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New method for evaluation of tongue-coating status

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SUMMARY The purpose of this study was to determine the viability of Tongue Coating Index, which is a new method for evaluating tongue-coating status. To determine the reliability and reproducibility of our new evaluation criteria (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), 10 observers evaluated 20 photographs of tongues. Each tongue surface was divided into nine sections. Observers evaluated each section according to our new criteria and each score for tongue-coating status was recorded in the pertinent section of the Tongue Coating Record form. They repeated the same evaluation 2 weeks after the first evaluation. The relationship between the scores obtained and number of oral microorganisms was investigated in 50 edentulous patients. Tongue coating was collected from the tongue surface after evaluation of tongue-coating status. The total number of anaerobic bacteria and the number of *Candida* species were counted from the specimens collected. Interobserver agreement and intraobserver agreement were 0·66 and 0·80 by Cohen's kappa, respectively. No significant difference was observed in the number of *Candida* species among the three scores. The number of total anaerobic bacteria, however, was significantly different among the scores ($P < 0·05$). Therefore, we conclude that our method for evaluating tongue-coating status offers new criteria that are superior in reliability and reproducibility, and that also reflect the total number of anaerobic bacteria present on the dorsum of the tongue.

KEYWORDS: tongue coating, criteria, oral malodour, anaerobic bacteria, *Candida*

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Introduction

More than 500 bacterial species inhabit the oral cavity (1), and the tongue coating, in particular, provides a reservoir for oral microorganisms. There have been a number of reports, therefore, on the relationship between the tongue coating and oral microorganisms. Lee *et al.* (2) reported that oral malodour was caused by volatile sulphur compounds (VSC), including H_2S and CH_3SH, produced by such oral microorganisms. The tongue coating has also been shown to be a major source of VSC production (3, 4). Aspiration pneumonia is caused by a mixed infection brought on mainly by the anaerobic bacteria that inhabit the oral cavity and pharyngeal region (5). Therefore, a regime of oral health care which includes the removal of tongue coating has been shown to decrease the total number of microorganisms that are aspirated into the lower respiratory tract (6–8), and thus play an important role in the prevention of aspiration pneumonia (9, 10).

Evaluation of tongue-coating status is necessary in assessing the effect of oral health care and motivating patients to clean their tongues. There are several simple, visual methods for evaluating tongue-coating status based on observation of the coated area, thickness and/or discolouration. Miyazaki *et al.* (3) evaluated tongue-coating status visually based on coated area. Miyazaki *et al.* pioneered visual evaluation of tongue coating, and their method has been used in many other studies because of its simplicity (11). However, this method has no clear criteria by which to determine whether tongue coating is present or not. Kojima (12) visually evaluated tongue-coating status based on coated area and thickness. Although Kojima's method includes evaluation of

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thickness, it has no clear criteria for making such an evaluation. Being simple, these visual evaluation methods are useful. However, they are likely to generate inconsistent evaluations because of lack of clear evaluation criteria. We investigated the consistency of Miyazaki's method (13) and found that inter- and intra-observer agreements were 0·33 and 0·42 by kappa value; revealing low consistency. Gomez *et al.* (14) evaluated tongue-coating status visually based on discolouration and thickness. Gomez's method allows more accurate evaluation as it divides the tongue surface into a number of areas. In their results based on discoloration, the percentages of agreement between and within observers were 50% and 69%, respectively. Agreement between observers revealed low consistency, the same as with other methods, perhaps because it is difficult to accurately distinguish grades of discolouration, making evaluation problematic.

One precise method for evaluating tongue hygiene is to count the number of microorganisms on the dorsum of the tongue directly. However, this method is time-consuming as it involves cultivation, and involves complex procedures requiring various tools. Therefore, we need an evaluation method that is simple enough to allow routine clinical application, and that is reliable, reproducible, and capable of providing an accurate assessment of the number of microorganisms in the tongue coating.

We have developed a new method for evaluating tongue-coating status using the Tongue Coating Index (TCI), and have tested it in a clinical setting. The purpose of this study was to (i) determine the consistency of this method in terms of observational agreement and (ii) determine its accuracy in terms of agreement between score and number of microorganisms.

Materials and methods

Consistency of observation

To determine the reliability and reproducibility of our new evaluation criteria, 10 dentists were recruited from our department as observers. Twenty photographs of tongues were evaluated by these observers, with all observers evaluating the same material. The length and width of each tongue were trisected in each photograph. In total, the tongue surface was divided into nine sections. The new criteria for evaluation of tongue-coating status shown in Fig. 1 were explained to the

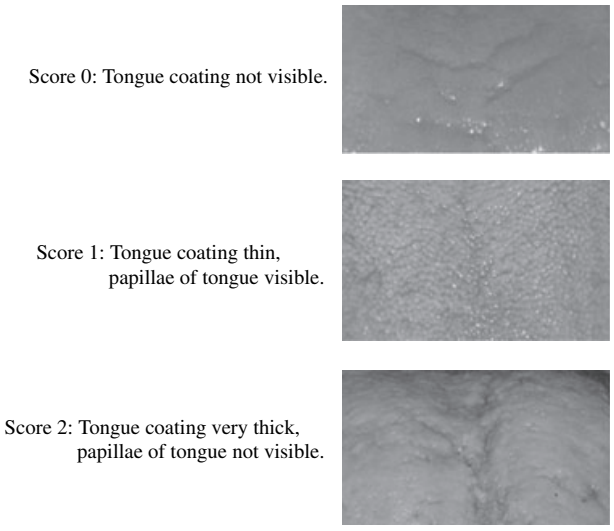

Fig. 1. Criteria for tongue-coating status and examples.

observers with the aid of photographs other than those to be used for the actual evaluation. For the experiment, photographs of 20 individual tongues were shown in random order, one at a time, to the observers. They then evaluated each of the nine sections according to our criteria, and each score for tongue-coating status was recorded in the pertinent section of the Tongue Coating Record (TCR) form (Fig. 2). If several different coating statuses were observed in one section, the score for the coating covering the larger area was employed as the final score. The observers individually evaluated each tongue, and were prohibited from re-examining or changing a score once it had been made. They repeated the evaluation of the same 20 tongues by the same procedure 2 weeks after the first evaluation. The order in which the tongues were shown in the second evaluation, however, was different from that in the first evaluation.

Agreement between score and number of microorganisms

We investigated the relationship between the scores obtained under the new evaluation criteria and number of microorganisms present in 50 edentulous home-care patients and outpatients attending the Department of Prosthodontic Dentistry at our facility (19 men and 31 women, mean age: 76 ± 10 years). None had taken antibiotics in the past 6 months, or used a tongue brush or mouthwash. One section of the tongue was randomly selected from the nine tongue sections for collection of tongue coating. The tongue coating status

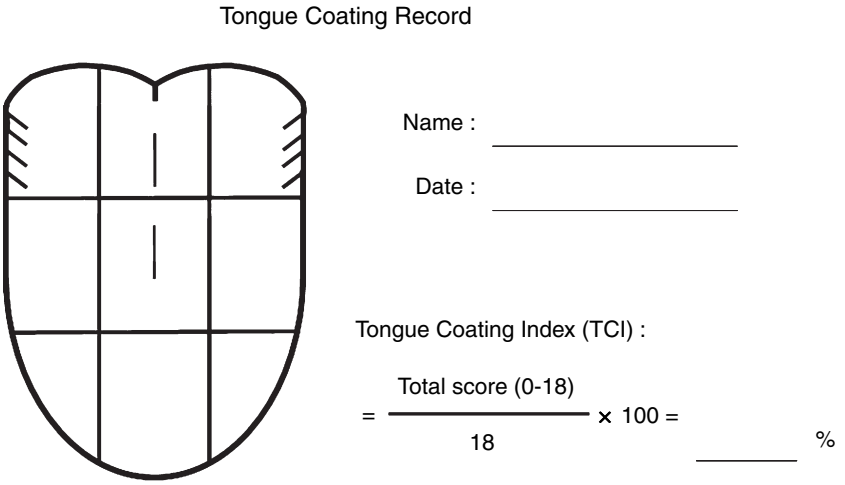

Fig. 2. Tongue Coating Record (TCR) form and method of calculation for Tongue Coating Index (TCI).

of each section was then evaluated according to our criteria by two examiners. When the two examiners made different evaluations, the evaluated section was excluded. To measure the number of microorganisms, tongue coating was collected from the tongue surface. Collection was performed by swabbing three times for 1 cm with a sterile cotton swab. One examiner collected all specimens. The collected samples were preserved in an anaerobic container at 4 °C and processed within 3 h. The sample was vigorously mixed in 1 mL of sterile saline, and then diluted to 10^{-1}–10^{-6}. An aliquot of 100 μL dilution was plated on culture media, and the total number of colony forming anaerobic bacteria after anaerobic culture on BHK agar medium at 37 °C for 5 days and number of colony forming *Candida* species were counted after aerobic culture on CHROM agar *Candida* medium at 25 °C for 48 h.

Statistical analysis

Reliability among the observers and reproducibility between the first and second evaluations were designated as the interobserver and intraobserver agreements, respectively, and were calculated using Cohen's kappa. Numbers of anaerobic bacteria and *Candida* species were converted to common logarithms and analysed with Leavene's test for equality of variance, one-way ANOVA, and the Bonferroni test as a multiple comparison among the scores for tongue-coating status. All statistical significance levels were set at 0·05. SPSS11·0J* was used for statistical analysis.

*SPSS, USA (SPSS Inc., Chicago, IL, USA).

This protocol was approved by the Ethics Committee of Tokyo Dental College (Agreement Number 101). All the experiments were performed in accordance with the Edinburgh Revision of the Helsinki Declaration.

Results

Consistency of observation

The inter- and intraobserver agreements obtained under the new evaluation criteria are shown in Table 1.

Agreement between score and number of microorganisms

In investigating the relationship between the score obtained under the evaluation criteria and the number of microorganisms, the mean number of total anaerobic bacteria and *Candida* species in relation to each score are shown in Table 2. Sixteen of the patients yielded no *Candida* species. Of these, six scored 0, eight scored 1 and two scored 2.

Table 1. Measurements of inter- and intraobserver agreements under new criteria

	Mean ± s.d.	Maximum	Minimum
Interobserver agreement			
First evaluation	0·66 ± 0·08	0·83	0·49
Second evaluation	0·66 ± 0·08	0·81	0·46
Mean of first and second evaluations	0·66 ± 0·07	0·81	0·50
Intraobserver agreement	0·80 ± 0·09	0·92	0·63

Table 2. Distributions of number of collections and mean number of anaerobic bacteria and *Candida* species for each score

		$\log_{10}$ CFU mL^{-1}	
	n	Anaerobic bacteria	*Candida*
Score 0	18	4·99 ± 0·72	2·90 ± 1·11
Score 1	19	5·92 ± 0·72	3·39 ± 0·76
Score 2	13	6·76 ± 0·70	3·72 ± 1·50

Variances in number of total anaerobic bacteria and *Candida* species were homogenous among the three scores. There were significant differences in the number of total anaerobic bacteria between Score 0 and 1, between Score 0 and 2, and between Score 1 and 2, as determined by the new criteria. No significant differences were found in the number of *Candida* species in any of the groups observed.

Discussion

The more the need for the prevention of oral malodour has increased, the more the need for an objective assessment method for tongue-coating status has grown. Complex methods such as digital imaging analysis may allow a more accurate evaluation of tongue-coating status than the method discussed here. However, such complex methods cannot be readily used in routine clinical practice, and so there is a need for a simple method, which dose not require the use of complex tools, applicable at the chair-side.

The methods described earlier (3, 12, 14) are widely used clinically and in studies. The problem with these methods, however, is that they lack clear criteria by which to determine the presence, absence, thickness or discolouration of the tongue coating, making observation unreliable. The difficulty of distinguishing grades of discolouration makes such evaluation inaccurate. Therefore, in this study, we focused on visual differences in the lingual papillae, assigning them a scale in our method. Visual calculation of the ratio of a coated area to the entire tongue surface is difficult as the tongue coating does not adhere to any one area with a clear boundary. In such methods, we stain the tongue coating with dyes such as erythrocin in order to improve the consistency of the evaluation by establishing a clearly demarked boundary. However, this results in the staining of the cornified layer of the tongue, making it impossible to obtain an accurate assessment. Therefore, in this study, we aimed to improve consistency of evaluation by clearly defining the evaluation criteria, and designing tongue-coating status criteria based on whether the morphology of the lingual papillae could be discerned from the tongue coating. As evaluation based on observation of the entire tongue at once is difficult, we divided the tongue surface into sections, as in earlier studies. Further subdivision may increase the degree of agreement, but accurate visual division of the tongue is difficult because of the absence of dividing landmarks. Originally, we attempted to divide the tongue surface into 10 or 12 sections. However, this made our method difficult to apply in a clinical setting. Therefore, we decided that division into nine sections was the optimum for clinical purposes. We then evaluated these nine sections according to our new criteria and calculated the percentage of the total score for the nine sections observed (Score 0–18) (Fig. 2). We call this tongue-coating status method the 'Tongue Coating Index (TCI)' and it is expressed as a percentage. We have used this new method in a clinical setting.

Landis and Koch (15) rated kappa values <0·00 as 'poor', 0·00–0·20 as 'slight', 0·21–0·40 as 'fair', 0·41–0·60 as 'moderate', 0·61–0·80 as 'substantial' and 0·81–1·00 as 'almost perfect'. Interobserver agreement under our criteria was 0·66, corresponding to 'substantial'. Intraobserver agreement under our criteria was 0·80, corresponding to 'substantial', showing that our criteria are superior in terms of reliability and reproducibility.

The pathogenic bacteria of aspiration pneumonia are detected as a mixed infection, and a particularly high detection rate of anaerobic bacteria has been reported (5). VSC produced by anaerobic bacteria is one of the reasons for oral malodour (2). Some reports have suggested that the number of *Candida* species serves as an indicator of general health condition in elderly persons (7). Based on these reports, we investigated the relationship between number of total anaerobic bacteria and *Candida* species and the scores obtained under our evaluation criteria. We determined the number of microorganisms in relation to the score for the randomly selected one section in each subject. Therefore this method is calculated by summing of scores, which reflect the number of microorganism in each section, of all sections in tongue surface. In this way, this method reflects the hygiene of the total tongue surface. Because of these reasons, we did not have to calculate the percentages of the total scores in

this study. That is to say, we did not compare the number of microorganism from all the surfaces of the tongue and TCI. However, we do not know the direct relationship between the TCI and the number of microorganisms for all surfaces of the tongue, because we did not investigate this point in this study. We need a further investigation of it.

To eliminate the influence of periodontal disease on oral microbial flora, only edentulous individuals were selected as subjects. In this study, no significant difference in the number of *Candida* species was found among the three scores of our criteria for tongue-coating status. Abe *et al.* (16), however, reported that the number of *Candida albicans* in saliva was significantly lower in edentulous patients without tongue coating than in those with tongue coating. Their samples were collected from saliva, and evaluation was based solely on whether tongue coating was present or not. The different methods used in this and Abe's study may have caused the difference between our respective results. Many fungi, including *C. albicans*, inhabit denture plaque (17, 18). All the patients in this study wore dentures, so it is possible that the results were affected by the degree of denture plaque. Nikawa *et al.* (19) reported that soft denture lining materials were easily colonized and deeply infected by *Candida* species. In this study, no subject used a denture with soft denture lining materials.

The number of total anaerobic bacteria was significantly different between the scores obtained under our criteria. Therefore, we conclude that our method for evaluating tongue-coating status offers new criteria that are superior in reliability and reproducibility, and that also reflect the total number of anaerobic bacteria present on the dorsum of the tongue. We have demonstrated a new method for evaluating tongue-coating status and believe that this method would be useful for various types of study such as surveillance for preventing aspiration pneumonia associated with tongue coating.

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