Evaluation of Factors Associated with Tongue Coating Status in Elderly with Care Needs

Koichiro Ogami, Takayuki Ueda, Masahiro Ryu, Sayaka Tajima and Kaoru Sakurai

Department of Removable Prosthodontics and Gerodontology, Tokyo Dental College, 2-9-18 Kanda-Misakicho, Chiyoda-ku, Tokyo 101-0061, Japan

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Abstract

The tongue surface in older people requiring nursing care is often coated with a layer believed to comprise, keratinized products of degeneration, food residue, bacteria, and leukocytes attached to the tongue papillae. Which factors affect the status of this tongue coating remain to be elucidated, however. The purpose of this study was to evaluate factors related to tongue coating status in older people requiring nursing care. The study participants comprised 41 individuals admitted to special nursing homes for the elderly. After undergoing tooth brushing and tongue cleaning by the facility staff, the participants were required to refrain from oral cleaning until evaluation of tongue coating status, which was performed just after lunch. The moisture level of the tongue surface was measured and total number of oral microbes determined. Food type, care level, and sex were determined by a questionnaire given by the attending nurses. Correlations between the tongue coating status and various factors were analyzed using Spearman's rank correlation coefficient. The participants were divided into 2 groups according to the median value of the tongue coating status. Factors related to tongue coating were analyzed using binomial logistic regression analysis ($\alpha=0.05$). Tongue coating status showed a significant correlation with the total number of oral microbes on the tongue surface ($r_s=0.449$, $p=0.003$), type of food ($r_s=0.388$, $p=0.012$), and care level ($r_s=-0.308$, $p=0.050$). Logistic regression analysis revealed that the food type of the side dish significantly affected tongue coating status. These results showed a correlation between tongue coating status and type of food of the side dish in older people requiring nursing care.

Key words: Tongue coating — Food style — Oral hygiene — Nursing care — Aged

Introduction

Pneumonia is a major cause of death in older people, and aspiration pneumonia, in particular, occupies a high percentage of

lethal pneumonia. Aspiration pneumonia is caused by silent aspiration of saliva containing resident microorganisms of the oral cavity and pharynx. In older people, in particular, the risk of aspiration pneumonia is believed

to increase as a result of decreased secretion of saliva and inadequate tooth brushing due to a decline motor function in the fingers. Moreover, the state of oral hygiene is likely to deteriorate in older people with a low score for activities of daily living. Plaque contains a high percentage of the bacteria responsible for pneumonia, with a buildup of this reservoir increasing the risk of aspiration pneumonia. Periodontal pathogens, a cause of aspiration pneumonia, were detected frequently on the tongue surface under edentulous conditions¹⁶⁾. Moreover, the tongue surface is often coated with tongue coating in older people requiring nursing care.

This coating resembles dental plaque, and is believed to comprise keratinized products of degeneration, food residue, bacteria, and leukocytes attached to the tongue papillae. It is significant, because it builds up on the mucosa over a wide area of the oral cavity, including the dorsum of the tongue, from its center to the base, and is observed regardless of age or state of dental caries or periodontal disease^{2,5,15)}. Serving as a reservoir for microorganisms, it harbors more than 700 species, and its status has been demonstrated to show a correlation with the total number of anaerobic bacteria on the tongue surface and in the saliva of edentulous people conditions¹⁶⁾.

In older people, the most common type of pneumonia is aspiration pneumonia, which is induced by a decline in swallowing function and the cough and swallowing reflexes. Thus, aspiration pneumonia can be caused by silent aspiration of saliva containing microorganisms present in the oral cavity and pharynx. In a 2-year follow-up study of 400 nursing home residents, the incidence of pneumonia was 11% in those receiving oral hygiene intervention by dentists and dental hygienists and 19% in those who were not, suggesting that oral hygiene care contributes to prevention of pneumonia^{17,18)}. Factors affecting tongue coating status remain to be elucidated, however. The purpose of the present study was to evaluate factors related to tongue coating status in older people with care needs.

Materials and Methods

The study participants comprised nursing home residents aged 65 years or above. All were receiving professional oral cleaning. Most had removable dentures, but some of them did not use them. Acute oral problems required exclusion from the study. The participants were instructed to refrain from cleaning of the oral cavity following an initial round of tooth brushing and tongue cleaning provided by care givers after breakfast. Tongue coating status was then evaluated after lunch by the method of Shimizu *et al* (Fig. 1)¹²⁾. Moisture level on the tongue surface, the total number of oral microbes on the tongue surface, type of food, care level, and sex were evaluated as items related to tongue coating status (Table 1). The moisture level on the tongue surface was measured using an oral moisture meter (Mucus®; Life, Saitama, Japan). To perform these measurements, the sensor of this device was brought into vertical contact with the surface of the tongue at 10 mm from its tip. Each measurement was performed 3 times and the median value used for the analysis. It is difficult to assess dryness of the mouth in older people with impaired comprehension by conventional methods such as the chewing gum or Saxon test, which require cooperation. The moisture meter used here, however, allows measurements to be made in only approximately 2 seconds, making it suitable for use in such an elderly population, as has already been reported elsewhere¹¹⁾. The total number of microbes on the tongue surface was measured using a rapid oral bacteria detection device (Bacterial Counter DU-AA01NP-H; Panasonic Health Care, Tokyo, Japan). This device was developed for a technique known as DiElectroPhoretic Impedance Measurement (DEPIM), which is based on dielectrophoresis and the measurement of impedance. Samples were collected using a sterilized swab and a constant-pressure sampler, which prevents exertion of pressure exceeding 20 gf on sampling. Before sampling, preliminary moistening was performed by spraying the tongue surface

Tongue Coating Record (TCR)

Name : _____

Date : _____

Score 0 : Tongue coating not visible.

Score 1 : Tongue coating thin,
papillae of tongue visible.

Score 2 : Tongue coating very thick,
papillae of tongue not visible.

$$\text{Tongue Coating Index (TCI)} = \frac{\text{Total score (0-18)}}{18} \times 100 = \text{_____} \%$$

Fig. 1 Tongue Coating Record (TCR) form and method of calculation for Tongue Coating Index (TCI)

Table 1 Correlation between tongue coating status and each factor

Factors	Mean	SD	r_s	p
Moisture level of the tongue	25.5	6.7	0.006	0.968
Total anaerobic bacteria on tongue surface	2.01×10^7	2.0×10^7	0.449	0.003
Type of food for grain dish	Tube feeding: 3 people Paste diet: 8 people Whole porridge: 0 people Soft rice: 11 people Regular diet: 19 people		0.286	0.07
Type of food for side dish	Jelly diet: 4 people Paste diet: 4 people Little grainy paste diet: 3 people Chopped diet: 22 people Regular diet: 8 people		0.388	0.012
Various levels of care	Requiring support: 3 people Requiring long-term care1: 1 person Requiring long-term care2: 5 people Requiring long-term care3: 6 people Requiring long-term care4: 14 people Requiring long-term care5: 12 people		-0.308	0.05
Sex	5 men, 36 women		-0.128	0.424

Fig. 2 Number of participants and tongue coating status

with approximately 2 ml of water. The sterilized swabs were dipped in tap water in advance. Samples were obtained by swabbing anteriorly 5 times, commencing from the anterior area of the terminal sulcus on the median groove of the tongue. After sampling, the used swab was inserted into a disposable cup containing pure water and the total number of oral microbes in the sample measured. As this device is portable, measurement can also be performed at the bedside in approximately 2 minutes, which is shorter than the time required for measurement by the culturing method. Therefore, it is considered suitable for sampling in individuals who cannot be easily transported due to care needs, such as those targeted in the present study. In addition, this method was adopted here as it has shown high reliability, as indicated by strong correlations with oral bacterial and microbial counts obtained by culturing and fluorescent microscopic methods³⁾. Food type, care level, and sex were determined by a questionnaire given by attending nurses. An ordinal scale was used based on the food type of the grain dish, the food type of the side dish, and level of care. The food type of the grain dish (staple dish) was classified as tube feeding (=1), paste (=2), gruel (rice: water=1:5) (=3), soft (=4), or regular (=5); that of the side dish was similarly classified as jelly as supplementary food (=1), paste (=2), small-grain

Table 2 Statistical analysis of tongue coating status

Mean	SD	Median	Range
43.7	16.8	44.4	5.6–77.8

paste (=3), chopped (=4), or regular (=5). Care needs were graded as support (=1), level 1 (=2), level 2 (=3), level 3 (=4), level 4 (=5), or level 5 (=6). Correlations between tongue coating status and each factor were analyzed using Spearman's rank correlation coefficient. The participants were divided into 2 groups according to the median value of the tongue coating index score. Binomial logistic regression analysis (simultaneous entry) was performed using group as the objective variable and factors related to each group as explanatory variables ($\alpha=0.05$). The statistical software used was IBM SPSS statistics 22.0 (International Business Machines Corporation, Chicago, IL, USA). This study was approved by the Ethics Committee of Tokyo Dental College (approval no. 453). Written informed consent was obtained from each participant prior to commencement of the study.

Results

A total of 41 individuals were enrolled in the study (mean age, 87.7 ± 7.7 years; 5 men and 36 women). Tongue coating status showed a mean value of 43.7 ± 16.8 and median value of 44.4 (5.6–77.8) (Fig. 2, Table 2). Among all participants, 15 showed a value of less than 44.4, while 26 showed a value of 44.4 or above. Table 1 shows the correlations between tongue coating status and the factors evaluated. Tongue coating status showed a correlation with the total number of microbes on the tongue surface ($r_s=0.449$, $p=0.003$), food type of the side dish ($r_s=0.388$, $p=0.012$), and care level ($r_s=-0.308$, $p=0.050$). The logistic regression analysis revealed a significant correlation with the

Table 3 Factors associated with tongue coating status

Factors	Odds ratio	95%CI	p value
Moisture level of the tongue	1.035	0.903–1.186	0.621
Total anaerobic bacteria on tongue surface	1	1.000–1.000	0.075
Type of food for grain dish	0.332	0.074–1.496	0.151
Type of food for side dish	9.599	1.009–91.340	0.049
Various levels of care	0.702	0.325–1.516	0.368
Sex	0.066	0.003–1.645	0.098

food type of the side dish (odds ratio, 9.599; 95%CI, 1.009–91.340; $p = 0.049$) (Table 3).

Discussion

The results of the present study revealed a correlation between tongue coating status and the total number of microbes on the tongue surface ($r_s = 0.449$, $p = 0.003$). The mean number of microbes on the tongue surface was 2.0×10^7 CFU/ml, which was higher than that previously reported in healthy older people¹⁰. It has become clear that the higher the tongue coating status, the greater the total number of microbes on the tongue surface¹², and that tongue coating status affects the number of anaerobic bacteria in saliva⁹. Furthermore, the profile of the microbial flora on the tongue surface has been reported to be similar to that in saliva^{4,10}. These findings suggest that the microbial count in the saliva observed in the present study is likely to be higher than that in healthy older people. Here, the mean moisture level of the tongue surface was less than 27, which is considered a criterion for dry mouth³, which was indeed present in many of the participants. The total number of microbes on the tongue surface showed an increase with an increase in the tongue coating index score, which is in agreement with the results of earlier studies¹⁴. Tongue coating status showed a correlation with the food type of the side dish ($r_s = 0.388$, $p = 0.012$). Jelly and paste have low adhesiveness and high aggregability, which means

bolus formation is easier with this type of food. On the other hand, paste is more adhesive than small-grain paste, and chopped food is more likely to be retained in the oral cavity, which may influence tongue coating status. The dorsum of the tongue is covered by 4 types of lingual papillae: filiform, fungiform, foliate, and circumvallate⁶. Because of these lingual papillae, the dorsum of the tongue shows fine convexities and concavities compared with other areas of the oral mucosa, and this contributes to the deposition of filth and proliferation of microorganisms in deep areas, which present anaerobic conditions.

The amount of time required before the bolus is transferred to the pharynx from the oral cavity is affected by the physical properties of the food being consumed. As the hardness of the food increases, compression grinding gives way to biting, thus prolonging retention time¹. This suggests that the chopped food and small-grain paste used in the present study would also have affected tongue coating status. Here, grain showed no correlation with the tongue coating index score, possibly because consumption of grain was lower than that of the side dishes.

Tongue coating status showed a correlation with care level ($r_s = -0.308$, $p = 0.050$). Assistance is necessary in maintaining oral hygiene in older people with care needs, as they have difficulty in performing such cleaning by themselves. Because of problems such as a shortage of care givers, however, it is difficult to provide sufficient oral cleaning frequently enough and for a long enough duration⁷.

Therefore, when an elderly person is considered to have need for only partial assistance or support, they are considered to be capable of maintaining oral hygiene by themselves. This is not always the case, however, and this can result in an increase in the tongue coating due to inadequate cleaning.

The results of the present logistic regression analysis revealed a correlation between tongue coating status and type of food in the side dish. One study reported a low level of autonomic nerve activity in individuals on a jelly diet, which can be swallowed without mastication or grinding, but a high level in individuals on a soft diet such as gruel, mashed potatoes, or well-cooked carrot⁸⁾. Another study reported lower tongue pressure in elderly people eating a soft food as their grain dish as well as their side dish than in those eating a soft food as their grain dish and ordinary food as part of their side dish¹³⁾. Taken together, these findings show that side dishes requiring tongue movement will compensate to some extent for an absence of foods that require chewing, and thus help maintain oral function, including oral hygiene.

As populations age worldwide, the number of older people requiring nursing care is likely to increase. Given this trend, the importance of prevention of aspiration pneumonia, a major cause of death in older people, is expected to increase. Care givers are not qualified to judge which type of food is best suited to the elderly person in their care. This means that older people are sometimes given an unnecessarily soft diet, which may result in a deterioration in mastication, swallowing, oral function, and oral hygiene, which in turn may lead to anorexia. Many organs and tissues are involved in the stomatognathic system, which is responsible for mastication. Mastication is considered confer many advantages, in addition to nutritional intake: it stimulates sense of taste; increases saliva secretion; improves self-cleaning of the mouth; and increases cerebral blood flow. The results of the present study support these favorable effects of mastication. Dentists and dental hygienists are encouraged to individually

assess mastication ability and determine the appropriate food type in promoting mastication.

Conclusion

The present results demonstrated a correlation between the status of the tongue coating and the type of food consumed in elderly individuals resident in a care home.

Conflict of Interest

The authors report no conflict of interest directly relevant to the content of this article.

References

- 1) Arai E, Yamada Y (1993) Effect of the texture of food on the masticatory process. *Jpn J Oral Biol* 35:312–322.
- 2) Hamada S, Slade HD (1980) Biology, immunology, and cariogenicity of *Streptococcus mutans*. *Microbiol Rev* 44:331–384.
- 3) Kikutani T, Tamura F, Takahashi Y, Konishi K, Hamada R (2012) A novel rapid oral bacteria detection apparatus for effective oral care to prevent pneumonia. *Gerodontology* 29: e560–e565.
- 4) Mager DL, Ximenez-Fyvie LA, Haffajee AD, Socransky SS (2003) Distribution of selected bacterial species on intraoral surfaces. *J Clin Periodontol* 30:644–654.
- 5) Nolte WA (1977) *Oral Microbiology*, pp.214–215, Mosby, Philadelphia.
- 6) Norton NS (2014) *Netter's Head and Neck Anatomy for Dentistry*, 2nd ed., pp.379–380, Saunders, Philadelphia.
- 7) Ogami K, Okada C, Tasaka A, Ogiwara T, Ueda T, Sakurai K (2010) Oral health care awareness of staffs in hospitals and nursing health care facilities for the elderly. *J J Gerodont* 25: 26–30.
- 8) Ohta M, Ueda T, Sakurai K (2017) Effect of chewing or compressing food on autonomic nervous activity in older adults. *Gerodontology* 34:434–440.
- 9) Ryu M, Ueda T, Saito T, Yasui M, Ishihara K, Sakurai K (2010) Oral environmental factors affecting number of microbes in saliva of com-

- plete denture wearers. *J Oral Rehabil* 37: 194–201.
- 10) Sachdeo A, Haffajee AD, Socransky SS (2008) Biofilms in the edentulous oral cavity. *J Prosthodont* 17:348–356.
 - 11) Saito M, Ono Y, Kitamura N, Yamaguchi M, Saito C (2008) A study of moisture content in oral mucosa in the elderly. Part I. Evaluating the precision of oral moisture checking devices. *Ann Jpn Prosthodont Soc* 23:90–96.
 - 12) Shimizu T, Ueda T, Sakurai K (2007) New method for evaluation of tongue-coating status. *J Oral Rehabil* 34:442–447.
 - 13) Tsuga K, Shimada M, Kuroda R, Hayashi R, Yoshikawa M, Sato K, Saito N, Yoshida M, Maeda Y, Kida O, Akagawa Y (2005) The relationship between tongue pressure and selected meal form of elderly people taking “Geriatric Soft Food”. *J J Dysphagia Rehabil* 9: 56–61.
 - 14) Ueno T, Tei K, Orui S, Nakagawa R, Yasumi N, Izumiyama Y, Totsuka Y (2000) A study on oral bacterial flora with relation to general health (I). The oral bacterial flora of elderly nursing home patients. *J J Gerodont* 14:265–269.
 - 15) Yaegaki K, Sanada K (1992) Biochemical and clinical factors influencing oral malodor in periodontal patients. *J Periodontol* 63: 783–789.
 - 16) Yasui M, Ryu M, Sakurai K, Ishihara K (2012) Colonisation of the oral cavity by periodontopathic bacteria in complete denture wearers. *Gerodontology* 29:494–502.
 - 17) Yoneyama T, Yoshida M, Horus T, Mukaiyama H, Okamoto H, Hoshiba K, Ihara S, Yanagisawa S, Ariumi S, Morita T, Mizuno Y, Ohsawa T, Akagawa Y, Hashimoto K, Sasaki H; Oral Care Working Group (2002) Oral care reduces pneumonia in older patients in nursing homes. *J Am Geriatr Soc* 50:430–433.
 - 18) Yoneyama T, Yoshida M, Matsui T, Sasaki H (1999) Oral care and pneumonia. *Oral Care Working Group. Lancet* 354:515.

Correspondence:

Dr. Koichiro Ogami
 Department of Removable
 Prosthodontics and Gerodontology,
 Tokyo Dental College,
 2-9-18 Kanda-Misakicho, Chiyoda-ku,
 Tokyo 101-0061, Japan
 Tel: +81-3-6380-9201,
 Fax: +81-43-270-3935
 E-mail: ogami@tdc.ac.jp