length from infancy through childhood, whereas no such relationship was identified in a human study [30]. However, in the present study we demonstrated a significant relationship between tongue thickness and AMA (an index indicating muscle mass) and age by applying multiple regression analysis. Neither HT, a marker of bone in humans, nor BW (a similar marker) was found to correlate with tongue thickness, suggesting that general muscle volume and/or age alone may affect this feature of the tongue.

Atrophy of the tongue may not be the only reason for reduced tongue function and inability to maintain nutritional status. However, Kikutani et al. [31] reported that oral functional training to maintain and/or improve feeding function is very efficient for improving the nutritional condition. It was reported that muscle is replaced by fat or fibrous tissues with aging [32], implying that tongue exercise might restore muscle tissue. Robbins et al. [32] and Yeates et al. [33] also reported that exercising the tongue prevented general sarcopenia. Therefore, effective measures or protocols to prevent malnutrition, which involve tongue exercise or rehabilitation, may be necessary to improve tongue disuse syndrome. For this purpose, our method of monitoring tongue thickness by ultrasonography may provide information for a tongue exercise protocol or treatment plan. We will study further the relationship between tongue pressure and tongue thickness in a future investigation.

Conclusion

The findings of this study suggest that tongue thickness is related to nutritional status in the elderly.

Acknowledgments The authors thank Drs. Tetsuo Hanagata and Akira Ozawa at Yamanashi Dental Association, Drs. Yasumasa Akagawa and Kazuhiro Tsuga at Hiroshima University, and Dr. Misaka Kimura at Kyoto Prefectural University of Medicine for helpful discussions. This study was supported in part by a Research Grant for Longevity Science (H19-2) from of the Ministry of Health, Labour and Welfare, Japan.

Conflict of interest The authors have no conflicts of interest to declare.

References

1. Feinberg MJ, Ekberg O. Videofluoroscopy in elderly patients with aspiration: importance of evaluating both oral and pharyngeal stages of deglutition. AJR Am J Roentgenol. 1991;156:293–6.
2. Rosenberg IH, Roubenoff R. Stalking sarcopenia. Ann Intern Med. 1995;123:727–8.
3. Greenlund LJ, Nair KS. Sarcopenia—consequences, mechanisms, and potential therapies. Mech Ageing Dev. 2003;124:287–99.
4. Roubenoff R. Sarcopenia: effects on body composition and function. J Gerontol A Biol Sci Med Sci. 2003;58:1012–7.
5. Ney DM, Weiss JM, Kind AJ, Robbins J. Senescent swallowing: impact, strategies, and interventions. Nutr Clin Pract. 2009;24:395–413.
6. White GN, O'Rourke F, Ong BS, Cordato DJ, Chan DK. Dysphagia: causes, assessment, treatment, and management. Geriatrics. 2008;63:15–20.
7. Leake JL. An index of chewing ability. J Public Health Dent. 1990;50:262–7.
8. Okada K, Enoki H, Izawa S, Iguchi A, Kuzuya M. Association between masticatory performance and anthropometric measurements and nutritional status in the elderly. Geriatr Gerontol Int. 2010;10:56–63.
9. Yoshida M, Kikutani T, Tsuga K, Utanohara Y, Hayashi R, Akagawa Y. Decreased tongue pressure reflects symptom of dysphagia. Dysphagia. 2006;21:61–5.
10. Chazot C, Laurent G, Charra B, Blanc C, VoVan C, Jean G, et al. Malnutrition in long-term haemodialysis survivors. Nephrol Dial Transpl. 2001;16:61–9.
11. Heymsfield SB, McManus C, Smith J, Stevens V, Nixon DW. Anthropometric measurement of muscle mass: revised equations for calculating bone-free arm muscle area. Am J Clin Nutr. 1982;36:680–90.
12. Okayama H, Tamura F, Kikutani T, Kayanaka H, Katagiri H, Nishiwaki K. Effects of a palatal augmentation prosthesis on lingual function in postoperative patients with oral cancer: coronal section analysis by ultrasonography. Odontology. 2008;96:26–31.
13. Portney LG, Watkins MP. Foundations of clinical research: applications to practice. Englewood Cliffs: Prentice-Hall; 2000.
14. Kikutani T, Tamura F, Nishiwaki K, Kodama M, Suda M, Fukui T, et al. Oral motor function and masticatory performance in the community-dwelling elderly. Odontology. 2009;97:38–42.
15. Hayashi R, Tsuga K, Hosokawa R, Yoshida M, Sato Y, Akagawa Y. A novel handy probe for tongue pressure measurement. Int J Prosthodont. 2002;15:385–8.
16. Ziegler W. Task-related factors in oral motor control: speech and oral diadochokinesis in dysarthria and apraxia of speech. Brain Lang. 2002;80:556–75.
17. Utanohara Y, Hayashi R, Yoshikawa M, Yoshida M, Tsuga K, Akagawa Y. Standard values of maximum tongue pressure taken using newly developed disposable tongue pressure measurement device. Dysphagia. 2008;23:286–90.
18. Klawe JJ, Tafil-Klawe M. Age-related response of the genioglossus muscle EMG-activity to hypoxia in humans. J Physiol Pharmacol. 2003;54(Suppl 1):14–9.
19. Peng CL, Miethke RR, Pong SJ, Lin CT. Investigation of tongue movements during swallowing with M-mode ultrasonography. J Orofac Orthop. 2007;68:17–25.
20. Ardakani FE. Evaluation of swallowing patterns of the tongue using real-time B-mode sonography. J Contemp Dent Pract. 2006;7:67–74.
21. Ajaj W, Goyen M, Herrmann B, Massing S, Goehde S, Lauenstein T, et al. Measuring tongue volumes and visualizing the chewing and swallowing process using real-time TrueFISP imaging—initial clinical experience in healthy volunteers and patients with acromegaly. Eur Radiol. 2005;15:913–8.
22. Bauer J, Kaiser M, Sieber CC. Sarcopenia in nursing home residents. J Am Med Dir Assoc. 2008;9:545–51.
23. Ota F, Connor NP, Konopacki R. Alterations in contractile properties of tongue muscles in old rats. Ann Otol Rhinol Laryngol. 2005;114:799–803.
24. Schwarz EC, Thompson JM, Connor NP, Behan M. The effects of aging on hypoglossal motoneurons in rats. Dysphagia. 2009;24:40–8.
25. Tamura F, Suzuki S. Effects of edentulism on lingual functions during swallowing. J Disabil Oral Health. 2004;5:83–7.
26. Tamura F, Mizukami M, Ayano R, Mukai Y. Analysis of feeding function and jaw stability in bedridden elderly. Dysphagia. 2002;17:235–41.
27. Saito T, Yamane A, Kaneko S, Ogawa T, Ikawa T, Saito K, et al. Changes in the lingual muscles of obese rats induced by high-fat diet feeding. Arch Oral Biol. 2010;55:803–8.
28. Humbert IA, Reeder SB, Porcaro EJ, Kays SA, Brittain JH, Robbins J. Simultaneous estimation of tongue volume and fat fraction using IDEAL-FSE. J Magn Reson Imaging. 2008;28:504–8.
29. Liu ZJ, Shcherbatyy V, Gu G, Perkins JA. Effects of tongue volume reduction on craniofacial growth: a longitudinal study on orofacial skeletons and dental arches. Arch Oral Biol. 2008;53:991–1001.
30. Siebert JR. A morphometric study of normal and abnormal fetal to childhood tongue size. Arch Oral Biol. 1985;30:433–40.
31. Kikutani T, Enomoto R, Tamura F, Oyaizu K, Suzuki A, Inaba S. Effects of oral functional training for nutritional improvement in

Japanese older people requiring long-term care. Gerodontology. 2006;23:93–8.

32. Robbins J, Gangnon RE, Theis SM, Kays SA, Hewitt AL, Hind JA. The effects of lingual exercise on swallowing in older adults. J Am Geriatr Soc. 2005;53:1483–9.
33. Yeates EM, Molfenter SM, Steele CM. Improvements in tongue strength and pressure-generation precision following a tongue-pressure training protocol in older individuals with dysphagia: three case reports. Clin Interv Aging. 2008;3:735–47.

Fumiyo Tamura DDS, PhD

Takeshi Kikutani DDS, PhD

Takashi Tohara DDS

Mitsuyoshi Yoshida DDS, PhD

Ken Yaegaki DDS, PhD

Original

Survey on the Issues and the Changes of Oral Health Condition of Inpatients in the Intensive Care Unit

Takafumi OOKA[1,2], Yoshinori INOUE[1], Nao ODA[2,3], Yoshimasa OKAMATSU[2,3,5], Yuriko ANDO[2,3,5], Shoji HIRONAKA[1,2], Mitsuhiro MATSUURA[2,4,5], Haruo SANO[2,5] and Yoshiharu MUKAI[1,2]

[1] *Division of Hygiene and Oral Health, Department of Special Needs Dentistry, Showa University School of Dentistry*
1-5-8 Hatanodai, Shinagawa-ku, Tokyo, 142-8555 Japan
(Chief: Prof. Yoshiharu Mukai)
[2] *Showa University Oral Health Care Center*
1-5-8 Hatanodai, Shinagawa-ku, Tokyo, 142-8555 Japan
(Chief: Prof. Yoshiharu Mukai)
[3] *Dental Clinic of Showa University Hospital*
1-5-8 Hatanodai, Shinagawa-ku, Tokyo, 142-8666 Japan
(Chief: Prof. Haruo Sano)
[4] *Dental Clinic at Showa University Karasuyama Hospital*
6-11-11 Kitakarasuyama, Setagaya-ku, Tokyo, 157-8577 Japan
[5] *Division of Community Based Comprehensive Dentistry, Department of Special Needs Dentistry, Showa University School of Dentistry*
2-1-1 Kitasenzoku, Ohta-ku, Tokyo, 145-8515 Japan
(Chief: Prof. Haruo Sano)

Abstract: The aim of this study was to consolidate oral health management systems in the acute stages. The practical status of oral health in perioperative patients and improvements achieved through coordinated oral health care were investigated. Subjects of the present study were 87 patients who underwent oral intubation in the intensive care unit (ICU). These patients attended an oral health care center from October 2010 to March 2011. Dentists rated the oral status of subjects within 24 h of admission to the ICU on a three-point scale by assessing the lips, teeth, mucous membrane, gingiva, tongue, and saliva. In addition, the number of *Candida* colonies detected on the tongue was noted at initial assessment. At initial assessment, 70% of participants with respiratory diseases were classified as having oral problems. However, few subjects showed presence of dental plaque or reported problems involving the mucous membrane. The proportion of *Candida*-positive participants was higher in those with respiratory diseases than those with cardiovascular diseases. When comparing the *Candida*-positive and -negative subjects, a greater proportion of the former had problems with the lips, saliva, mucous membrane, and tongue. With regard to the time-dependent changes recorded on these problems, improvement in the condition of the lips tended to occur earlier than the conditions of the tongue. As it has been suggested that maintaining a clean tongue can be critical in patients undergoing oral intubation, it is important to continue appropriate oral health care in the acute stages.

Key words: acute stage, intensive care unit, oral health care, oral intubation.

Recent studies suggest that oral health care can be effective in the prevention of respiratory tract infections such as pneumonia and bronchitis.[1~5] Since one of the parameters most frequently emphasized is the prevention of ventilator-associated pneumonia (VAP), which is a severe respiratory infection seen in patients with poor oral hygiene undergoing mechanical ventilation, oral health care has gained recognition as a key nursing intervention in the acute stages.[6~9] However, difficulties can be encountered while trying to maintain good oral health

(Received June 29, 2012; Accepted for publication September 3, 2012)

care in acutely ill patients ventilated mechanically, partly because of oral intubation and partly because of their inability to maintain oral hygiene by brushing teeth. Such situations can lead to bacterial contamination of the oral and pharyngeal areas. On the other hand, it is reported that oral cleaning and functional support from the early phase in the acute stages is effective in avoiding secondary infectious diseases.[10, 11] Based on these findings, studies have examined the activities and efforts by dentists and dental hygienists in the arena of professional oral health care in the acute or emergency stage.[12~14] On the other hand, these reports indicated that how the oral health status of patients was an indicator of the difficulties faced when aiming to improve the oral health with regard to general health issues and exacerbation of diseases.[15] Moreover, although a broad range of symptoms in the oral cavity could be improved fairly easily while others could not, few studies have been conducted on the process of improving oral health problems through intervention by dental professionals in the acute stages.[16, 17]

Showa University Oral Health Care Center was established in April 2008 in cooperation with a multidisciplinary team to implement oral health care and to create a standardized method of oral health care for patients in the acute stages. Feedback from facilities providing oral health care in the general wards of acute hospitals indicated that the characteristics of oral health and prevalence of intraoral problems varied among patients depending on their primary illness.[17] Therefore, on the basis of the assumption that patients in the ICU have the same range of oral problems as those in general wards, the oral health status of the ICU patients was investigated and compared statistically among groups classified by primary diagnosis. It was hypothized that the oral health status of patients would be worse when the oral bacterial flora levels increase. The objective of the present study was to establish an oral health care system in acute hospitals that focused on the prevention of secondary infectious diseases. Therefore, the oral health status of patients admitted to the ICU was investigated and any change was monitored following multidisciplinary oral health care management, which included dentists and dental hygienists.

Materials and Methods

The subjects of this study were 87 patients (49 male and 38 female) in the ICU of Showa University Hospital and who underwent mechanical ventilation and oral intubation between October 2010 and March 2011. All subjects were consulted by dentists attached to the Showa University Oral Health Care Center, and their consent for participation in this study was obtained prior to commencement of the investigation. Data regarding the subjects' primary disease diagnoses were obtained from the medical and nursing records of the ward, and the subjects were categorized into the following four groups: cerebrovascular disease group, respiratory disease group, gastrointestinal disease group, and cardiovascular disease group. This classification was determined by reference to previous studies, and Table 1 shows typical diagnosis by group.[12, 17] The following categories of patients were excluded: those with undiagnosed primary disease, such as multisystem diseases; those who had developed metastasis secondary to carcinoma; and edentulous individuals.

The oral health status of participants was evaluated by dentists and dental hygienists attached to the Oral Health Care Center within 24 h of admission to the ICU as the initial assessment. Evaluation criteria were based on the Revised Oral Assessment Guide (ROAG), with the exception of the items "vocalization" and "swallowing," and were rated on a three-point scale (Table 2).[18, 19] Daily oral health care in the ICU was provided every 6 h (06:00, 12:00, 18:00, 24:00), and the oral health condition was evaluated between 13:00 and 14:00. Oral health care in the ICU was performed by nurses using commercial toothbrushes and mouth swabs. Syringed water was not used, but intraoral suction by vacuum tube was included. The protocol of oral health care was standardized through the training of dental professionals prior to the onset of interventions, which were monitored by dental hygienists. When a rate of 2 or 3 was observed for any assessment

Table 1 Major diagnosis in each group.

Disease group	Examples of diagnosis
Cerebrovascular disease	Cerebral infarction, subdural hematoma, subarachnoid hematoma, traumatic head injury
Cardiovascular disease	Thoracic aortic dissection, aortic aneurysm, cardiac infarction
Respiratory disease	Pneumonia (including aspiration pneumonia), phthisis, acute respiratory distress syndrome
Gastrointestinal disease	Bowel cancer, intestinal perforation

Table 2 Assessment items and criteria.

Category	Rating 1	Rating 2	Rating 3
Lips	Smooth and pink	Dry or cracked, and/or angular chelitis	Ulcerated or bleeding
Teeth/dentures	Clean, no debris	Plaque or debris in local areas	Plaque or debris generalized
Mucous membrane	Pink and moist	Dry and/or change in color, red blue-red or white	Very red, or thick, white coating Blisters or ulceration
Gums	Pink and firm	Edematous and/or red	Bleeding easily under finger pressure
Tongue	Pink, moist and papillae present	Dry, no papillae present or change in color, red or white	Very thick white tongue coating Blisters or ulceration
Saliva	No friction between the mouth mirror and mucosa	Slightly increased friction, no tendency for the mirror to adhere the mucosa	Significantly increased friction, the mirror adhering or tending to adhere to the mucosa

item, the problems were explained and instructions on the appropriate remedial treatment, such as the usage of oral moisturizing gel, were conveyed to the attending nurses by the dental professionals. At initial evaluation, swabs of biologic specimens were obtained from the surface of the tongue in contact with the endotracheal tube (approximately 20 mm from the tip of tongue). Specimens were then cultured for 48 h at 37°C on selective agar medium (Kanto Chemical Co., Inc., Tokyo, Japan), and the number of colony-forming units (CFU) of *Candida* was counted. Oral health status was evaluated once per day after initial evaluation and continued until either oral intubation was no longer required or the patient was moved to another ward.

Following intervention, patient data on the classification of diagnosis and detection of *Candida* were collated, and the frequently noted changes in oral health status were investigated for patients undergoing three or more interventions.

Prevalence of oral health problems based on ROAG was compared among the four groups by both the chi-square and Steel-Dwass tests. Comparison of detection rates among the disease groups and comparison between the detection of *Candida* and prevalence of oral health problems was processed statistically by the chi-square test. All statistical analyses were performed using SPSS 16.0 (SPSS, Tokyo, Japan).

All experimental protocols of this study were approved in advance by the institutional review board of the School of Dentistry, Showa University (Approval number 2010-22).

Results

Mean age and standard deviation of subjects was 63.7± 13.2 years (range, 42–90). Patient characteristics are shown in Fig. 1.

Figure 2 shows the oral health status of subjects at initial evaluation. Prevalence of "Lip" problems was 23.5% and 25.0% in the cerebrovascular and respiratory disease groups, respectively, with both groups including subjects evaluated with the rating 3. For problems related to the items "Teeth/dentures" and "Gingiva," the rate was <10% in all groups, and no subject was rated as 3. In the cerebrovascular disease group, 11.8% and 5.9% of subjects were as rated 2 and 3, respectively. The rating of "Tongue" problem in the respiratory disease group yielded the highest percentage (70%), and prevalence of this problem in the other three groups was also higher than

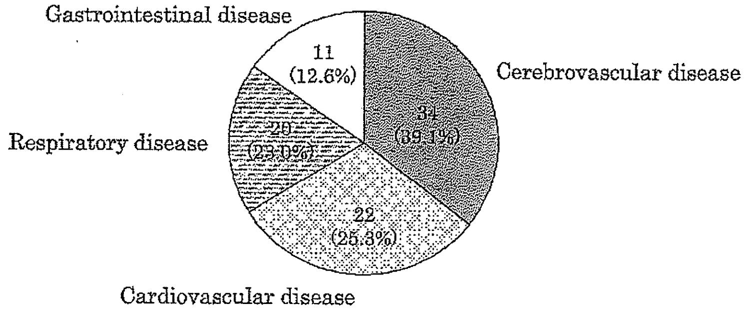

Fig. 1 Main diagnosis of subjects.

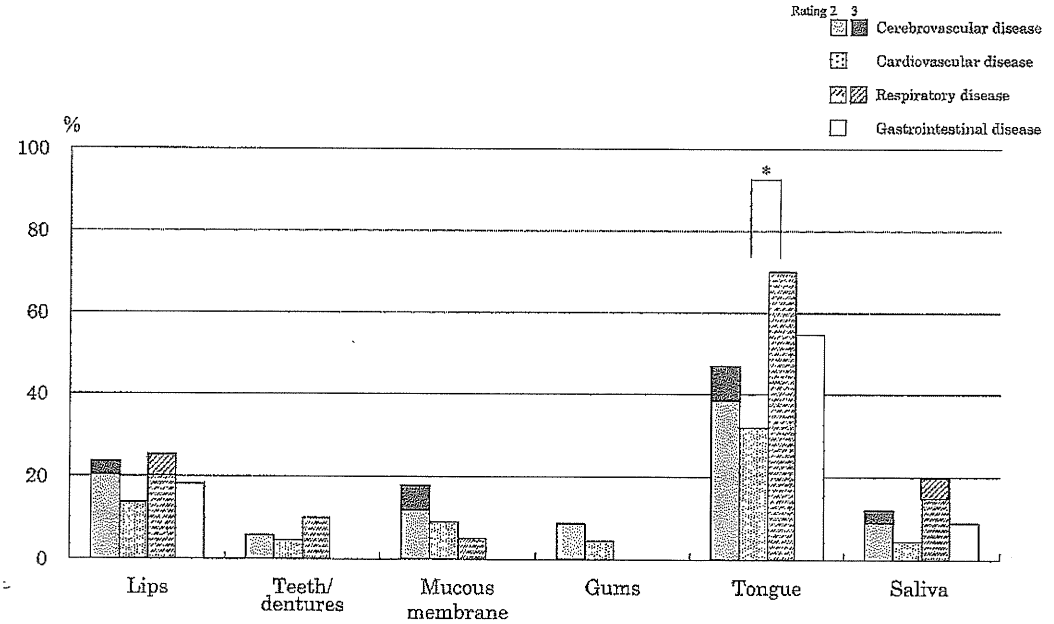

Fig. 2 Frequencies of problems of oral health.
* : $p<0.05$ by chi-squared test and Steel-Dwass test.

Table 3 Number of CFU of *Candida* specimen and detection rate

Disease group	*C. albicans*	*C. glabrata*	*C. krusei*	*C. tropicalis*	*C. parapsilosis*
Cerebrovascular disease	7/34 (20.6%)	2/34 (5.9%)	1/34 (2.9%)	2/34 (5.9%)	2/34 (5.9%)
Cardiovascular disease	2/22 (9.1%)	2/22 (9.1%)	2/22 (9.1%)	0/22 (0%)	0/22 (0%)
Respiratory disease	4/20 (20%)	2/20 (10%)	1/20 (5.0%)	0/20 (0%)	2/20 (10%)
Gastrointestinal disease	2/11 (18.2%)	1/11 (9.1%)	0/11 (0%)	0/11 (0%)	0/11 (0%)

that for the other items. There was a statistically significant difference ($p<0.05$) between the prevalence in the respiratory and cardiovascular disease groups on tongue. Twenty and percent of the subjects in the respiratory and 11.8% in the cerebrovascular disease group were rated as 2 or 3 for the item "Saliva."

Figure 3 and Table 3 show the detection rate for various *Candida* species. The number of subjects negative for *Candida* was 20 (58.8%) in the cerebrovascular, 16 (72.7%) in the cardiovascular, 11 (55.0%) in the respiratory, and 8 (72.7%) in the gastrointestinal disease groups. In addition, more than 100 CFU were observed in two subjects both in the cerebrovascular and respiratory disease groups (5.9% and 10.0%, respectively). However, the detection rates of the 4 disease groups did not show statistic difference (p=0.66). Among the *Candida* species, the prevalence of *C. albicans* was highest, especially in the cerebrovascular disease group (7 subjects, 20.6%), which was higher than that for the other groups. Other *Candida* species detected were *C. glabrata*, *C. krusei*, *C. tropicalis*, and *C. parapsilosis*, all showing rates lower than that of *C. albicans*.

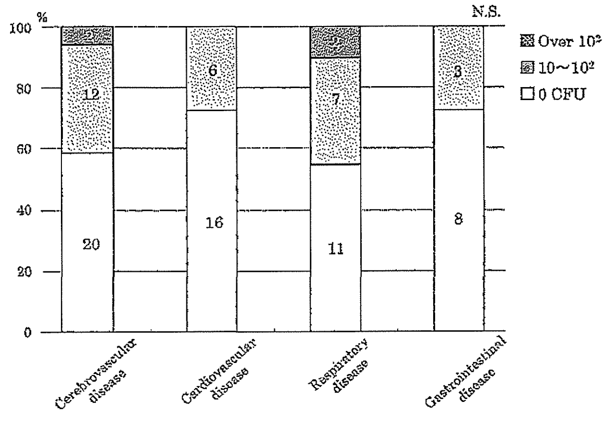

Fig. 3 Detection rate of *Candida* specimen.
N.S.: Not significant by chi-squared test.

Figure 4 shows the prevalence of oral health problems in the four groups according to positive or negative presence of *Candida*. In the cerebrovascular disease group, the prevalence of problems with the items "Lips" and "Tongue" was significantly higher in the *Candida*-positive subjects than in the *Candida*-negative subjects ($p < 0.05$). Similarly, the prevalence of problems with the items "Mucous membrane" in the cardiovascular disease group and "Tongue" in the respiratory disease group was higher in the *Candida*-positive subjects ($p < 0.05$). No *Candida*-negative subjects indicated any problems in regard to the items "Lips," "Teeth/dentures," "Mucous membrane," "Gingiva," or "Saliva" in the cardiovascular and respiratory disease groups.

In the gastrointestinal disease group, all the *Candida*-negative subjects indicated problems with the item "Tongue." On the other hand, no *Candida*-negative subjects in this group were rated as 2 or 3, except for the

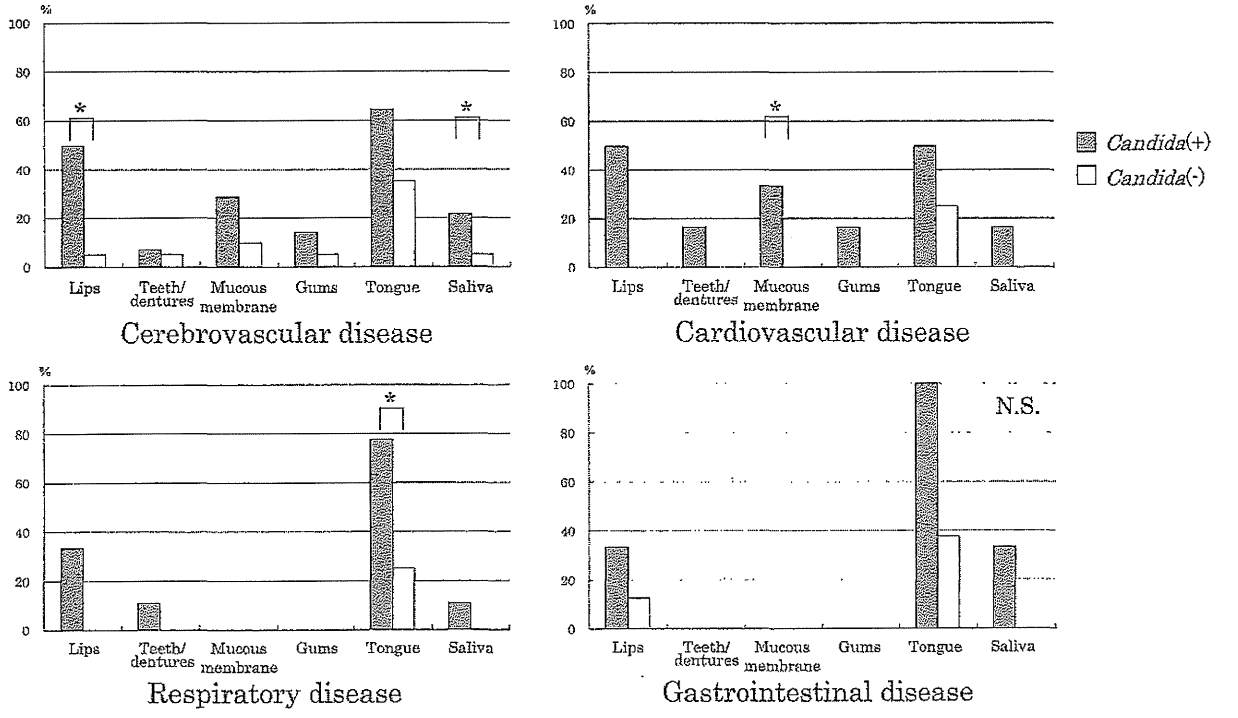

Fig. 4 Frequencies of oral health regarding to detection of *Candida* specimen.
* : $p<0.05$ by chi-squared test.
N.S.: Not significant.

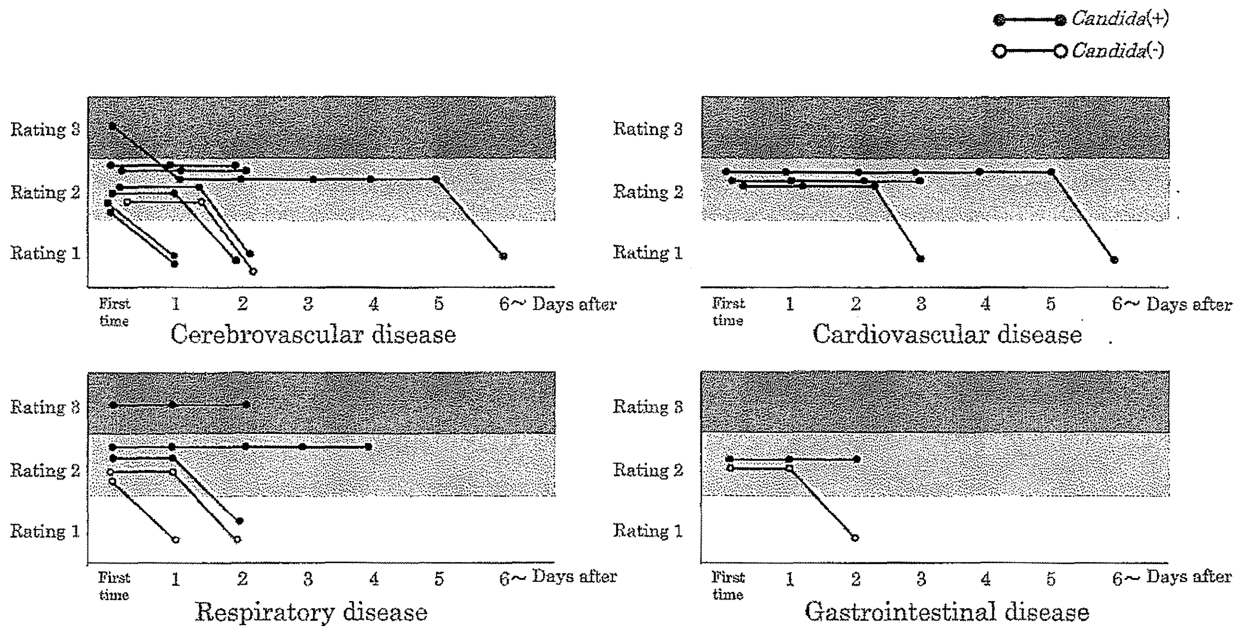

Fig. 5 Changes of the condition of lips.

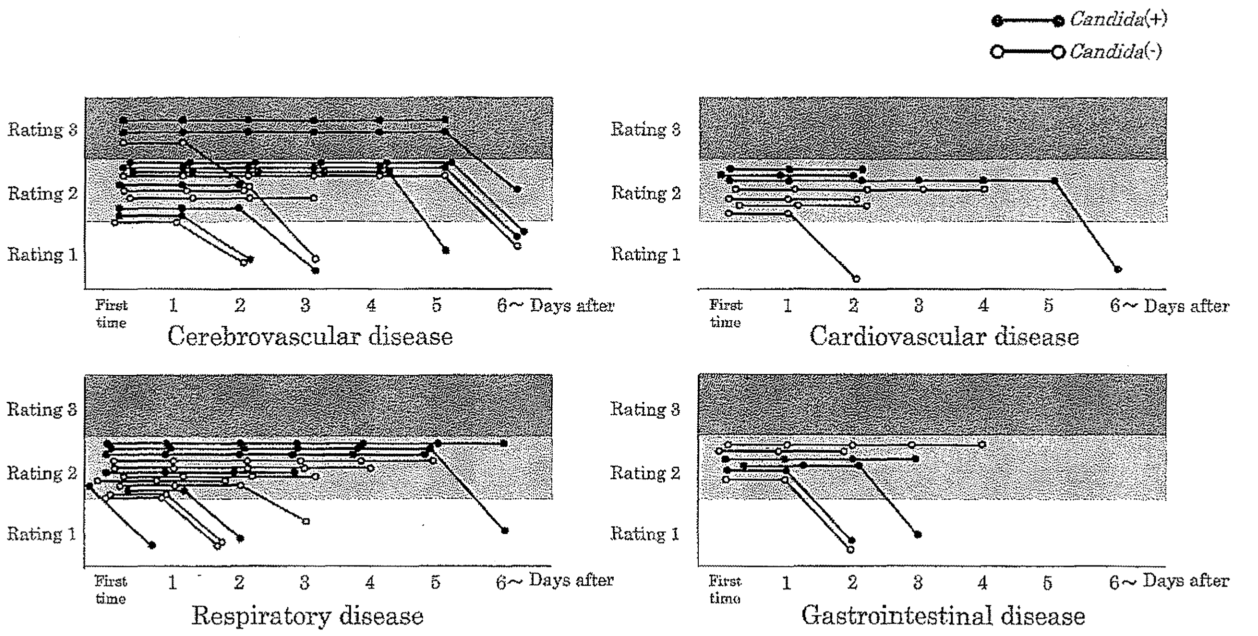

Fig. 6 Changes of the condition of tongue.

items "Lips" (1 subject, 12.5%) and "Tongue" (3 subjects, 37.5%).

Figures 5 and 6 show changes in the rates for the items "Lips" and "Tongue," respectively, in subjects who received three or more interventions. For the item "Lips," the number of subjects rated as 2 or 3 at initial evaluation was eight, three, five, and two in the cerebrovascular, cardiovascular, respiratory, and gastrointestinal disease groups, respectively. Among these, only two subjects in the respiratory disease group and one each in the cerebrovascular and gastrointestinal disease groups were *Candida*-negative. In the cerebrovascular disease group, two subjects rated as 2 changed to the rating of 1 after 1 day, and similarly three changed after 2 days, while