or nutritional status is unknown. In the many studies of elderly patients in long-term care, there is a high incidence of malnutrition.[9] Problems associated with malnutrition include reduced immunity and increased susceptibility to infection.[10] Malnutrition is also a risk factor for respiratory tract infections, including aspiration pneumonia[11] and in-hospital infections.[12] Furthermore, it has been found that malnutrition can result from masticatory disorders due to tooth loss,[13,14] but there have been no reports of malnutrition resulting from masticatory disorders due to motor impairment.[15] The purpose of the present study was to determine the incidence of primitive reflexes in older adults living in nursing homes, and to identify the effects of such reflexes on eating function, nutritional status and prognosis.

Methods

The participants were 121 of 127 elderly patients who lived in two nursing homes in Tokyo, Japan, and who required care (mean age 86.1 ± 7.9 years; 33 males [81.6 ± 8.3 years]; 94 females [87.7 ± 7.2 years]). Individuals under nutritional management by feeding tube were excluded.

The criterion for patient selection was that physical symptoms and cognitive impairment must have been stable for the preceding 3 months. During this 3-month period, no patient had acute disorders (e.g. severe infection, heart failure, or stroke requiring special treatment or intensive care).

In addition, the association between primitive reflexes and nutritional status was examined in 110 participants (mean age 86.2 ± 7.6 years; 30 males [82.4 ± 7.6 years]; 80 females [87.7 ± 7.2 years]) whose serum albumin could be measured. Under the approval of the Ethics Committee in the School of Life Dentistry, Nippon Dental University, the present study was carried out after obtaining informed consent from the participants or their families. The Clinical Dementia Rating (CDR)[16] was used for evaluating cognitive functions, and the Barthel Index[17] was used for evaluating activities of daily living (ADL). The basic survey was conducted in May 2009 and the subjects were then observed over the course of the next 6 months.

The protocol for this study was approved by the Ethics Committee of the Nippon Dental University School of Life Dentistry at Tokyo (#09–11).

Primitive reflex evaluation methods

The presence of primitive reflex was evaluated at the beginning of the present study.

Using the methods of Paulson,[18] participants were examined in the mornings in a quiet room of the nursing home for the presence or absence of a sucking reflex, snout reflex or phasic bite reflex.

Primitive reflexes were evaluated as follows by the same dentist:

Sucking. Incomplete sucking, with only weak contraction of the orbicularis oris muscle, or full sucking, with sucking movements of the tongue and pharynx, after the tip of the patient's index finger is firmly placed between his closed lips.

Snout. Weak puckering or protrusion of the lips, with elevation of the lower lip, after the examiner taps lightly on the midline of the subject's upper lip with his index finger.

Phasic bite. Vertical movement of the lower jaw, as in mastication, after the examiner presses downward with one finger on the molar region of the lower jaw.

Physical and oral examinations

ADL and cognitive functions

In the results of evaluation using the Barthel Index,[17] ADL was considered stable at 45 points or more, but as having declined at 40 points or less. In the present study, based on the results of evaluation by CDR, cognitive function was considered normal at code 1 or lower, and decreased at code 2 or higher.

Nutrition indicators

Nutritional status was evaluated at baseline.

Bodyweight and height were measured and body mass index (BMI) was calculated. In addition, blood samples were taken for the measurement of serum albumin. Values less than 3.5 mg/dL were considered to indicate malnutrition. The texture of the food served at each of the nursing homes was also recorded. Participants who could not ingest an adequate amount of calories as a result of dysphagia were supplemented with high-calorie foods; the participants supplemented with ≥200 kcal per day were assigned to a dietary supplementation group.

Swallowing function

Participants were asked to swallow 3 cc of water and underwent auscultation of the cervical area after swallowing. If choking was produced in conjunction with swallowing or if a wet or gargling sound was detected by auscultation, the participant was considered to have dysphagia.

Other

Medical information at the nursing facilities was examined in order to determine whether the participants had

a history of aspiration pneumonia over the past 12 months. Aspiration pneumonia was diagnosed by a medical doctor.

Statistical analysis

For comparison of two groups, unpaired *t*-tests were used. To examine the independence of each group, χ^2-tests were used. The presence or absence of malnutrition and the development of aspiration pneumonia during 6 months were evaluated as dependent variables. Associated factors were screened by means of logistic regression analysis. For the selection of variables, the stepwise method was applied. All statistical analyses were carried out using the Japanese version of SPSS for Windows (version 16; IBM Japan, Tokyo, Japan), and *P*-values less than 0.05 were considered to be significant. Numerical values in this text are expressed as mean ± standard deviation.

Results

The mean ages of the participants were 87.7 ± 7.2 years for females and 81.6 ± 8.3 years for males, which was a significant difference ($P < 0.001$). The mean Barthel Index was 29.6 ± 27.2; 41.9 ± 28.9 for males and 27.2 ± 25.5 for females, which was significantly different ($P < 0.05$). No sex-based differences in CDR were noted.

Present rate of primitive reflexes

The sucking reflex was noted in 31 (25.6%) participants (mean age 87.7 ± 8.3 years), the snout reflex was found in 15 (12.4%) participants (mean age 86.8 ± 9.3 years) and the phasic bite reflex was found in 28 (23.1%) participants (mean age 86.8 ± 7.6 years). All three reflexes were observed in 11 (9.0%) participants (mean age 89.6 ± 6.8 years). The sucking reflex plus the snout reflex were present in three (2.5%) participants (mean age 81.0 ± 13.8 years), the sucking reflex plus the phasic bite reflex were found in 10 (8.3%) participants (mean age 85.9 ± 9.2 years), the snout reflex plus the phasic bite reflex were found in one (73.0 years) participant, the sucking reflex alone was noted in seven (5.8%) participants (mean age 90.0 ± 5.9 years) and the phasic bite reflex alone was noted in six (5.0%) participants (mean age 85.7 ± 2.1 years); the snout reflex alone was not observed in any participants. One or more of these reflexes were found in 38 (31.4%) participants (mean age 86.9 years).

Relationship between primitive reflexes and characteristics

The presence of primitive reflexes was observed in a large number of participants who had a decline in cognitive function and/or a reduction in ADL. It was also recognized that a significant number of participants often ate foods in which the food texture was modified. In those who showed the sucking reflex, insertion of dentures in either the upper or lower jaw was very difficult. No relationship between age and the appearance of primitive reflexes was noted (Table 1).

Primitive reflexes and nutritional status

A relationship was found between the presence of primitive reflexes and current bodyweight (sucking reflex $P = 0.042$; snout reflex $P = 0.028$). In addition, a relationship was observed between the appearance of the phasic bite reflex at 6 months or 12 months and the rate of change in bodyweight (6 months $P = 0.009$; 12 months $P = 0.042$). The presence of the sucking reflex and phasic bite reflex was also related to serum albumin levels (sucking reflex $P = 0.015$, phasic bite reflex $P = 0.0001$). Participants who had any of the primitive reflexes showed a relationship between bodyweight and serum albumin levels (bodyweight $P = 0.022$, serum albumin level $P = 0.0001$; Table 2).

A serum albumin level of less than 3.5 mg/dL was considered to show malnutrition, and the relationship with each evaluation parameter was investigated.

The following results were obtained: presence/absence of assistance in eating ($P = 0.003$), sucking reflex ($P = 0.005$), snout reflex ($P = 0.02$), phasic bite reflex ($P = 0.001$), participants with some type of primitive reflex ($P = 0.003$) and age (76 participants with adequate nutrition, aged 85.1 ± 7.8 years; and 34 participants with malnutrition, aged 88.7 ± 6.7 years; $P = 0.025$). Malnutrition, viewed in terms of serum albumin levels, was taken as the response variable. Significant parameters (assistance in eating, some type of primitive reflex and age) were taken as explanatory variables, and in the logistic regression analysis, age and appearance of some type of primitive reflex were selected as significantly independent explanatory variables (age: exp = 1.070, 1.007–1.137, $P = 0.029$; some type of primitive reflex: exp = 3.886, 1.582–9.545, $P = 0.003$; Table 3).

Relationship between primitive reflexes and developing aspiration pneumonia

In the course of the study, 22 participants with a mean age of 86.9 ± 8.8 years (9 males: mean age 83.6 ± 6.6 years; 13 females: mean age 89.1 ± 9.6 years) developed aspiration pneumonia. The relationship between each evaluation parameter and the onset of aspiration pneumonia was investigated. Relationships were identified between aspiration pneumonia onset and ADL ($P = 0.026$), sucking reflex ($P = 0.022$), phasic bite reflex ($P = 0.009$), and some type of primitive reflex ($P = 0.011$; Table 4).

Table 1 Relationship between primitive reflexes and basic information

	Suck reflex			Snout reflex			Phasic bite reflex			One or more		
	–	+	*P*-value	–	+	*P*-value	–	+	*P*-value	–	+	*P*-value
Sex (male/female)	27/63	5/26	0.16	30/76	2/13	0.35	27/66	5/23	0.3	27/56	5/33	0.03
Age, years (mean ± SD)	85.8 ± 7.7	87.7 ± 8.3	0.25	86.2 ± 7.7	86.8 ± 9.3	0.78	86.1 ± 7.9	86.8 ± 7.6	0.7	85.9 ± 7.9	86.9 ± 7.9	0.51
BI (<45/≥40)	59/31	29/2	0.00	74/32	14/1	0.00	62/31	26/2	0.0	52/31	36/2	0.00
CDR (<1/≥2)	30/60	1/30	0.07	30/76	1/14	0.11	30/63	1/27	0.0	30/53	1/37	0.00
Food (solid/modified)	17/73	1/30	0.04	18/88	0/15	0.12	18/75	0/28	0.0	17/66	1/37	0.01
Swallowing disorder (yes/no)	68/22	20/11	0.25	80/26	8/7	0.12	70/23	18/10	0.3	64/19	24/14	0.13
History of aspiration pneumonia (yes/no)	83/7	27/4	0.47	97/9	13/2	0.63	87/6	23/5	0.1	77/6	33/5	0.32
Use of upper dentures, yes/no ($n = 104$)	28/51	19/6	0.00	40/52	7/5	0.37	32/48	15/9	0.1	26/46	21/11	0.01
Use of lower dentures, yes/no ($n = 100$)	25/48	22/5	0.00	39/48	8/5	0.37	32/44	15/9	0.1	23/43	24/10	0.00

BI, Barthel Index; CDR, Clinical Dementia Rating.

Table 2 Relationship between primitive reflexes and nutritional status

	Suck reflex			Snout reflex			Phasic bite reflex			One or more		
	–	+	*P*-value	–	+	*P*-value	–	+	*P*-value	–	+	*P*-value
Bodyweight	45.67 ± 8.39	42.27 ± 6.38	0.04	45.40 ± 8.15	40.54 ± 5.8529	0.03	45.45 ± 8.34	42.61 ± 6.60	0.1	45.93 ± 8.57	42.33 ± 6.15	0.02
BMI	20.43 ± 3.02	19.58 ± 2.54	0.16	20.43 ± 2.89	18.66 ± 2.78	0.03	20.45 ± 3.09	19.40 ± 2.14	0.1	20.52 ± 3.08	19.55 ± 2.45	0.09
Weight change rate during 6 months (%)	1.53 ± 5.37	−0.54 ± 6.4	0.10	1.19 ± 5.74	−0.55 ± 5.52	0.30	1.76 ± 5.55	−1.69 ± 5.57	0.0	1.68 ± 5.49	−0.58 ± 5.98	0.06
Weight change rate during 12 months (%)	0.90 ± 7.30	−1.40 ± 9.22	0.21	0.51 ± 7.93	−1.35 ± 7.94	0.44	1.22 ± 7.82	−2.65 ± 7.65	0.0	1.1 ± 7.54	−1.42 ± 8.47	0.15
Serum albumin (g/dL)	3.73 ± 0.32	3.56 ± 0.26	0.02	3.705 ± 0.32	3.53 ± 0.23	0.08	3.75 ± 0.30	3.49 ± 0.26	0.0	3.756 ± 0.31	3.52 ± 0.27	0.00
Dietary supplements (yes/no)	75/15	17/14	0.00	82/24	10/5	0.35	75/18	17/11	0.0	68/15	24/14	0.04
Development of aspiration pneumonia, +/– ($n = 121$)	78/12	21/10	0.02	88/16	11/4	0.03	81/12	18/10	0.0	73/10	26/12	0.01

BMI, body mass index.

Table 3 Relationship between nutritional status and basic information

	Well nourished	Malnourished†	*P*-value
Sex (male/female)	23/53	7/27	0.21
Age (years)	85.1 ± 7.8	88.7 ± 6.7	0.03
BI (<45/≥40)	23/53	6/28	0.12
CDR (<1/≥2)	22/54	5/29	0.08
Feeding assistance (dependent/independent)	48/28	11/23	0.00
Food (solid/modified)	12/64	5/29	0.57
Sucking reflex (presence/absence)	64/12	20/14	0.01
Phasic bite reflex (presence/absence)	64/12	21/13	0.01
Snout reflex (presence/absence)	72/4	27/7	0.02
One or more of these reflexes (presence/absence)	60/16	17/17	0.00
Use of upper dentures (yes/no)	37/39	15/19	0.41
Use of lower dentures (yes/no)	39/37	16/18	0.42
Swallowing disorder (yes/no)	56/20	25/9	0.58
History of aspiration pneumonia (yes/no)	66/10	25/9	0.08

†Malnourished: a serum albumin level of less than 3.5 mg/dL. BI, Barthel Index; CDR, Clinical Dementia Rating.

Table 4 Relationship between primitive reflexes and developing aspiration pneumonia

	Development of aspiration pneumonia		
	No	Yes	*P*-value
Sex (male/female)	23/76	9/13	0.08
BI (<45/≥40)	31/68	2/20	0.03
CDR (<1/≥2)	26/73	5/17	0.48
Feeding assistance (dependent/independent)	57/14/28	7/4/11	0.08
Food (solid/modified)	15/84	3/19	0.58
Sucking reflex (presence/absence)	78/21	12/10	0.02
Snout reflex (presence/absence)	88/11	18/4	0.28
Phasic bite reflex (presence/absence)	81/18	12/10	0.01
One or more of these reflexes (presence/absence)	73/26	10/12	0.01
History of aspiration pneumonia (yes/no)	86/13	14/8	0.02
Use of upper dentures (yes/no)	48/51	13/9	0.25
Use of lower dentures (yes/no)	50/49	13/9	0.31
Swallowing disorder (yes/no)	72/27	16/6	0.61
Malnourished (yes/no)	25/66	9/10	0.08

BI, Barthel Index; CDR, Clinical Dementia Rating.

When onset of aspiration pneumonia was taken as the response variable, significant parameters were taken as explanatory variables, and logistic regression analysis was carried out. The appearance of a bite reflex was selected as a significantly independent explanatory variable (bite reflex: exp = 4.679, 1.39–15.74, $P = 0.013$; Table 5).

Discussion

Primitive reflexes appear during the developmental process of neonatal infants. Primitive reflexes are not observed clinically as the child becomes older, because they are inhibited at a higher level, namely the cerebral cortex and pyramidal tract. The disappearance of

Table 5 Results of logistic regression analysis for onset of aspiration pneumonia

	Coefficient	SE	Wald	*P*-value	Relative risk	95% CI Lower	Upper
History of aspiration pneumonia	1.31	0.67	3.79	0.05	3.71	0.99	13.81
BI	−1.99	1.12	3.19	0.07	0.14	0.015	1.21
Gender	−1.49	0.66	5.17	0.02	0.23	0.06	0.81
Bite reflex	1.54	0.62	6.21	0.013	4.68	1.39	15.74

BI, Barthel Index; CI, confidence interval; SE, standard error.

primitive reflexes is an important sign that shows that the infant is developing normal neurological functions.[19–21] However, primitive reflexes can reappear when a pathological condition is present in the central nervous system.[22]

Such cases are often seen in elderly people with dementia,[4] and the relationship between whether these reflexes appear with age or changes in cognitive function,[4,5] and the relationship between whether these reflexes appear with cerebral disorders are under investigation. However, the relationship between these reflexes and nutritional status and prognosis remains unclear.

The results of the present research showed that elderly people in nursing homes show high rates of primitive reflexes.

Among participants with the sucking reflex, 45.1% also showed the snout reflex, and among those with the phasic bite reflex, 67.7% also had the sucking reflex.

Because the sucking reflex is a superficial reflex and the snout reflex is a deep reflex, they should be differentiated, but they appear together in some people.[18] In the present study, these reflexes often appeared in the same person.

Mastication is controlled by suprabulbar structures, and consists of coordinated movements of masticatory organs, such as the tongue, lips, cheeks and mandible. Motor functions of these organs are known to deteriorate with age,[23,24] and to influence masticatory performance.[15]

Humans chew and swallow their food based on its texture, and masticatory patterns differ depending on the food.[25] The basic masticatory pattern is controlled by a central pattern generator in the brainstem, supplemented by centers in the motor cortex and the basal ganglia, and modified by peripheral information from the masticatory system. Degenerative disease, and infarction lesions and hemorrhaging in these areas of the central nervous system might, thus, have profound effects on mastication. Mandibular movement observed in the phasic bite reflex is a simple up and down movement with no lateral displacement. As the simple up and down mandibular movement observed during eating occurs as a result of disorders in the cerebral cortex and basal ganglia at a higher level than the brainstem used for reference in masticatory coordination, it appears that movement controlled by the central pattern generator in the brainstem has priority. This means that this movement is clearly different from masticatory movement.

When the movement pattern cannot be changed in accordance with differences in the food texture, foods that do not require mastication, such as pureed or mashed foods, must be eaten. However, the movement observed when eating is occasionally different from mastication movement, and involves information different from decisions based on food texture.

Malnutrition is known to occur at a high frequency in the elderly that require care,[9] and is a major problem that affects survival prognosis. Therefore, we investigated whether the appearance of primitive reflexes is related to malnutrition.

When primitive reflexes were observed, it was assumed that the individuals could not carry out basic masticatory movement, that they could not eat food with proper timing, food processing in the oral cavity was not sufficient and oral propulsion was not carried out. Disorders in the preparatory stage and problems in the oral stage in swallowing such foods could also affect nutritional status.

Foods with a texture that requires modification to allow consumption without swallowing are often connected with poor nutrition per unit volume, and can become a cause of malnutrition. The results of this research are important, because they show that the appearance of primitive reflexes that affect motor function in the oral cavity can be used as an indicator of nutritional status.

Elderly people with dementia show reduced eating function,[26] and have numerous problems with low bodyweight.[27,28] It has been reported that marked bodyweight reduction in patients with severe dementia is often associated with death as a result of aspiration pneumonia, and that many deaths as a result aspiration pneumonia occur in patients with dysphagia or abnormal behaviors, such as not chewing their food or not swallowing properly. We showed that the presence of problems in the stage before dysphagia has an effect on survival prognosis,[28,29] and found that many patients

with severe dementia often contract fatal diseases associated with eating function disorders and noted that palliative care is necessary. In such studies to date, dysphagia observed in patients with severe dementia affects the nutritional status, and is also involved in survival prognosis. However, although many of the subjects of studies carried out to date have primitive reflexes, no surveys or studies on the appearance of primitive reflexes were included in any of the previous reports. The appearance of a sucking reflex or the phasic bite reflex suggests that voluntary propulsion of food from the oral cavity to the pharynx is disturbed, and discrepancies between swallowing motion and timing occur. It is possible that the risk of accidental swallowing is increased. It has been suggested that the increased risk of accidental swallowing, together with malnutrition, affects the onset of aspiration pneumonia, which is closely connected with the survival prognosis of elderly patients.

Based on the results of the present study, it is clear that primitive reflexes appear in many patients with reduced cognitive function, and that these reflexes are related to the onset of aspiration pneumonia. Based on careful consideration, it is necessary to provide elderly people who have primitive reflexes with assistance in eating.

When eating difficulties are observed, it is necessary to take measures to prevent malnutrition, such as providing food supplements.

Acknowledgments

This study was supported by the Ministry of Health, Labour and Welfare, Japan. The authors thank all the patients and caregivers, and the nurses and dentist who participated in the study.

Disclosure statement

No potential conflicts of interest were disclosed.

References

1 Vreeling FW, Jolles J, Verhey FR, Houx PJ. Primitive reflexes in healthy, adult volunteers and neurological patients: methodological issues. *J Neurol* 1993; **240**: 495–504.
2 Gossman MD, Jacobs L. Three primitive reflexes in parkinsonism patients. *Neurology* 1980; **30**: 189–192.
3 Jacobs L, Gossman MD. Three primitive reflexes in normal adults. *Neurology* 1980; **30**: 184–188.
4 van Boxtel MP, Bosma H, Jolles J, Vreeling FW. Prevalence of primitive reflexes and the relationship with cognitive change in healthy adults: a report from the Maastricht Aging Study. *J Neurol* 2006; **253**: 935–941.
5 Damasceno A, Delicio AM, Mazo DF *et al.* Primitive reflexes and cognitive function. *Arq Neuropsiquiatr* 2005; **63**: 577–582.
6 Patti F, Emmi N, Restivo DA *et al.* Neurogenic dysphagia: physiology, physiopathology and rehabilitative treatment. *Clin Ter* 2002; **153**: 403–419.
7 Isakov E, Sazbon L, Costeff H, Luz Y, Najenson T. The diagnostic value of three common primitive reflexes. *Eur Neurol* 1984; **23**: 17–21.
8 Vreeling FW, Houx PJ, Jolles J, Verhey FR. Primitive reflexes in Alzheimer's disease and vascular dementia. *J Geriatr Psychiatry Neurol* 1995; **8**: 111–117.
9 Abbasi AA, Rudman D. Undernutrition in the nursing home: prevalence, consequences, causes and prevention. *Nutr Rev* 1994; **52**: 113–122.
10 Gavazzi G, Krause KH. Ageing and infection. *Lancet Infect Dis* 2002; **2**: 659–666.
11 Chouinard J, Lavigne E, Villeneuve C. Weight loss, dysphagia, and outcome in advanced dementia. *Dysphagia* 1998; **13**: 151–155.
12 Schneider SM, Veyres P, Pivot X *et al.* Malnutrition is an independent factor associated with nosocomial infections. *Br J Nutr* 2004; **92**: 105–111.
13 Sheiham A, Steele JG, Marcenes W *et al.* The relationship among dental status, nutrient intake, and nutritional status in older people. *J Dent Res* 2001; **80**: 408–413.
14 Nowjack-Raymer RE, Sheiham A. Association of edentulism and diet and nutrition in US adults. *J Dent Res* 2003; **82**: 123–126.
15 Kikutani T, Tamura F, Nishiwaki K *et al.* Oral motor function and masticatory performance in the community-dwelling elderly. *Odontology* 2009; **97**: 38–42.
16 Morris JC. The Clinical Dementia Rating (CDR): current version and scoring rules. *Neurology* 1993; **43**: 2412–2414.
17 Mahoney FI, Barthel DW. Function evaluation: the Barthel index. *Md State Med J* 1965; **14**: 61–65.
18 Paulson G, Gottlieb G. Development reflexes: the reappearance of foetal and neonatal reflexes in aged patients. *Brain* 1968; **91**: 37–52.
19 Stevenson RD, Allaire JH. The development of normal feeding and swallowing. *Pediatr Clin North Am* 1991; **38**: 1439–1453.
20 Delaney AL, Arvedson JC. Development of swallowing and feeding: prenatal through first year of life. *Dev Disabil Res Rev* 2008; **14**: 105–117.
21 Zafeiriou DI. Primitive reflexes and postural reactions in the neurodevelopmental examination. *Pediatr Neurol* 2004; **31** (1): 1–8.
22 Schott JM, Rossor MN. The grasp and other primitive reflexes. *J Neurol Neurosurg Psychiatry* 2003; **74**: 558–560. Review.
23 Baum BJ, Bodner L. Aging and oral motor function: evidence for altered performance among older persons. *J Dent Res* 1983; **62**: 2–6.
24 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**: 385–388.
25 Piancino MG, Bracco P, Vallelonga T, Merlo A, Farina D. Effect of bolus hardness on the chewing pattern and activation of masticatory muscles in subjects with normal dental occlusion. *J Electromyogr Kinesiol* 2008; **18**: 931–937.
26 Horner J, Alberts MJ, Dawson DV, Cook GM. Swallowing in Alzheimer's disease. *Alzheimer Dis Assoc Disord* 1994; **8**: 177–189.

27 Wang SY, Fukagawa N, Hossain M, Ooi WL. Longitudinal weight changes, length of survival, and energy requirements of long-term care residents with dementia. *J Am Geriatr Soc* 1997; **45**: 1189–1195.
28 Enomoto R, Kikutani T, Suzuki A, Inaba S. Relationship between eating dysfunction and life span and mortality in institutionalized elderly people. *Nippon Ronen Igakkai Zasshi* 2007; **44**: 95–101.
29 Mitchell SL, Teno JM, Kiely DK *et al.* The clinical course of advanced dementia. *N Engl J Med* 2009; **15**: 1529–1538.

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

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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.

Accepted for publication 16 February 2012.

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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

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).

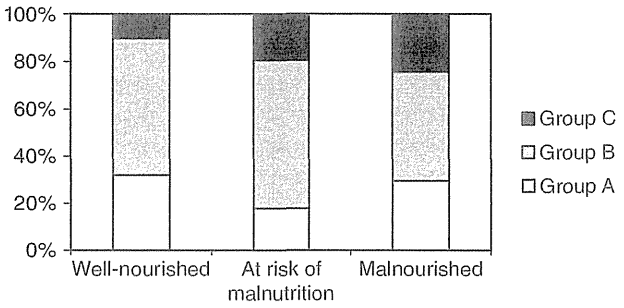

Figure 1 Relationship between nutrition and occlusion (χ^2-test, $P < 0.05$). Group A: natural dentition with adequate function. Group B: partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws. Group C: functionally inadequate occlusion with no dentures.

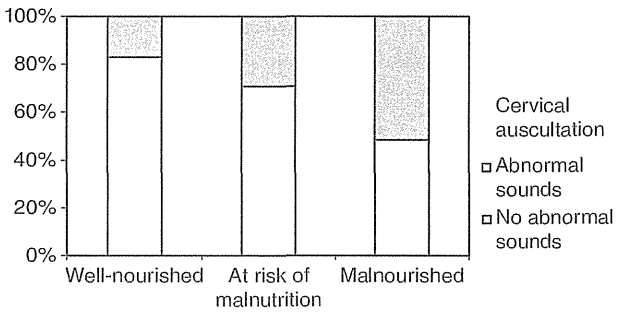

Figure 2 Relationship between nutrition and abnormal swallowing sounds detected by cervical auscultation (χ^2-test, $P < 0.05$).

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.

Original Article

Effect of Difference of Oral Health Care on Oral Health

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Abstract：The aim of this study was to determine the difference in effect of oral hygiene management between the methods, we surveyed the characteristics of the oral hygiene condition and actual state of the number of microorganisms in the postoperative period, and investigated differences in these due to variations in the oral hygiene management method.

Subjects of the present study were 162 patients who underwent oral intubation in the intensive care unit (ICU) and attended an oral health care center from October 2010 to September 2011. From October 2010 to March 2011 Q・Care® (Sage, USA) was used for 87 subjects of the patients (experimental group) and ordinal oral health care was provided for other 75 subjects from April to September 2011 (control group). Dentists rated the oral status of subjects within 24 hours of admission to the ICU on a three-point scale by assessing 'lips', 'teeth/dentures', 'mucous membrane', 'gums', 'tongue', 'saliva', 'condition of teeth' and 'halitosis'. In addition, the number of *Candida* colonies detected on the surface of the tongue was noted at initial assessment.

As a result, at initial assessment, 60% of subjects were classified as having problems of tongue and 40% of them were classified as having problems of lips. The proportion of *Candida*-positive subjects was 24% in experimental group and 20% in control group. The rates of improvement of each problem in oral health, the rates of mucous membrane and saliva were higher in the experimental group than that of control group. The mean length of day until being improvement of these problems in oral cavities was shorter in the experimental group for lips, teeth/dentures and tongue.

These findings suggest that the oral health care with Q・Care® instructed by dental professionals can improve the problems of oral cavities, especially in the problems of lips, mucous membrane and tongue. Therefore, it is considered that appropriate oral health care is effective for these problems；however, further continuous intervention is needed to improve other problems.

Key words：Acute stage, Intensive care unit, Oral health care, Oral intubation

Introduction

There are risks of various complications in the pre- and postoperative periods, and the incidence of respiratory complications including pneumonia is particularly high[1~3]. The incidence of ventilator-associated pneumonia (VAP) is the highest among hospital infections in the acute phase, and, reportedly, it occurs in 10-20% of patients under artificial respiration[4,5]. Several countermeasures to prevent these postoperative infections have been reported, in which the association between the oral hygiene condition and secondary respiratory infection development has been described[6~8]. Therefore, the importance of oral hygiene management from the perioperative period and acute phase has been recognized, and a decrease in the incidence of these infections including VAP by specialized oral hygiene management by dental care workers has been reported[9~11].

The objective of oral hygiene management in the perioperative period is to not only improve oral cleanliness, but also reduce the number of microorganisms in the oral cavity and pharynx to prevent respiratory infection. It has been reported that oral hygiene management decreases the number of microorganisms in these regions, and high-concentration chlorhexidine gluconate reduces the number[12~14]. However, chlor-

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(Received on May 9, 2013)
(Accepted on August 28, 2013)

hexidine gluconate was used at 0.12 or 0.2% in many studies, and oral hygiene management at these concentrations is contraindicated in Japan. Thus, an oral hygiene management method using other drugs is needed. Several oral health care methods have been devised for patients who cannot perform their own oral health care both domestic and overseas and recently packaged oral health kits are used[15~17]. Additionally, it has been reported that liquid for oral health care with etylpyridinium chloride is effective in antiplaque benefit or preventing plaque accumulation[14]. In contrast, there are few reports that compared the difference of the effects among these protocols of oral health care for patients in the acute stage or with ventilators. Especially, only few studies have been carried out to discuss the effects on the oral health through using the packaged kits in Japan.

In this study, to determine the difference in effect of oral hygiene management between the methods, we surveyed the characteristics of the oral hygiene condition and actual state of the number of microorganisms in the postoperative period, and investigated differences in these due to variations in the oral hygiene management method.

Materials and Methods

The subjects were 162 patients who were admitted to the intensive care unit (ICU) of our university hospital between October 2010 and September 2011, used a ventilator for 2 days or longer, and gave consent to intervention and participation in this study at the Oral Care Center of our university. The diseases of the patients were extracted from their ward medical and nursing records, and the main diseases were classified into cerebrovascular, respiratory, digestive, and circulatory diseases. Patients in whom the main disease was unclear, such as those with multiple organ failure and malignant tumor metastasis, and those who required surgery for diseases other than the main disease during the intervention period were excluded. Only patients who received artificial respiratory management through oropharyngeal intubation were included, and those who received tracheotomy and face mask management were excluded. Prior to or after admission to ICU, the informed consent about participation in this study was obtained from the patients or their spouses and sons.

The oral hygiene condition of the patients was evaluated by dentists and dental hygienists at the Oral Care Center, in which the Revised Oral Assessment Guide (ROAG) and its draft revision were used as the criteria, and 8 items excluding those not suitable for patients with oropharyngeal intubation, such as food ingestion and verbalization, were evaluated by 3-step grading[18~20]. The raters were sufficiently calibrated beforehand. The evaluation items and criteria are shown in Table 1. Oral care was performed 4 times a day in the ICU (at 6 : 00, 12 : 00, 18 : 00, and 24 : 00) using Q·Care® products in the experimental group and commercial toothbrushes and mouth swabs in the control group. Syringed water was not used, but intraoral suction by vacuum tube was included. The oral hygiene condition was evaluated between 13 : 00 and 14 : 00 after the 2nd oral care. The care method was calibrated through the lecturing by dental hygienists before the onset of this study, and repeated every two weeks after the onset of the intervention. After evaluation, the dentists and dental hygienists explained intraoral problems to nurses in charge, and informed them of oral care methods, use of oral mucosa-moisturizing agents, and oral care methods to solve problems. For oral hygiene management of the patients, Q·Care® (Sage Products Inc., USA) was used between October 2010 and March 2011. Q·Care® is used to bring a comprehensive, organized approach to oral hygiene for patients who cannot expectorate and cannot perform their own oral care including patients with oral intubation. Especially, this system is designed for the purpose of removing source of healthcare-associated pneumonia and used in ICU and acute stage hospitals. Patients treated during this period were designated as an intervention group. From April to September, the oral cavity was cleaned using commercial tooth and sponge brushes without a dentifrice, and patients treated during this period were designated as a control group. In this group, the commercial oral mucosa-moisturizing gel (WET KEEPING®, OralCare Inc., Tokyo) was used for improving oral dryness. The main ingredients of the mouth wash and moisturizing agent contained in Q·Care® and WET KEEPING® are shown in Table 2. For intervention, dental hygienists explained the Q·Care® application method and common oral hygiene management to

Table 1 Evaluation 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
Condition of teeth	There are not teeth needing dental treatment	There are the teeth disturbing the oral care or becoming the source of infection	There are teeth needing immediate dental treatment including tooth extraction
Halitosis	No halitosis	Halitosis is felt when closer to less than 30 cm from oral cavity	Halitosis is felt when separated from oral cavity more than 30 cm

Table 2 Principal agents of Q·Care® and WET KEEPING®

Group	Product	Elements
Experimental group	Q·Care® Mouthwash	Water, etylpyridinium chloride, sorbitol, potassium sorbate
	Q·Care® Mouth moisturizer	Water, palm oil, ethanol, tocopheryl acetate, cetylpyridinium chloride, xylitol
Control group	WET KEEPING®	Water, glycerin, betaine, xylitol, hydroxyethyl cellulose, lactoferrin, melia azadirachta leaf extract, ethanol

ICU nurses. For these patients, suction tooth brush, soft-tipped covered suction tube, mouth wash liquid and mouth moisturizer were used.

On the first evaluation, the dorsal surface of the tongue contacted by an oropharyngeal intubation tube (about 20 mm posterior from the tongue apex) was scraped with a swab and cultured on selective agar medium (Kanto Chemical Co., Inc., Tokyo) for 48 hours, and fungal colonies of *Candida* species were counted. *Candida* species are not thought as a direct cause of VAP, however, it is considered as an indirect factor which promotes the incidence of VAP[21]. Therefore, this species were used for an index of oral health status in this study. After the first evaluation, the oral hygiene condition was evaluated at the same time daily, and the intervention was completed when the oropharyngeal tube was removed or the patient was discharged from the ICU.

After the completion of intervention, intraoral problems of the patients were summed and they were divided into intervention and control groups, and the frequency of intraoral problems was compared. When the ROAG score decreased from that on the first evaluation, the oral condition was regarded as 'improved', and the number of patients in whom the oral condition was improved during the intervention period was determined. This number of patients was divided by the number of patients with an initial score of 2 or 3 to calculate the improvement rate. In improved cases, the mean number of days required to improve the condition was calculated. Regarding the number of fungal colonies of *Candida* species (CFU), CFU was classified into 3 categories : 0, 1-100, and over 100, and compared between the intervention and control

Table 3 Attributes of each group

Items	Experimental group (n=87)	Control group (n=75)	p value
Gender	Male, 49/Female, 38	Male, 44/Female, 31	0.87 (chi-squared test)
Mean age (SD)	63.7 (13.2) years old	66.5 (14.8) years old	0.47 (Mann-Whitney's U test)
Main diagnosis	Cerebrovascular disease, 34 Cardiovascular disease, 22 Respiratory disease, 20 Gastrointestinal disease, 11	Cerebrovascular disease, 23 Cardiovascular disease, 19 Respiratory disease, 20 Gastrointestinal disease, 13	0.65 (chi-squared test)
Intubation period (SD)	9.1 (11.1) days	4.5 (3.9) days	<0.01 (Mann-Whitney's U test)
Residual teeth	Existing, 77/Nil, 10	Existing, 68/Nil, 7	0.65 (chi-squared test)

groups. Detected *Candida* species were also compared between the groups. In addition, intraoral problems were divided into those which improved and did not improve, and the association of each problem with the CFU distribution (0, 1-100, and over 100) was compared.

On statistical analysis, the association between the improvement of intraoral problems and CFU was analyzed using the chi-squared test for each item, and when a significant difference was detected, the item was compared among the CFU distribution categories employing Fisher's exact test. For comparison of the frequencies and improvement rates of intraoral problems and CFU and species of *Candida*, the chi-squared test was used. For comparison of the number of days required to improve the condition, Mann-Whitney's U test was used. All analyses were performed using statistical analysis software, SPSS 17.0 (SPSS Japan, Tokyo), and the significance level was set at 0.05 and 0.01. This research was carried out after all experimental protocols of this study were approved and no conflict of interest was had in advance by the institutional review board of the School of Dentistry, Showa University (Approval number 2010-22).

Results

The attributes of the intervention and control groups are shown in Table 3. No significant differences were noted in the gender, mean age, or rates of main diseases or dentulous patients between the intervention and control groups. The mean duration of oropharyngeal intubation was 9.1 days in the intervention group and 4.5 days in the control group, showing that the duration was significantly longer in the intervention group.

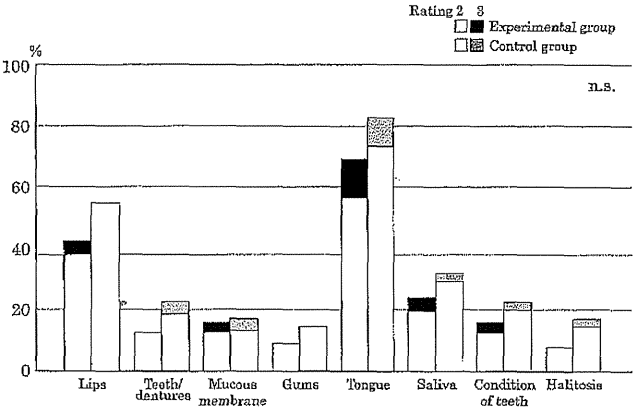

Fig. 1 Frequencies of problems of oral cavity condition
n.s. : not significant by chi-squared test

The oral cavity condition on the first evaluation is shown in Fig. 1. Of the 8 items, the tongue condition was most frequently graded 2 or higher : 69.0% in the intervention group and 82.7% in the control group, followed by the lips : 42.5 and 54.7%, respectively. Saliva was also frequently graded 2 or higher : 24.1 and 32.0%, respectively. In contrast, gums and halitosis were graded high only in about 10%. No significant differences were noted in any items between the intervention and control groups. The CFU and species of *Candida* in samples collected on the first evaluation are shown in Fig. 2 and Table 4. In the intervention group, CFU was 0, 1-10^2, and over 10^2 in 21 (24.1%), 34 (39.1%), and 32 (36.8%) patients, respectively, and

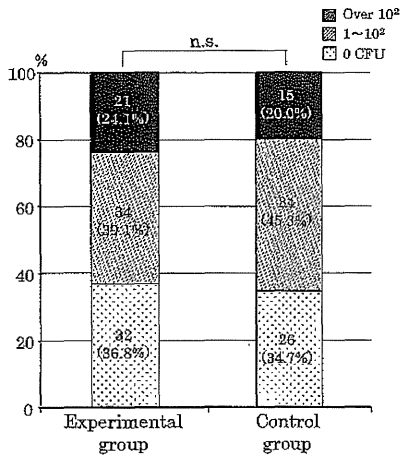

Fig. 2 CFU and species of *Candida*
n.s. : not significant by chi-squared test

Table 4 Detected *Candida* species and the detection rates

	Experimental group (n=55)	Control group (n=49)	p value
C. albicans	36 (65.5%)	27 (55.1%)	
C. glabrata	13 (23.6%)	9 (18.4%)	
C. parapsilosis	12 (21.8%)	5 (10.2%)	0.39
C. krusei	5 (9.1%)	3 (6.1%)	
C. tropicalis	3 (5.5%)	3 (6.1%)	
C. kefyr	1 (1.8%)	2 (4.1%)	

tested by chi-squared test

those in the control group were 15 (20.0%), 34 (45.3%), and 26 (34.7%) patients, respectively. No significant differences were noted in the rates between the groups. The most frequently detected species was *Candida albicans* in both groups, and it was detected in 36 (65.5%) and 27 (55.1%) patients, respectively, followed by *Candida glabrata* and *Candida parapsilosis*, but no significant difference was noted in the frequency of any species between the groups.

The improvement rates of intraoral problems are shown in Fig. 3. The improvement rates of the mucous membrane were 77.8 in the experimental group and 31.1% in the control group. Those of saliva were 65.0 and 34.2%, respectively. The improvement rates of these 2 items were significantly higher in the experimental group than in the control group. The improvement rates of other items did not show significant differences between the 2 groups.

The mean day required to improve the condition is shown in Table 5. The days required to improve for

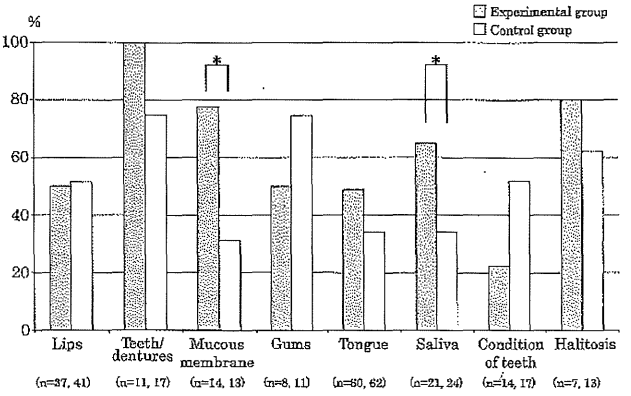

Fig. 3 Improvement rates of intraoral problems
* : $p<0.05$ by chi-squared test

the lips, teeth/dentures, and tongue were significantly shorter in the intervention group, and that for the tooth condition was significantly shorter in the control group. The numbers of days needed to improve the initial problems showed no significant differences in other items.

The results of analysis of the association between the improvement of intraoral problems and CFU are shown in Table 6. Associations between the presence or absence of improvement and grade of CFU were noted in the mucous membrane and tongue in the experimental group, and only in the tongue in the control group. In the experimental group, the rate of patients with $1\text{-}10^2$ CFU was significantly lower in the group with than in the group without improvement of the mucous membrane, and the rate of patients with over 10^2 CFU was significantly lower in the group with than in the group without improvement of the tongue. Similarly, in the control group, the rate of patients with over 10^2 CFU was significantly lower in the group with than in the group without improvement of the tongue.

Discussion

The importance of oral hygiene management for the acute, chronic, and terminal phases to prevent respiratory infections including pneumonia has become widely recognized[3,6,22]. Secondary infection readily occurs in the environment of the acute phase, particularly the perioperative period, such as conditions with reduced organ functions and immunity and artificial respiratory management, for which oral

Table 5 Mean day to improve of intraoral problems

	Experimental group mean (SD) minimum-maximum	Control group mean (SD) minimum-maximum	p value
Lips	1.9 (0.7) 1-3	2.9 (1.0) 1-5	<0.01
Teeth/dentures	1.2 (0.4) 1-2	2.4 (1.5) 1-5	<0.05
Mucous membrane	3.1 (1.3) 1-5	4.8 (1.7) 2-7	0.11
Gums	1.6 (0.5) 1-2	1.9 (0.8) 1-3	0.54
Tongue	5.2 (1.4) 2-7	7.4 (1.7) 3-9	<0.01
Saliva	2.4 (2.0) 1-7	3.2 (1.2) 2-6	0.16
Condition of teeth	5.6 (1.7) 2-7	4.0 (1.7) 1-7	<0.05
Halitosis	2.4 (1.3) 1-4	1.9 (1.0) 1-4	0.43

tested by Mann-Whitney's U test

Table 6 Association between improvements of intraoral problems and CFU numbers

	Experimental group		Control group	
	p value (chi-squared test)	p value (Fisher's exact test)	p value (chi-squared test)	p value (Fisher's exact test)
Lips	0.18	—	0.42	—
Teeth/dentures	—	—	0.97	—
Mucous membrane	0.02	0.03 '1-10^2' was less in improvement group	0.24	—
Gums	0.26	—	0.38	—
Tongue	0.03	0.03 'over 10^2' was less in improvement group	0.04	0.03 'over 10^2' was less in improvement group
Saliva	0.11	—	0.31	—
Condition of teeth	—	—	0.56	—
Halitosis	0.65	—	0.85	—

hygiene management is recommended to prevent VAP and postoperative infection[7,17,23]. We investigated changes in the oral hygiene condition with an oral hygiene management kit used in the US and whether the hygiene condition was different from that managed using the common method.

On the first evaluation, no significant differences were noted in the intraoral problems between the experimental and control groups. It has been reported that the frequencies of dryness of the mouth, tongue coating, and injuries of the lips and oral mucosa were high in patients under artificial respiratory management, particularly those with oropharyngeal intubation[24~27]. In our patients, problems were noted in the lips and tongue at a high frequency, suggesting that they had symptoms characteristic of patients with oropharyngeal intubation. Moreover, *Candida* species were detected in more than 60% of the patients in both groups. Detection of *Candida* in the oral cavity in 25-54% of inpatients has been reported[24,28,29]. The *Candida* species detection rate was higher than these reported rates, but the differences may have been due

to variations in the culture medium and judgment criteria used. *Candida* is indigenous to the oral cavity and pharynx, and *C. albicans* and *C. glabrata* are typical pathogenic species[30]. These species may overgrow in the oral cavity in diseases and a drug-induced immunocompromised condition. *Candida albicans* was most frequently detected in our patients, and multiple l species were detected in some patients. These were similar to the findings of reported studies, showing overgrowth of *Candida* species in the oral cavity in patients with oropharyngeal intubation.

Regarding intraoral problems, the improvement rates of the mucous membrane and saliva differed due to variations in the oral hygiene management method. In addition, the day required to improve the conditions of the lips, teeth/dentures and tongue was significantly shorter in the experimental group than in the control group. In contrast, the day to improve the condition of teeth was significantly shorter in the control group. It has been reported that dryness of the mouth and mucosal ulcer were frequently noted in patients with oropharyngeal intubation, and these were less likely to be improved within a short duration[31]. Regions with dryness and ulcer were protected by applying the moisturizing agent included in the Q• Care® set in the experimental group and a commercial oral mucosa-moisturizing agent in the control group. The moisturizing agent used in the experimental group contained DL-α-tocopherol acetate and palm oil with a moistening effect, and the moisturizing agent used in the control group contained melia azadirachta leaf extract. Although there has been no report on the difference in the moisturizing effect between these agents, DL-α-tocopherol acetate not only moisturizes but also protects the cell membrane, suggesting that it influenced the improvement of dryness in the oral cavity[32]. In addition, water is the base material in the composition, which may have markedly lubricated and softened the oral mucosa. Since the cause of dryness of the oral mucosa is diverse and the condition may not be improved during oropharyngeal intubation, improvement of dryness by oral hygiene management using a moisturizing ingredient may be important to reduce new mucosal injuries and the risk of infection[8,33,34].

On the other hand, the improvement rates of teeth/dentures and halitosis were high in both groups. Since a poor condition of the teeth/dentures and halitosis are caused by organic contaminations in many cases, such as dental plaque on the tooth surface and the retention of sputum and secretions, common cleaning methods, such as brushing and a bed bath, may have achieved sufficient improvement[25]. The day required to improve the condition of the teeth/dentures was shorter in the experimental group, suggesting that the mouth wash used with brushing readily removed dental plaque and secretions.

The causes of the lip problems may have been pressing by the intubation tube and dryness of the lips, and nurses were advised on a tube fixation method, changing the position, and the application of a moisturizing agent to the lips and angles of the mouth in both groups. Although no difference in the improvement rate due to these countermeasures was noted between the groups, the day required to improve the condition was shorter in the experimental group. Similar findings were also noted in the tongue. The tongue problems were dryness and coating in many patients, for which a bed bath using a sponge brush with moisturizing was performed. Since it is generally difficult to remove the tongue coating within a short duration and set a sufficient visual or operative field due to oropharyngeal intubation, removal of the tongue coating requires a prolonged duration in many cases, as observed in this study[24]. However, using Q• Care®, particularly the moisturizing agent, the day required for improvement was shortened, suggesting its significance for the improvement of oral hygiene. The results of the lips and tongue may have been due to the effect of the moisturizing agent used in the experimental group on dryness of the mouth.

Regarding the tooth condition, the improvement rate was low because tooth extraction, fixation with the adjacent tooth, and grinding of sharp ridges may have been necessary for many patients. However, dental treatment was limited due to the systemic condition and immune function. Therefore, these dental treatments including tooth extraction were provided for about half of subjects in control group. Conversely, no subject in experimental group could have the dental treatments due to their general conditions and in some cases it took a few days to obtain the permission from their chief physicians about providing dental treatments. It could cause the longer

duration for improvement of this problem. Moreover, the duration of oropharyngeal intubation was longer in the experimental group, suggesting that appropriate timing was needed to initiate these dental interventions, for which sufficient consultation with attending physicians and investigation of the application of emergency measures may be necessary, in addition to oral hygiene management.

No significant differences were found in the gum and halitosis between the experimental and control group. While mouthwash in Q·Care® contains etylpyridinium chloride which exert a constraining influence on gingival inflammation, the improvement rate and the day required to improve the problems of gum showed no significant differences between the experimental and control group[35]. In this item, the evaluation criteria were focused on edematous and bleeding, edematous and rubor were shown only in a few subjects in this study. It has been reported that cetylpyridinium chloride is effective for reduction of dental plaque in surface of teeth, the effect in the controlling gingivitis that is equivalent to the oral health care using etylpyridinium chloride can be obtained by appropriate orthodox toothbrushing[36]. Suction toothbrushes included with Q·Care® were used in the experimental group and orthodox toothbrushes were used in the control group. However, little difference exist between these toothbrushes with regard to the structure of brush, therefore, these are equivalent in efficacy of mechanical cleaning. From these, it is thought that no significant difference was found in the improvement of the gum condition between the both groups.

Regarding the association of the CFU of *Candida* species and intraoral problems, associations were noted in the mucous membrane and tongue. In the experimental group, the mucous membrane and tongue conditions were less improved in the patients with $1–10^2$ and over 10^2 CFU, respectively. Regarding the control group, it has been reported that tongue coating was frequently noted in the oral cavity in which many *Candida* species were detected, but there has been no report on the course thereafter[23]. Many factors, such as long-term antibiotic treatment and the immune function, are involved in changes in the number of *Candida*, which is indigenous to the oral cavity and pharynx. Thus, the presence of many *Candida* species in the oral cavity suggests that the oral hygiene condition is poor or sensitive to infection, which may have led to difficulty in improving the oral mucosal condition, tongue coating, and dryness in patients with many *Candida* species. The mouth wash used in the experimental group contained cetylpiridinium chloride, which exhibits a fungicidal effect on *Candida* species[37,38]. However, the tongue condition was improved in only a small number of patients with a CFU of over 10^2 in both experimental and control groups, suggesting that the condition at the initiation of intervention is more influential than the intervention method on the improvement. All patients were treated with antibiotics because they were in the perioperative period, but the duration and dose varied. Moreover, changes in the CFU of *Candida* species after intervention were not investigated. These remain to be clarified.

The number of patients with onset VAP was 4 during this study period. Therefore, the relationship between the VAP onset and oral health status was not discussed in this study. The important purpose of oral health management for patients with oral intubation is prevention of the onset of VAP and recent studies reported that low-cost oral care protocol and simple care bundle led to a significantly decreased risk of onset of VAP in the acute stage[39,40]. In addition, it is necessary to examine the effect from not only the incidence but also an aspect of costs and the effort. Consequently, further researches for a long term on incidence of VAP and the differences of oral health status in patients with or without VAP onset are needed.

Conclusion

Diverse problems, such as injuries of the lips, angular cheilitis, and dryness of the tongue, occurred in the ICU patients with oropharyngeal intubation. Oral hygiene management using Q·Care® achieved higher improvement rates of mucous membrane ulcers and dryness compared to the common method. In addition, lip problems, contamination of the teeth, and dryness of the tongue were improved within a short period. However, the improvement rate of tongue problems was low using either cleaning method in patients in whom a high CFU of *Candida* was detected. These