subgroups in age, handgrip strength, BMI, or the number of remaining teeth (Table 3).

Discussion

The results of the current study confirmed previous findings that a significant correlation exists between the one-leg standing time with eyes open and the number of remaining teeth. Furthermore, the authors found that the one-leg standing time was significantly shorter with the mouth opened than with the mouth closed. It may be concluded that the vertical mandibular position affects the one-leg standing time.

Gangloff and Perrin[11] report that body swaying increases when conduction anesthesia is performed on the mandibular foramen in young, healthy subjects, and they also indicate that the center of gravity changes, depending on experimentally conferred mandibular positions.[12] Both studies support the possibility that the periodontal membrane functions as a proprioceptor that governs body balance.

On the other hand, Perinetti *et al.*[13] found no evidence of changes to the center of gravity in patients with malocclusion, and concluded that postural control is not different in the closed-mouth state, which includes mandibular rest and the intercuspidation positions.[14]

Based on the authors' hypothesis that muscle spindles are more important than the periodontal membrane for postural control, the one-leg standing times with the mouth opened and with the mouth closed were compared. Bracco *et al.*[15] report that the myocentric position determined by muscle contractions lead to smaller differences in the center of gravity, compared to the rest position of the mandibular joints and centric occlusion. In addition, Sforza *et al.*[16] found that changes to the center of gravity can be stabilized with equivalent muscular activity from the right and left masseter muscles during sprinting. Previous studies by the authors indicate that edentulous patients with an unstable lower jaw are more prone to shifts of their centers of gravity and that the number of falls can be reduced in patients with dementia who wear dentures.[4,17] These observations suggest that mandibular stability is important for postural control, and the results of the current study support this conclusion.

However, many methods are available for measuring the one-leg standing time, and researchers select the method.[18] It remains to be seen whether the methods used in this study (e.g. one measurement lasting up to 60 seconds) were appropriate. To gain further insights into the role of the mandibular position on postural control, the authors believe that a more detailed investigation employing a stabilometer will be necessary.

Table 3 Comparison between the 'shortened' and 'prolonged' subgroups

	Subgroup		
Physical indices	Shortened	Prolonged	*P*
Age (years)	75.5±5.4	75.7±4.5	0.896^{NS}
Hand grip strength (kg)	23.5±8.6	23.6±7.2	0.592^{NS}
BMI	24.2±2.9	25.1±3.1	0.237^{NS}
Number of remaining teeth	20.9±8.9	18.6±9.6	0.266^{NS}

Note: NS=No significant differences (at P=0.05, based on the Mann–Whitney U test).
In the 'shortened' group patients, the one-leg standing time was equal or shortened with the mouth open than with the mouth closed. In the 'prolonged' group patients, the one-leg standing time was prolonged with the mouth open.

Conclusion

In this study, the authors found that the one-leg standing time with the mouth opened was significantly shorter than the time with the mouth closed. This may be because the proprioception of the periodontal membrane and muscle spindles becomes functional in the mouth-closed condition. The authors conclude that the vertical mandibular position may affect body posture.

Disclaimer Statements

Contributors Mitsuyoshi Yoshida has contributed in conceiving and designing the study, and writing the article in whole; Yayoi Kanehisa has contributed in collecting the data; Yoshie Ozaki has contributed in collecting the data and obtaining ethics approval; Yasuyuki Iwasa has contributed in collecting the data and analysing the data; Takaki Fukuizumi has contributed in collecting the data and revising the article; Takeshi Kikutani has contributed in obtaining funding.

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References

1 WHO Scientific Group on the Burden of Musculoskeletal Conditions at the Start of the New Millennium. The burden of musculoskeletal conditions at the start of the new millennium. World Health Organ Tech Rep Ser. 2003;919:1–218.
2 Yoshimura N, Oka H, Muraki S, Akune T, Hirabayashi N, Matsuda S, *et al.* Reference values for hand grip strength, muscle mass, walking time, and one-leg standing time as indices

for locomotive syndrome and associated disability: the second survey of the ROAD study. J Orthop Sci. 2011;16(6):768–77.
3 Yamaga T, Yoshihara A, Ando Y, Yoshitake Y, Kimura Y, Shimada M, *et al.* Relationship between dental occlusion and physical fitness in an elderly population. J Gerontol A Biol Sci Med Sci. 2002;57(9):M616–20.
4 Yoshida M, Kikutani T, Okada G, Kawamura T, Kimura M, Akagawa Y. The effect of tooth loss on body balance control among community-dwelling elderly persons. Int J Prosthodont. 2009;22(2):136–9.
5 Moriya S, Muramatsu T, Tei K, Nakamura K, Muramatsu M, Notani K, *et al.* Relationships between oral conditions and physical performance in a rural elderly population in Japan. Int Dent J. 2009;59(6):369–75.
6 Okuyama N, Yamaga T, Yoshihara A, Nohno K, Yoshitake Y, Kimura Y, *et al.* Influence of dental occlusion on physical fitness decline in a healthy Japanese elderly population. Arch Gerontol Geriatr. 2011;52(2):172–6.
7 Cuccia A, Caradonna C. The relationship between the stomatognathic system and body posture. Clinics (Sao Paulo). 2009;64(1):61–6.
8 Ferrario VF, Sforza C, Schmitz JH, Taroni A. Occlusion and center of foot pressure variation: is there a relationship? J Prosthet Dent. 1996;76(3):302–8.
9 Sakaguchi K, Mehta NR, Abdallah EF, Forgione AG, Hirayama H, Kawasaki T, *et al.* Examination of the relationship between mandibular position and body posture. J Craniomandib Pract. 2007;25(4):237–49.
10 Baldini A, Nota A, Tripodi D, Longoni S, Cozza P. Evaluation of the correlation between dental occlusion and posture using a force platform. Clinics (Sao Paulo). 2013;68(1):45–9.
11 Gangloff P, Perrin PP. Unilateral trigeminal anaesthesia modifies postural control in human subjects. Neurosci Lett. 2002;330(2):179–82.
12 Gangloff P, Louis JP, Perrin P. Dental occlusion modifies gaze and posture stabilization in human subjects. Neurosci Lett. 2000;293(3):203–6.
13 Perinetti G, Contardo L, Biasati AS, Perdoni L, Castaldo A. Dental malocclusion and body posture in young subjects: a multiple regression study. Clinics (Sao Paulo). 2010;65(7):689–95.
14 Perinetti G. Dental occlusion and body posture: no detectable correlation. Gait Posture. 2006;24(2):165–8.
15 Bracco P, Deregibus A, Piscetta R. Effects of different jaw relations on postural stability in human subjects. Neurosci Lett. 2004;356(3):228–30.
16 Sforza C, Tartaglia GM, Solimene U, Morgun V, Kaspranskiy RR, Ferrario VF. Occlusion, sternocleidomastoid muscle activity, and body sway: a pilot study in male astronauts. J Craniomandib Pract. 2006;24(1):43–9.
17 Yoshida M, Morikawa H, Kanehisa Y, Taji T, Tsuga K, Akagawa Y. Functional dental occlusion may prevent falls in elderly individuals with dementia. J Am Geriatr Soc. 2005;53(9):1631–2.
18 Michikawa T, Nishiwaki Y, Takebayashi T, Toyama Y. One-leg standing test for elderly populations. J Orthop Sci. 2009;14(5):675–85.

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ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Prognosis-related factors concerning oral and general conditions for homebound older adults in Japan

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Purpose: The present study examined the relationship between oral function, such as eating/swallowing, and life prognosis among a homebound elderly population, considering physical and mental function.

Methods: The participants were 511 homebound older adults aged 65 years or older living in four Japanese prefectures. Sex, age, activities of daily living (ADL), cognitive function, underlying disease, nutritional status as Mini-Nutritional Assessment-Short Form (MNA®-SF), swallowing function, dietary modification and occlusal status were examined at baseline. Participants were categorized into poor outcome (died or admitted to hospital or nursing home) and good outcome (still under home care) groups at 1-year follow up, and significant related baseline factors were analyzed. In addition, these groups were compared by the ADL subgroup divided into <60 (lower) and ≥60 (higher) by Barthel Index.

Results: In total, 473 participants were followed up (poor outcome group 177 [37.4%], good outcome group 296 [62.6%]). Sex, age, ADL, MNA®-SF, swallowing function, dietary modification and occlusal support were significantly different between these groups. Logistic regression analysis showed that sex and MNA®-SF score were significantly related to prognosis in the lower ADL group, and sex, age, Charlson Comorbidity Index and occlusal support were significantly related in the higher ADL group.

Conclusions: ADL was strongly correlated with life prognosis in homebound older adults. Within the higher ADL participants, occlusal support was related to this outcome. **Geriatr Gerontol Int 2014; ••: ••–••.**

Keywords: activities of daily living, elderly, nutrition, occlusion, prognosis.

Introduction

Among the elderly population, malnutrition induces decreased immune competence[1] and sarcopenia.[2] As decreased immune competence increases the risk of infections and sarcopenia impairs physical function, malnutrition is important as a factor causing health disorders in these older people. It was reported that more than half of Japanese older adults requiring home care were malnourished or at risk of malnutrition.[3] Malnutrition occurred under these conditions as: (i) chronic diseases, such as cancer, chronic cardiac failure, chronic renal failure and chronic obstructive pulmonary disease; (ii) acute diseases or wounds, such as surgery, acute infection and multiple trauma; and (iii) starvation as a result of insufficient ingestion of energy and protein.[4] Among these, the risk of malnutrition as a result of (iii) is high in older adults, as dietary intake decreases with aging.[5] The risk of malnutrition becomes higher when older adults require long-term care, because these factors are combined with difficulty in oral ingestion as a result of impaired eating/swallowing functions.[6]

It has been reported that malnutrition is directly linked to longevity;[7,8] however, it has not been shown that impaired eating/swallowing function that causes malnutrition[9] is related to life expectancy. The aim of

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the present study was to clarify the relationship between oral function, such as eating/swallowing, and life prognosis among a homebound elderly population, considering physical and mental function.

Methods

We examined 716 homebound older adults aged 65 years or older living in four prefectures of Japan (Tokyo, Kanagawa, Niigata and Fukuoka) from October to December in 2010.[10] Among these participants, 511 participants were followed up 1 year later (162 men, 349 women, mean age 84.2 ± 7.6 years). This study was approved by the ethics committee of Nippon Dental University. All the patients and/or their families gave written informed consent before study participation.

At baseline, sex, age, basic activities of daily living (ADL), cognitive function, underlying disease, nutritional status, swallowing function, dietary modification and occlusal status were examined. The present living status was determined at 1-year follow up by interviewing care managers and physicians of the participants.

ADL

ADL was evaluated using the Barthel Index, which is a widely used index.[11] The participants with a Barthel Index score of ≥60 points (those whose basic actions in daily life were almost independent[12]) were classified as the higher ADL group, and participants with a Barthel Index score of <60 points were classified as the lower ADL group.

Cognitive function

Cognitive function was evaluated using Washington University Clinical Dementia Rating (CDR), an observational method that is widely used to evaluate the severity of dementia throughout the world.[13] Participants with a score of zero and 0.5 were classified as "absence of dementia", and participants with a score of ≥1 were classified as "presence of dementia".

Underlying disease

The underlying disease in each participant was obtained based on the diagnosis of the physician in charge and evaluated using the Charlson Comorbidity Index (concomitant underlying disease index), a concomitant disease index for prognostic evaluation.[14]

Nutritional status

The nutritional status was evaluated using Mini-Nutritional Assessment-Short Form (MNA®-SF) consisting of six screening items in the first step of MNA®, a simple evaluation method for older adults.[15]

Swallowing function

Swallowing function was evaluated according to the neck auscultation method by Zenner *et al.*[16] Each participant was made to ingest 3 mL of water from a glass and the swallowing status was evaluated by neck auscultation.[17] At this time, when a symptom such as choking, respiratory distress or wheezing occurred or the water was swallowed in multiple portions, "presence of swallowing disorder" was judged, and otherwise "absence of swallowing disorder" was judged. The dentist in charge of the test was instructed about the neck auscultation method in advance of the test.

Dietary modification

The interview showed whether the dietary modification, such as puree and nectar, was used or not in the every day diet. Drinking thickened water was also included in the dietary modification.

Occlusal status

A dentist carried out an oral examination at home, and depending on the occlusion status in the molar region, the participants were classified as follows. Participants with occlusion of the molar region with natural teeth or denture(s) at one or more sites were classified as "presence of occlusal support", whereas those with no molar region occlusion with either natural teeth or denture(s) were classified as "absence of occlusal support".

Statistical analysis

According to the follow-up examination, the participants were classified into two groups: (i) participants still receiving home care in the same manner as 1 year ago; and (ii) participants who were admitted to hospital or a nursing home, or died during the last 1-year period. Participants in group (i) were handled as the "good outcome group", and participants in group (ii) were handled as the "poor outcome group." These two groups were compared by the χ^2-test and Mann–Whitney *U*-test. Furthermore, multicollinearity was investigated with Spearman's rank correlation coefficient and Cramer's coefficient of association (Cramer's V). In addition, the participants were divided by Barthel Index score, and the influence of each factor ($P < 0.10$) was investigated by logistic regression analysis in each ADL subgroup. In statistical analysis, PASW Statistics 18 (IBM, Tokyo, Japan) was used, and the level of statistical significance was set at 95%.

Results

Excluding 38 participants (7.4%) in whom the follow-up investigation was not possible as the nursing-care service provided had changed or consent was not obtained, 473 participants (145 men, 328 women, mean age 84.1 ± 7.6 years) were followed up. The good outcome group consisted of 296 participants (75 men, 221 women, mean age 83.5 ± 7.7 years). The poor outcome group consisted of 177 participants (70 men, 107 women, mean age 85.1 ± 7.4 years). Among the poor outcome group, 119 participants (25.2%) were admitted to a hospital or nursing home. The reason for this admission was orthopedic disease in 19, pneumonia in 18, cerebrovascular disease in six, malignant neoplasm in five, cardiac disease in five, other in 30 and unclear in 36. Deceased participants accounted for 58 (12.3%), and the cause of death was pneumonia in 12, senile deterioration in 12, cardiac disease in eight, malignant neoplasm in seven, cerebrovascular disease in three, other in 10 and unclear in six.

The items that showed a significant difference between the good outcome group and poor outcome group were sex, age, ADL, MNA®-SF, swallowing function, dietary modification and occlusal support (Table 1).

Looking at the inter-item correlation, a strong correlation ($P < 0.001$) was detected between Barthel Index and other items, as shown in Table 2. Then, the participants were divided into the following two ADL subgroups for analysis. The lower ADL group with a Barthel Index score of <60 points consisted of 211 participants (67 men, 144 women, mean age 84.5 ± 8.0 years), and the higher ADL group with a Barthel Index score of ≥60 points consisted of 262 participants (78 men, 184 women, mean age 83.8 ± 7.3 years).

Comparing the good outcome group and poor outcome group in each ADL subgroup, a significant difference was recognized for MNA®-SF in the lower ADL group, and for sex, age, Charlson Comorbidity Index, swallowing function and occlusal support in the higher ADL group (Table 3). In addition, the stepwise logistic regression analysis showed that sex and MNA®-SF were identified as prognostic factors ($P < 0.05$) in the lower ADL group, and sex, age, Charlson Comorbidity Index and occlusal support were identified as prognostic factors ($P < 0.05$) in the higher ADL group (Table 4).

Table 1 Comparison between good outcome group and poor outcome group

	Prognosis		Odds ratio (95% CI)	*P*-value
	Good outcome group (n = 296)	Poor outcome group (n = 177)		
Men, n (%)	75 (25.3)	70 (39.5)	0.519 (0.348–0.773)	0.001
Age, mean (SD)†	83.5 (7.7)	85.1 (7.4)		0.034
ADL (Barthel Index), mean (SD)†	64.2 (26.7)	51.1 (29.0)		<0.001
CDR not less than 1, n (%)	157 (53.0)	105 (59.3)	1.291 (0.886–1.882)	0.184
Charlson Comorbidity Index, mean (SD)†	1.3 (1.2)	1.6 (1.4)		0.052
MNA®-SF, mean (SD)†	10.4 (2.3)	9.5 (2.3)		<0.001
Presence of swallowing disorder, n (%)	73 (24.7)	73 (41.2)	2.144 (1.438–3.196)	<0.001
Dietary modification, n (%)	70 (23.6)	69 (39.0)	2.063 (1.377–3.089)	<0.001
Absence of occlusal support, n (%)	26 (8.8)	31 (17.5)	2.205 (1.261–3.855)	0.005

†Mann–Whitney U-test, others: χ^2 test. ADL, activities of daily living; CDR, Clinical Dementia Rating; CI, confidence interval; MNA®-SF, Mini-Nutritional Assessment-Short Form.

Table 2 Correlation between activities of daily living (Barthel Index) and each examination item

	Sex	Age	CDR	Charlson Comorbidity Index	MNA®-SF	Swallowing disorder	Dietary modification	Occlusal support
Correlation coefficient	0.233†	−0.069	−0.205	−0.194	0.519	−0.261	−0.489	−0.116
P-value	0.178	0.134	<0.001	<0.001	<0.001	<0.001	<0.001	0.011

†Cramer's coefficient of association (Cramer's V). ADL, activities of daily living; CDR, Clinical Dementia Rating; MNA®-SF, Mini-Nutritional Assessment-Short Form.

Table 3 Comparison between good outcome group and poor outcome group in lower and higher activities of daily living group

	Lower ADL group				Higher ADL group			
	Outcome		Odds ratio (95% CI)	*P*-value	Outcome		Odds ratio (95% CI)	*P*-value
	Good outcome group (n = 109)	Poor outcome group (n = 102)			Good outcome group (n = 187)	Poor outcome group (n = 75)		
Men, n (%)	28 (25.7)	39 (38.2)	0.558 (0.311–1.004)	0.050	47 (25.1)	31 (41.3)	0.476 (0.271–0.839)	0.010
Age, mean (SD)†	84.2 (8.4)	84.8 (7.5)		0.714	83.1 (7.2)	85.5 (7.2)		0.008
CDR not less than 1, n (%)	66 (60.6)	71 (69.6)	1.492 (0.843–2.640)	0.168	91 (48.7)	34 (45.3)	0.875 (0.511–1.497)	0.626
Charlson Comorbidity Index, mean (SD)†	1.7 (1.5)	1.6 (1.4)		0.992	1.2 (1.0)	1.6 (1.4)		0.040
MNA®-SF, mean (SD)†	9.3 (2.2)	8.6 (2.2)		0.013	11.1 (2.1)	10.8 (1.8)		0.128
Swallowing disorder, n (%)	41 (37.6)	49 (48.0)	1.533 (0.886–2.654)	0.126	32 (17.1)	24 (32.0)	2.279 (1.230–4.223)	0.008
Dietary modification, n (%)	49 (45.0)	57 (55.9)	1.551 (0.901–2.670)	0.113	21 (11.2)	12 (16.0)	1.506 (0.700–3.240)	0.293
Absence of occlusal support, n (%)	13 (11.9)	19 (18.6)	1.690 (0.787–3.630)	0.175	13 (7.0)	12 (16.0)	2.549 (1.105–5.881)	0.024

†Mann–Whitney U-test, others: χ^2-test. ADL, activities of daily living; CDR, Clinical Dementia Rating; CI, confidence of interval; MNA®-SF, Mini-Nutritional Assessment-Short Form.

Table 4 Results of stepwise logistic regression analysis in lower and higher activities of daily living group

	B	Standard deviation	Wald test	*P*-value	Exp (B)	95% CI
Lower ADL group						
Sex	−0.657	0.307	4.588	0.032	0.518	0.284–0.946
MNA®-SF	−0.174	0.067	6.875	0.009	0.840	0.737–0.957
Constant	2.605	0.849	9.429	0.002	13.537	
Higher ADL group						
Sex	−0.896	0.326	7.534	0.006	0.408	0.215–0.774
Age	0.085	0.023	13.356	0.000	1.089	1.040–1.140
Charlson Comorbidity Index	0.417	0.142	8.631	0.003	1.518	1.149–2.004
Occlusal support	1.039	0.453	5.254	0.022	2.826	1.163–6.870
Constant	−8.306	2.076	16.012	0.000	0.000	

ADL, activities of daily living; B, partial regression coefficient; Exp (B), exponential function (partial regression coefficient); MNA®-SF, Mini-Nutritional Assessment-Short Form.

Discussion

The results of the present study suggested that occlusal support could be related to life prognosis in homebound older adults whose ADL is relatively maintained.

Regarding the correlation between nutritional status and outcome, low body mass index and hypoalbuminemia were handled as poor-prognostic factors in homebound older adults.[18] In addition, Tsai *et al.* reported that MNA® is a factor capable of predicting the nutritional status and outcome in older adults admitted to a nursing home.[19]

The Barthel Index is a globally used tool for ADL evaluation, and it was reported that the level of independence is high with a Barthel Index score of ≥60 points, severe disability is seen with a score of <40 points and total aid is necessary with a score of <20 points.[12] In the present study, a strong correlation was recognized between ADL and other examination items. Then, in order to avoid multicollinearity, the participants were divided into lower ADL group with a Barthel Index score of <60 points and higher ADL group with a Barthel Index score of ≥60 points for statistical analysis. As a result, in the lower ADL group, a significant correlation was recognized between malnutrition risk and life prognosis, the same as in previous studies.[18,19]

In contrast, in the higher ADL group, nutritional status was not related to life expectancy. In the higher ADL group, the items that showed a significant correlation with life prognosis were underlying disease and occlusal support, as well as sex and age. It could indicate that someone who has maintained relatively high ADL is admitted into the hospital or nursing home suddenly because of deterioration of their underlying medical problems. Furthermore, a significant correlation was recognized between occlusal support and prognosis, so we speculate that loss of occlusal support resulted in a chewing disorder and caused an eating disorder leading to malnutrition.

Many studies have shown that teeth, occlusal support and chewing ability were correlated with nutritional status in older adults, and it is concluded that the presence of occlusal support and chewing ability are favorable factors for nutritional status.[20–22] Chewing ability was produced by occlusal support as well as oral function including tongue, cheek and lips movement,[23] and oral function was significantly related to ADL.[24] It could be quite reasonable in the lower ADL group that oral function had already decreased in the same manner as general physical function, and eating/swallowing disorder and malnutrition were caused by the chewing disorder. In contrast, oral movement for chewing could be maintained in the higher ADL group, so that the existence of occlusal support might be directly involved in maintenance of chewing and eating function.

In the present study, the reason for admission to hospital or a nursing home did not focus on the underlying disease status, so further studies will be required to show that occlusal support is related to life prognosis in homebound older adults whose ADL is relatively maintained. Furthermore, as malnutrition accompanying loss of occlusal support was the cause of sudden worsening of outcome among the relatively ADL maintained group, we should investigate the possibility that recovery of chewing function by restoring occlusal support with denture(s) might improve eating function, leading to improvement of nutritional status and further to improvement of life expectancy.

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Disclosure statement

The authors declare no conflict of interest.

References

1 Lesourd B. Nutrition: a major factor influencing immunity in the elderly. *J Nutr Health Aging* 2004; **8**: 28–37.
2 Vandewoude MF, Alish CJ, Sauer AC, Hegazi RA. Malnutrition-sarcopenia syndrome: is this the future of nutrition screening and assessment for older adults? *J Aging Res* 2012; **2012**: 651570.
3 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.
4 Jensen GL, Mirtallo J, Compher C *et al.* Adult starvation and disease-related malnutrition: a proposal for etiology-based diagnosis in the clinical practice setting from the International Consensus Guideline Committee. *JPEN J Parenter Enteral Nutr* 2010; **34**: 156–159.
5 Wakimoto P, Block G. Dietary intake, dietary patterns, and changes with age: an epidemiological perspective. *J Gerontol A Biol Sci Med Sci* 2001; **56** (Spec 2): 65–80.
6 Kikutani T, Kodama M, Nishiwaki K, Fukui T, Inaba S, Yoneyama T. The relationship of oral, physical and mental functions to the nutritional status in the frail elderly. *Jpn J Gerodont* 2003; **18**: 10–16.
7 Corti MC, Guralnik JM, Salive ME, Sorkin JD. Serum albumin level and physical disability as predictors of mortality in older persons. *JAMA* 1994; **272**: 1036–1042.
8 Ogawa K, Mehata Y, Asano T *et al.* Factors contributing to survival of elderly inpatients with chronic disease. *Nihon Ronen Igakkai Zasshi* 1997; **34**: 492–498.
9 Semba RD, Blaum CS, Bartali B *et al.* Denture use, malnutrition, frailty, and mortality among older women living in the community. *J Nutr Health Aging* 2006; **10**: 161–167.
10 Kikutani T, Yoshida M, Enoki H *et al.* Relationship between nutrition status and dental occlusion in community-dwelling frail elderly people. *Geriatr Gerontol Int* 2013; **13**: 50–54.
11 Mahoney FI, Barthel DW. Functional evaluation; the Barthel index. *Md State Med J* 1965; **14**: 61–65.
12 Granger CV, Albrecht GL, Hamilton BB. Outcome of comprehensive medical rehabilitation: measurement by PULSES profile and the Barthel Index. *Arch Phys Med Rehabil* 1979; **60**: 145–154.
13 Burke WJ, Miller JP, Rubin EH *et al.* Reliability of the Washington University Clinical Dementia Rating. *Arch Neurol* 1988; **45**: 31–32.
14 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.
15 Rubenstein LZ, Harker JO, Salvà A, Guigoz Y, Vellas B. Screening for undernutrition in geriatric practice: developing the short-form mini-nutritional assessment (MNA-SF). *J Gerontol A Biol Sci Med Sci* 2001; **56**: M366–M372.
16 Zenner PM, Losinski DS, Mills RH. Using cervical auscultation in the clinical dysphagia examination in long-term care. *Dysphagia* 1995; **10**: 27–31.
17 Sudo E, Tanuma S, Sudo E *et al.* The usefulness of the water swallowing test and videofluorography in swallowing rehabilitation in patients with cerebrovascular disease. *Nihon Ronen Igakkai Zasshi* 2002; **39**: 427–432.
18 Kitamura K, Nakamura K, Nishiwaki T, Ueno K, Hasegawa M. Low body mass index and low serum albumin are predictive factors for short-term mortality in elderly Japanese requiring home care. *Tohoku J Exp Med* 2010; **221**: 29–34.
19 Tsai AC, Ku PY. Population-specific Mini Nutritional Assessment effectively predicts the nutritional state and follow-up mortality of institutionalized elderly Taiwanese regardless of cognitive status. *Br J Nutr* 2008; **100**: 152–158.
20 Samnieng P, Ueno M, Shinada K, Zaitsu T, Wright FA, Kawaguchi Y. Oral health status and chewing ability is related to mini-nutritional assessment results in an older adult population in Thailand. *J Nutr Gerontol Geriatr* 2011; **30**: 291–304.
21 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.
22 Nordenram G, Ljunggren G, Cederholm T. Nutritional status and chewing capacity in nursing home residents. *Aging (Milano)* 2001; **13**: 370–377.
23 Kikutani T, Tamura F, Nishiwaki K *et al.* Oral motor function and masticatory performance in the community-dwelling elderly. *Odontology* 2009; **97**: 38–42.
24 Miura H, Arai Y, Sakano S, Hamada A, Umenai T, Isogai E. Subjective evaluation of chewing ability and self-rated general health status in elderly residents of Japan. *Asia Pac J Public Health* 1998; **10**: 43–45.

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ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Relationship between oral bacteria count and pneumonia onset in elderly nursing home residents

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Aim: Oral bacteria, which are a source of infection for aspiration pneumonia, were examined in frail older adults with the aim of establishing a standard bacteria count that indicates the risk of pneumonia onset in this group.

Methods: A survey of bacteria count in the saliva using a simple instrument for measurement of the number of oral bacteria, along with factors including swallowing function and nutritional status, was carried out in 691 elderly individuals requiring care (137 men; mean age 82.6 ± 8.3 years; 554 women; mean age 88.0 ± 7.1 years; total mean age 86.7 ± 7.8 years) at 16 nursing homes in Japan. All participants gave their consent for inclusion in the present study. During a 6-month follow-up period, participants who developed pneumonia were identified, and relationships between the factors measured at the start of the period and pneumonia onset were examined.

Results: During the 6-month follow-up period, 33 participants (4.8%; 5 men, 28 women; mean age 88.3 ± 7.4 years) developed pneumonia. Pneumonia onset was significantly associated with reduced activities of daily living, swallowing dysfunction and undernourishment. Logistic regression analysis identified a saliva bacteria count of $10^{8.5}$ colony-forming units/mL as an independent explanatory factor for pneumonia onset ($P = 0.012$, $RR = 3.759$).

Conclusions: Oral bacteria count of $10^{8.5}$ colony-forming units/mL saliva in an elderly person requiring care was identified as a risk factor for pneumonia onset. **Geriatr Gerontol Int 2014; ••: ••–••.**

Keywords: aspiration pneumonia, oral bacteria count, oral health care.

Introduction

Older adults are known to have a high incidence of aspiration pneumonia, and this is believed to be associated with intraoral bacteria infection.[1] Many bacteria that are specific causative agents of pneumonia are present in the oral cavity,[2] and it is difficult to selectively reduce the number of pneumonia-causing bacteria. Oral care can lead to favorable changes in the composition and abundance of oral bacteria,[3,4] and it has been reported that specialist oral care can reduce the number of days of fever and the frequency of pneumonia onset,[5,6] as well as reduce the mortality rate from pneumonia.[7]

Terpenning *et al.* discussed the economic effectiveness of carrying out oral care in these cases, and also calculated the cost of oral care in terms of human resources.[8] They found that oral care is highly effective. We determined the oral bacteria count in older adults requiring care using a simple instrument recently developed for the measurement of the number of oral bacteria,[9,10] and investigated the relationship between the oral bacteria count and subsequent pneumonia onset. We then used these findings to identify individuals at high risk of pneumonia onset. We expect that this type of screening program will enable the implementation of intensive oral care for high-risk individuals and will contribute to the prevention of aspiration pneumonia onset, which is significant from the perspective of medical economics.

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The present study focused on the number of oral bacteria, which are a source of infection in aspiration pneumonia, with the aim of establishing a standard oral bacteria count for assessing the risk of pneumonia onset.

Methods

Participants

The survey was carried out in 691 older adults requiring care (137 men; mean age 82.6 ± 8.3 years; 554 women; mean age 88.0 ± 7.1 years; total mean age 86.7 ± 7.8 years) at 16 nursing homes in Japan who gave their consent to participate in the present study. We explained the purpose and procedure of the study to the participants both orally and in writing, and we obtained written informed consent from all participants or their families. The study was approved by the ethics committee of The Nippon Dental University, School of Life Dentistry at Tokyo.

Bacteria count

Oral bacteria count was determined using saliva collected from the sublingual area within 30 min of waking. To obtain a specimen, we rinsed a cotton swab in saliva in the floor of the oral cavity for 10 s. Participants were not permitted to eat or drink between waking and saliva collection. Bacteria were enumerated using a simple instrument for the measurement of the number of oral bacteria developed by Hamada *et al.*[9] and Kikutani *et al.*,[10] and counts were stratified into the following categories (colony-forming units [CFU]/mL): $<10^{6.5}$; $\geq 10^{6.5}$ to $<10^{7}$; $\geq 10^{7}$ to $<10^{7.5}$; $\geq 10^{7.5}$ to $<10^{8}$; $\geq 10^{8}$ to $<10^{8.5}$; $\geq 10^{8.5}$ to $<10^{9}$; and $\geq 10^{9}$.

Comorbidities

Comorbidities in participants were determined from medical records.

Swallowing disorders

Swallowing disorders were defined as being present in cases where choking or accidental aspiration were present, as well as in cases exhibiting a gargling sound on auscultation of the neck region[11] after swallowing 3 mL of water.

Nutritional status

Nutritional status of participants was determined by calculating body mass index (BMI) from height and weight. BMI < 18.5 was considered to show undernourishment.

Xerostomia

The presence or absence of xerostomia was assessed according to the following categories reported by Kakinoki *et al.*: dry, mildly dry, wet (normal) and wet (high).[12] Dry and mildly dry categories indicate the presence of xerostomia.

Activities of daily living

Evaluation of activities of daily living was carried out using the Barthel Index 1.[13]

Survey of aspiration pneumonia

The follow-up period was 6 months, and onset of aspiration pneumonia during this period was assessed. Pneumonia was diagnosed by each participant's primary physician. Criteria for diagnosis of pneumonia were a new pulmonary infiltrate seen on a chest radiograph and one of the following features: cough, temperature greater than 37.5°C or subjective dyspnea.

Statistical analysis

The χ^2-test was used to assess the relationship between pneumonia onset and various factors, and to test the cut-off point for bacteria count with respect to pneumonia onset. In addition, onset and bacteria count were analyzed using multiple logistic regression analysis to identify statistically significant levels.

Statistical analysis was carried out using PASW Statistics 18 (IBM, Tokyo, Japan) with a 95% significance level.

Results

Onset of pneumonia

A total of 33 participants (4.8%; 5 men, 28 women; mean age 88.3 ± 7.4 years) developed pneumonia during the 6-month follow-up period. No differences in distribution as a result of sex or age were observed. The Barthel Index was significantly lower among participants who developed pneumonia (pneumonia group; 14.71 ± 24.65) than among those of who did not (non-pneumonia group; 33.46 ± 27.95; $P = 0.007$). The proportion of participants with malnourishment was greater in the pneumonia group (40.7%) than in the non-pneumonia group (31.4%; $P = 0.2$). Dysphagia was also significantly more common in the pneumonia group (56.3%) than in the non-pneumonia group (39.0%; $P = 0.04$). No significant differences were found between the two groups with respect to the incidence of comorbidities, with the exception of heart disease and dementia (Table 1).

Table 1 Pneumonia onset and baseline characteristics

	Pneumonia (+)	Pneumonia (–)	*P*-value
Total % of men	15.0	20.4	0.40
Age (years)	88.36 ± 7.47	86.63 ± 7.81	0.31
Barthel Index score	14.71 ± 24.65	33.46 ± 27.95	0.007
Nutritional status (% malnourished)	40.7	31.4	0.20
Presence of swallowing disorder (%)	56.3	39	0.04
Presence of xerostomia (%)	43.8	34.7	0.193
Presence of cerebrovascular disease (%)	39.3	47.9	0.242
Presence of ischemic heart disease (%)	42.9	22.3	0.02
Presence of hypertension (%)	46.4	38.9	0.271
Presence of diabetes mellitus (%)	10.7	15.36	0.353
Presence of dementia (%)	78.6	58.7	0.026

Data are expressed as mean ± standard deviation.

Table 2 Relationship between pneumonia onset and bacteria count

Bacteria count, log (CFU mL-1)	Pneumonia (+)	Pneumonia (–)	Total
<6.5	2	39	41
≥6.5–<7	1	29	30
≥7–<7.5	6	114	120
≥7.5–<8	5	218	223
≥8–<8.5	10	165	175
≥8.5–<9	7	70	77
≥9	2	23	25
Total	33	658	691

CFU, colony-forming unit.

Setting the cut-off point

Table 2 shows the relationship between pneumonia onset and bacteria count category. In order to identify an index for carrying out specialist oral care, the following oral bacteria count cut-off points were considered (CFU/mL): $\geq 10^{7.5}$, 10^{8}, $10^{8.5}$ and 10^{9}. The models with $\geq 10^{8}$ CFU/mL and $\geq 10^{8.5}$ CFU/mL as cut-off points showed significant differences in the incidence of pneumonia ($\geq 10^{8}$ CFU/mL: *RR* = 1.052, 95% CI 0.988–1.120, *P* = 0.041; $\geq 10^{8.5}$ CFU/mL: *RR* = 1.037, 95% CI 1.000–1.076, *P* = 0.029; Table 3).

Logistic regression analysis

A logistic regression model was used to examine whether an established cut-off value for oral bacteria count could be a factor in predicting pneumonia onset. The correlation matrix for the tested factors is shown in Table 4. As the Barthel Index showed a significant correlation with bacteria count, it was excluded from the logistic regression analysis to avoid multicollinearity. Oral bacteria count $\geq 10^{8.5}$ CFU/mL was an independent explanatory factor for pneumonia onset (*P* = 0.012, *RR* = 3.759, 95% CI 1.332–10.611; Table 5).

Discussion

Aspiration pneumonia develops when pathogenic bacteria are drawn from the oral cavity or pharynx into the trachea during respiration.[1] Aspiration of bacteria in oropharyngeal secretions is considered to be a major risk factor for nosocomial pneumonia in older adults;[14,15] therefore, poor oral hygiene is thought to be an important cause of pneumonia. Oral bacteria count can be reduced through specialist oral care.[3,4] In a random intervention study at a nursing home, the incidence of pneumonia was reduced through oral care intervention.[5,7] Abe *et al.* identified a relationship between saliva bacteria count and visual evaluation of tongue coating and dental plaque, as well as a relationship between the results of visual evaluation and pneumonia onset.[16,17] It has been reported that, as a result of the wide varieties of weak pathogenic bacteria that can cause aspiration pneumonia, bacteria count is a more important indicator than bacterial type or species in the prevention of aspiration pneumonia.[18] As bacteria count is likely to be a useful parameter for evaluating the risk of aspiration pneumonia, saliva bacteria count was used as an indicator of the oral environment in the present study.

The mechanism of aspiration pneumonia onset involves not only bacteria as the source of infection, but also includes aspiration as the route of infection and undernourishment as a factor in the status of the infected host.[19] Specifically, swallowing function plays a significant role in the onset of aspiration pneumonia,[20,21] and the need to evaluate swallowing function in the prevention of aspiration pneumonia has often been reported. Teramoto *et al.* described the "swallowing

Table 3 Relationship between pneumonia onset and cut-off point

	Bacteria count (log)	Pneumonia (+)	Pneumonia (–)	*P*-value	RR	Lower	Upper
Model 1	≥7.5	72.7%	72.3%	0.57	1.001	0.964	1.039
Model 2	≥8	57.6%	39.2%	0.029	1.037	1	1.076
Model 3	≥8.5	27.3%	14.1%	0.041	1.052	0.988	1.12
Model 4	≥9	6.1%	3.5%	0.338	1.036	0.922	1.165

RR, relative risk.

Table 4 Correlation matrix for tested factors

		Bacteria count category	Barthel Index	Age	Nutritional status	Swallowing disorder
Bacteria count category	Correlation	1.000	–0.146	–0.019	–0.069	–0.035
	P-value		0.001	0.676	0.093	0.369
Barthel Index	Correlation	–0.146	1.000	–0.125	0.167	–0.360
	P-value	0.001		0.009	0.000	0.000
Age	Correlation	–0.019	–0.125	1.000	0.003	–0.037
	P-value	0.676	0.009		0.948	0.421
Nutritional status	Correlation	–0.069	0.167	0.003	1.000	–0.112
	P-value	0.093	0.000	0.948		0.006
Swallowing disorder	Correlation	–0.035	–0.360	–0.037	–0.112	1.000
	P-value	0.369	0.000	0.421	0.006	

Table 5 Logistic regression analysis of independent predictors for pneumonia onset

	B	SE	*P*-value	Relative risk (95% confidence interval)
Sex (reference, male)	–0.288	0.672	0.688	0.750 0.201–2.800
Age	–0.020	0.034	0.552	0.980 0.980–1.047
Nutritional status (reference, malnourished)	0.211	0.520	0.685	1.235 0.445–3.424
Swallowing disorder (reference, presence)	–0.362	0.492	0.462	0.696 0.265–1.827
Bacteria count category (reference, <log 8.5)	1.324	0.529	0.012	3.759 1.322–10.611

provocation test" and the "simple swallowing provocation test" as effective methods for testing swallowing function in the prediction of aspiration pneumonia onset.[22] Poor nutritional status is associated with reduced immune function, and has been identified as a cause of various infectious diseases in older adults.[23,24]

Few reports on the relationship between pneumonia onset and oral bacteria have taken swallowing function and nutritional status into account, and these studies were limited to univariate analysis[25] or the addition of variables, such as the presence of periodontal disease or tooth decay and the use of artificial teeth.[19,26] The present study included swallowing function and nutritional status in the evaluation of pneumonia onset risk, and used multivariate analysis to determine a cut-off point at which oral bacteria count alone increases the risk of pneumonia.

A limitation of the present study was the use of a prospective cohort. Future studies should include oral care interventions in older adults with various oral bacteria counts in order to investigate whether reducing the oral bacteria count to a set level is effective in reducing the incidence of pneumonia. We set the observation period for 6 months in the present study. The reason why the follow-up period was 6 months in the present study was that the previous study reported that oral care intervention for approximately 6 months was required for significantly decreasing the number of oropharyngeal bacteria.[27] In this regard, in cases of prolongation of oral care intervention, there is a possibility of producing different results.

In the present study, pneumonia onset was observed for all bacteria count categories, suggesting that controlling oral bacteria might not completely prevent

pneumonia onset; however, the presence of oral bacteria in saliva at a level of $10^{8.5}$ CFU/mL or higher in an older adult was identified as a risk factor for pneumonia onset in the present study.

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Disclosure statement

The authors declare no conflict of interest.

References

1 Pierce AK, Sanford JP. Aerobic gram negative bacillary pneumonia. *Am Rev Respir Dis* 1974; **110**: 647–658.
2 Sumi Y, Miura H, Nagaya M, Michiwaki Y, Uematsu H. Colonisation on the tongue surface by respiratory pathogens in residents of a nursing home – a pilot study. *Gerodontology* 2006; **23**: 55–59.
3 Hirota K, Yoneyama T, Ota M, Hashimoto K, Miyake Y. Pharyngeal bacteria and professional oral health care in elderly people. *Nippon Ronen Igakkai Zasshi* 1997; **34**: 125–129. (In Japanese.)
4 Ishikawa A, Yoneyama T, Hirota K, Miyake Y, Miyatake K. Professional oral health care reduces the number of oropharyngeal bacteria. *J Dent Res* 2008; **87**: 594–598.
5 Adachi M, Ishihara K, Abe S, Okuda K, Ishikawa T. Effect of professional oral health care on the elderly living in nursing homes. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2002; **94**: 191–195.
6 Yoneyama T, Yoshida M, Matsui T, Sasaki H. Oral care and pneumonia. Oral Care Working Group. *Lancet* 1999; **354**: 515.
7 Yoneyama T, Yoshida M, Ohrui T *et al.* Oral Care Working Group. Oral care reduces pneumonia in older patients in nursing homes. *J Am Geriatr Soc* 2002; **50**: 430–433.
8 Terpenning MS, Taylor GW, Lopatin DE, Kerr CK, Dominguez BL, Loesche WJ. Aspiration pneumonia: dental and oral risk factors in an older veteran population. *J Am Geriat Soc* 2001; **49**: 557–563.
9 Hamada R, Suehiro J, Nakano M, Kikutani T. Development of rapid oral bacteria detection apparatus based on dielectrophoretic impedance measurement method. *IET Nanobiotechnol* 2011; **5**: 25–31.
10 Kikutani T, Tamura F, Takahashi Y, Konishi K, Hamada R. A novel rapid oral bacteria detection apparatus for effective oral care to prevent pneumonia. *Gerodontology* 2012 (Jun); **29** (2): e560–e565. doi: 10.1111/j.1741-2358.2011.00517.x.
11 Takahashi K, Groher ME, Michi K. Methodology for detecting swallowing sounds. *Dysphagia* 1994; **9**: 54–62.
12 Kakinoki Y, Nishihara T, Arita M, Shibuya K, Ishikawa M. Usefulness of new wetness tester for diagnosis of dry mouth in disabled patients. *Gerodontology* 2004; **21**: 229–231.
13 Mahoney FI, Barthel DW. Functional evaluation: the Barthel index. *Md State Med J* 1965; **14**: 61–65.
14 Johanson WG, Pierce AK, Sanford JP, Thomas GD. Nosocomial infections with gram-negative bacilli: the significance of colonization of the respiratory tract. *Ann Intern Med* 1972; **77**: 701–706.
15 Johanson WG, Harris GD. Aspiration pneumonia, anaerobic infection and lung abscess. *Med Clin North Am* 1980; **64**: 385–394.
16 Abe S, Ishihara K, Adachi M, Sasaki H, Tanaka K, Okuda K. Professional oral care reduces influenza infection in elderly. *Arch Gerontol Geriatr* 2006; **43**: 157–164.
17 Abe S, Ishihara K, Adachi M, Okuda K. Tongue-coating as risk indicator for aspiration pneumonia in edentate elderly. *Arch Gerontol Geriatr* 2008; **47**: 267–275.
18 Inglis TJ, Sherratt MJ, Sproat LJ, Gibson JS, Hawkey PM. Gastroduodenal dysfunction and bacterial colonisation of the ventilated lung. *Lancet* 1993; **341**: 911–913.
19 Langmore SE, Terpenning MS, Schork A *et al.* Predictors of aspiration pneumonia: how important is dysphagia? *Dysphagia* 1998; **13**: 69–81.
20 Cabre M, Serra-Prats M, Palpmera E, Almirall J, Pallares R. Prevalence and prognostic implications of dysphagia in elderly patients with pneumonia. *Age Ageing* 2010; **39**: 39–45.
21 van der Maarel-Wierink CD, Vanobbergen JN, Bronkhorst EM, Schols JM, de Baat C. Meta-analysis of dysphagia and aspiration pneumonia in frail elders. *J Dent Res* 2011; **90**: 1398–1404. doi: 10.1177/0022034511422909.
22 Teramoto S, Fukuchi F. Detection of aspiration and swallowing disorder in older stroke patients: simple swallowing provocation test versus water swallowing test. *Arch Phys Med Rehabil* 2000; **81**: 1517–1519.
23 Akner G, Cederholm T. Treatment of protein-energy malnutrition in chronic nonmalignant disorders. *Am J Clin Nutr* 2001; **74**: 6–24.
24 Margetts BM, Thomoson RL, Elia M, Jackson AA. Prevalence of risk of undernutrition is associated with poor health status in older people in the UK. *Eur J Clin Nutr* 2003; **57**: 69–74.
25 Scannapieco FA, Papandonatos GD, Dunford RG. Associations between oral conditions and respiratory disease in a national sample survey population. *Ann Periodontol* 1998; **3**: 251–256.
26 Terpenning M, Shay K. Oral health is cost-effective to maintain but costly to ignore. *J Am Geriatr Soc* 2002; **50**: 584–585.
27 Ishikawa A, Yoneyama T, Hirota K, Miyake Y, Miyatake K. Professional oral health care reduces the number of oropharyngeal bacteria. *J Dent Res* 2008; **87**: 594–598.

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Case Report

Management of Lacerated and Swollen Tongue after Convulsive Seizure with a Mouth Protector: Interprofessional Collaboration Including Dentists in Intensive Care

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We encountered a 74-year-old male patient with tongue laceration after convulsive seizures under intensive care. The tongue showed severe swelling, and the right ventral surface had been lacerated by his isolated and pointed right lower canine. Our university hospital has established a perioperative management center, and is promoting interprofessional collaboration, including dentists, in perioperative management. Dentists collaborating in the perioperative management center took dental impressions, with the support of anesthesiologists who opened the patient's jaw under propofol sedation, to produce a mouth protector. By raising the patient's bite, the completed mouth protector prevented the isolated tooth from contacting the tongue and protected the lacerated wound. Use of the mouth protector prevented the lacerated tongue from coming into contact with the pointed tooth, and the tongue healed gradually. These findings underscore that interprofessional collaboration including dentists can improve the quality of medical care.

Key words: mouth protector, tongue laceration

Tongue laceration under anesthesia and/or sedation is a relatively uncommon complication, although it may occur in patients with disturbance of consciousness due to convulsive seizures. In such cases, interprofessional collaboration can improve the quality of medical care, particularly if dentists are among the professionals consulted. Dentists often use mouth splints or mouth guards in daily clinical practice, *e.g.*, in orthodontic therapy or to prevent dental injury in athletes [1, 2]. We considered that these devices could also be useful for successfully management of the lacerated tongue.

Here, we present a case of tongue laceration caused by convulsive seizures after cardiopulmonary resuscitation in a patient who received intensive care after laryngectomy and esophagectomy for esophageal cancer. The management of this case demonstrated how interprofessional collaboration can lead to better perioperative management.

Case Description

The patient was a 74-year-old man who underwent total laryngopharyngeal and esophageal resection, bilateral neck dissection, and reconstructive surgery

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of the pedicle jejunum for esophageal cancer. After surgery, he received intensive care. This patient developed disturbance of consciousness due to a convulsive seizure on postoperative day (POD) 17. Five days after recovery (POD 22), laceration of the ventral surface of the tongue was discovered by the intensive care unit (ICU) staff (Fig. 1A), and a consultation with the dentist in the Perioperative Management Center was made. Our university hospital has established a perioperative management center, and is promoting interprofessional collaboration with the inclusion of dentists in perioperative management. The dentist noted a severely swollen tongue, the right ventral surface had been lacerated mainly by the right lower canine, which was pointed and isolated without adjoining teeth. The dental staff developed a plan to manage the lacerated tongue with a mouth protector that would raise the bite on the right side, thereby making space for the swollen tongue on the left side and preventing further laceration from the isolated right canine. It is rare in dental treatment to raise the bite on only one side, while making space for the swollen tongue on the opposite side, as in this case (Fig. 1B).

To aid in taking a dental impression, the anesthesiologists sedated the patient with propofol, then assisted in holding his jaw open. The impression was used to produce a mouth protector at the Division of Dental Laboratory, Clinical Support Department, Okayama University Hospital. A 3-mm sheet of ethylene vinyl acetate copolymer (Dreve Dentamid GmbH, Unna, Germany) was vacuum-molded by Angel

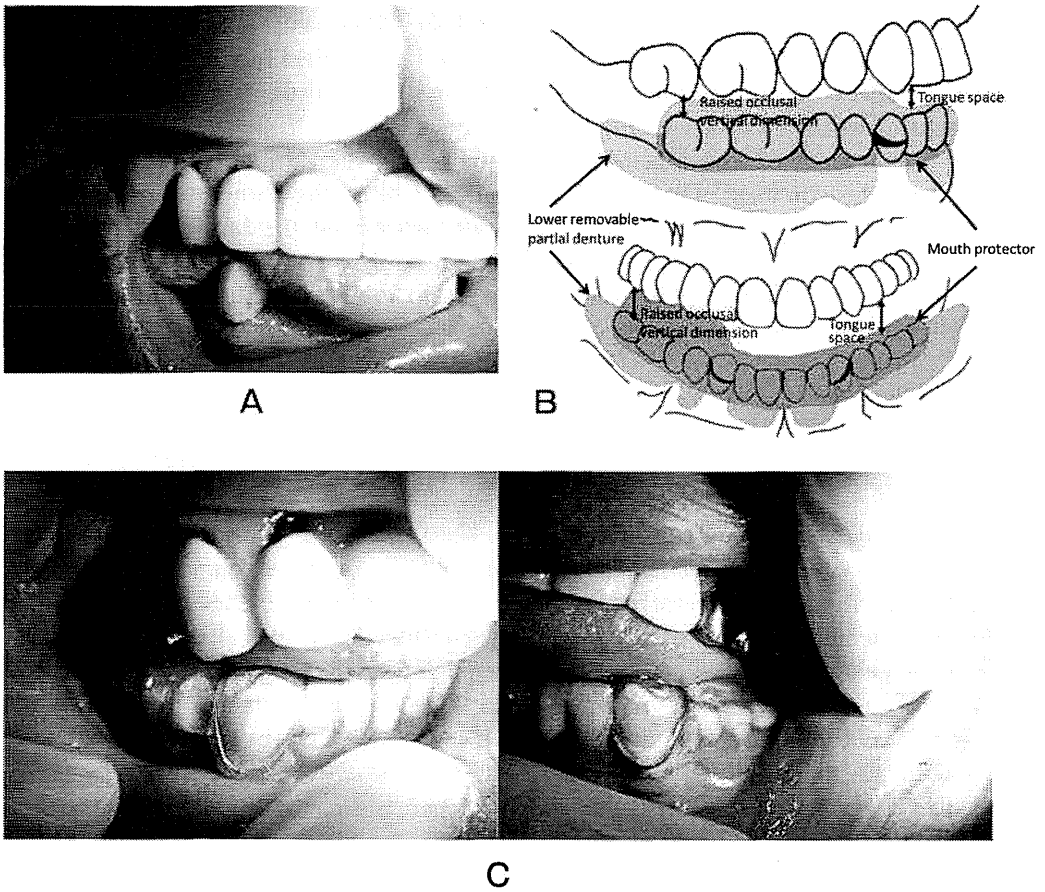

Fig. 1 A, Laceration of the right ventral surface of the swollen tongue. The lacerated swollen tongue frequently made contact with the pointed right lower canine; B, Detailed structure of the mouth protector. To manage the lacerated tongue, space was made for the swollen tongue. The mouth protector prevented biting by raising the bite; C, The inserted mouth protector. The swollen and lacerated tongue was protected from biting. The laceration healed gradually.

DUALFORMER (Daiei Dental Product Co., Ltd., Osaka, Japan) with a plaster figure made from a dental impression taken in the ICU. The detailed structure of the mouth protector is shown in Fig. 1B.

One day after taking the dental impression, the custom-made mouth protector was inserted, and the swollen and lacerated tongue was protected from further injury (Fig. 1C). Five days after inserting the custom-made mouth protector, healing of the tongue wound was observed, while swelling of the tongue remained. On the following day, swelling of the tongue subsided, and no further tongue laceration occurred.

Discussion

In this case, we produced a custom-made mouth protector for a patient after a convulsive seizure, which was designed to prevent aggravation of a tongue laceration. The possibility of recurrence was not high in this case, but the lacerated swollen tongue frequently made contact with the pointed lower canine. The bite-raising custom-made mouth protector was effective for creating a space for the swollen tongue, and for protecting the ventral surface of the tongue by covering the pointed tooth.

A recent review [2] described investigations on the use of mouth guards to protect athletes from dental injury, and classified these guards into 3 basic types based on their manufacture and use—*i.e.*, stock prefabricated, mouth-formed, and custom-made mouth guards. Stock prefabricated mouth guards can be made from either rubber or a plastic material. These are disposable and inexpensive, and do not require any special preparation. However, they fit loosely and their potential for modification is limited. Most mouth-formed mouth guards are constructed from a preformed thermoplastic shell of polyvinyl acetate polyethylene copolymer or polyvinyl chloride that is softened in warm water and then molded in the mouth by the user. However, mouth-formed mouth guards tend to be bulky. To overcome this drawback, custom-made mouth guards are individually made in a laboratory on a plaster figure poured from impressions of the wearer's mouth. Because these protectors are carefully modified by dental technicians in the laboratory, this method has the best operability, [3]. Custom-made mouth guards are thus a better option than the other types in current medical use, and should be the first choice when possible.

Similar approaches were reported previously. The effectiveness of mouth protectors to prevent self-induced injury in the ICU was reported [4, 5]. The oral self-injuries in these reports were similar to that in our patient. That is, these patients had cerebral disorders due to traumatic accidents, and bit or otherwise injured their own lips or tongue in the ICU [4, 5]. The impressions for their mouth protectors were taken after oral self-injury. The mouth protectors described by Wilkinson *et al.* [4] were similar to that reported here, although their subjects were relatively young and had almost all of their teeth. Older subjects may have advanced periodontitis, and thus may have an isolated tooth that is more likely to lacerate the tongue. Our case demonstrated the usefulness of a mouth protector to prevent further laceration of the tongue and promote wound healing. The mouth protector reported by Roberts (1995) [5] and Aristidis *et al.* (2010) [6], which was made of wire and acrylic, was more complicated than that described here, and was effective for long-term use because of its durability. In the present case we selected a simpler type of mouth protector for short-term use.

It would be difficult for a doctor or dentist working alone to make such a custom-made mouth protector. Doctors working alone would not be able to take an adequate impression, while dentists working alone would have difficulty in taking an impression in patients under intensive care management, who sometimes cannot open their mouth in response to instructions. However, with interprofessional collaboration between doctors and dentists, it is not difficult to take a dental impression under anesthesia.

Custom-made mouth protectors made by dentists will be more expensive than stock-prefabricated and mouth-formed mouth protectors [2]. However, the modification, application, and adequateness of custom-made mouth protectors are much better than those of the stock-prefabricated and mouth-formed types. There is no standardized treatment protocol for oral self-injury, so therapy must be individualized [7]. Custom-made mouth protectors could prevent further tongue laceration and promote healing, in addition to preventing bleeding and problems associated with infection. If infectious problems occur, the costs required for treatment would be much higher than the cost of a mouth protector. Therefore, we feel that the

application of a custom-made mouth protector for each patient would be more economical than subsequent treatment of complications that may arise without such intervention.

In conclusion, we managed a patient with tongue laceration after a convulsive seizure under intensive care following surgery using a mouth protector. The mouth protector contributed to wound healing of the lacerated swollen tongue by preventing contact with a pointed isolated tooth. Under such conditions, interprofessional collaboration including dentists can lead to better medical care.

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References

1. Henry WF and William RP: Contemporary Orthodontics. 5th Ed, Elsevier, Amsterdam (2013) pp472–523.
2. Sigurdsson A: Evidence-based Review of Prevention of Dental Injuries. Journal of Endodontics (2013) 39: S88–S93.
3. Stokes AN, Croft GC and Gee D: Comparison of laboratory and intraorally formed mouth protectors. Endod Dent Traumatol (1987) 3: 255–258.
4. Wilkinson PA and Wilkinson GR: The use of bite raiser in the intensive care unit. Anaesthesia (1992) 47: 772–773.
5. Roberts GJ: Use of a modified occlusal bite guard to prevent self-induced injury intensive care patients. Anaesthesia (1995) 50: 144–145.
6. Arhakis A, Topouzelis N, Kotsiomiti E and Kotsanos N: Effective treatment of self-injurious oral trauma in Lesch-Nyhan syndrome: a case report. Dent Traumatol (2010) 26: 496–500.
7. Limeres J1, Feijoo JF, Baluja F, Seoane JM, Diniz M and Diz P: Oral self-injury. An update. Dental Traumatology (2013) 29: 8–14.

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REVIEW ARTICLE

Basic oral care for hematology–oncology patients and hematopoietic stem cell transplantation recipients: a position paper from the joint task force of the Multinational Association of Supportive Care in Cancer/International Society of Oral Oncology (MASCC/ISOO) and the European Society for Blood and Marrow Transplantation (EBMT)

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Abstract
Purpose Hematology–oncology patients undergoing chemotherapy and hematopoietic stem cell transplantation (HSCT) recipients are at risk for oral complications which may cause significant morbidity and a potential risk of mortality. This emphasizes the importance of basic oral care prior to, during and following chemotherapy/HSCT. While scientific evidence is available to support some of the clinical practices used to manage the oral complications, expert opinion is needed to shape the current optimal protocols.
Methods This position paper was developed by members of the Oral Care Study Group, Multinational Association of Supportive Care in Cancer/International Society of Oral Oncology (MASCC/ISOO) and the European Society for Blood and Marrow Transplantation (EBMT) in attempt to provide guidance to the health care providers managing these patient populations.
Results The protocol on basic oral care outlined in this position paper is presented based on the following principles: prevention of infections, pain control, maintaining oral function, the interplay with managing oral complications of cancer treatment and improving quality of life.
Conclusion Using these fundamental elements, we developed a protocol to assist the health care provider and present a practical approach for basic oral care. Research is warranted to provide robust scientific evidence and to enhance this clinical protocol.

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Introduction

Hematology–oncology patients and patients undergoing hematopoietic stem cell transplantation (HSCT) are a unique cancer patient population. The main characteristic of this patient population is that they experience myelosuppression and immunosuppression due to their disease, the cancer therapy or both and immune-mediated outcomes in survivorship. Frequently, all blood lineages are affected resulting in neutropenia, thrombocytopenia and anemia.

This damage to the blood cells and immunosuppression result in a common profile of oral complications that include

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infections, bleeding and anemia-related oral manifestations (75). Furthermore, direct and indirect effects of cytotoxic therapies to oral tissues lead to a series of additional complications. For example, mucositis, dry mouth and dysgeusia are frequently observed in these patients (Table 1). Oral complications differ in their timing and duration with some referred as early complications, while some develop later following cancer treatment presenting survivorship issues.

Oral complications in these patient populations are common and estimated to affect 80 % of patients [1–4]. These oral complications have a significant impact on the patient's oral function, including the basic need to eat, drink or speak. Pain is also often associated with these oral complications and may lead to increased need for systemic narcotics, increased length of stay at hospital and an increased risk for life-threatening systemic infections [5]. All these sequelae may lead to impaired health-related quality of life (QoL) adversely affecting the patient and his or her family. Some patients have rated oral mucositis as the most distressing aspect of anti-cancer treatment [6]. Therefore, it is well-recognized that attempts should be made to prevent oral complications, ease the patient's pain and minimize late consequences.

Several oral care guidelines have been published in an attempt to assist the clinician [7–14]. However, the clinical practice of oral care varies between and within centers and may not always be optimal. There are various reasons for this, including the availability of oral/dental care services in cancer centers, difficulty with implementing guidelines into daily practice, lack of consistency between various guidelines and preference of traditional views over scientific evidence [15].

The aim of this position paper is to clearly state the recommendation of the Multinational Association of Supportive Care in Cancer/International Society of Oral Oncology (MASCC/ISOO) and the European Society for Blood and Marrow Transplantation (EBMT) for basic oral care in patients with hematologic cancer and those undergoing HSCT.

This position paper does not intend to detail the specific management protocols of various oral complications related to the underlying disease or related to the cancer treatment. An overview of such oral complications is included in the

Table 1 Oral complications in hematology–oncology patients and HSCT recipients

Category	Tissue	Oral complication	Early presentation	Late presentation
Tissue-specific manifestations	Mucosa	Mucositis	+	+
		Atrophy and burning, paleness (anemia)	+	
		Neutropenic ulcer	+	
		Lichenoid, erythema and ulcers (cGVHD)		+
		Pyogenic granuloma		+
	Salivary glands	Salivary gland hypofunction	+	+
		Sialadenitis	+	+
		Mucocele (cGVHD)		+
	Musculo-skeletal	Loss of elasticity, reduced range of motion and limited mouth opening (i.e. scleroderma-like manifestations) (cGVHD)		+
		Drug-induced osteonecrosis of the jaw		+
		Temporomandibular disorders		+
	Sensory disturbances	Dysgeusia	+	+
		Neuropathy		+
		Tooth hypersensitivity		+
	Teeth and gingivae	Increased dental demineralization and caries		+
		Gingival enlargement		+
		Desquamative gingivitis (cGVHD)		+
		Acute periodontal infections (symptomatic)	+	+
		Pre-existent chronic periodontal infections (asymptomatic)	+	+
Non-tissue-specific manifestations		Bleeding	+	+
		Infection—bacterial, viral, fungal	+	+
		Squamous cell carcinoma		+
		Post-transplantation lymphoproliferative disorder		+
		Developmental disturbances of teeth and craniofacial growth in pediatric patients		+

HSCT hematopoietic stem cell transplantation, *cGVHD* chronic graft versus host disease