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荒木, 淳

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The utility of oral moisture measurement for the diagnosis of Sjögren's syndrome: Its potential application as a diagnostic criterion

Mizuki Sakamoto [a,1], Jun Araki [a,1], Masafumi Moriyama [b,c,*], Yuka Miyahara [a], Tatsuya Kawado [a], Aiko Yano [a], Risako Koga [a], Ryuichi Aoyagi [a], Yuka Murakami [a], Naoki Kaneko [a], Shintaro Kawano [a], Seiji Nakamura [d]

[a] Section of Oral and Maxillofacial Oncology, Division of Maxillofacial Diagnostic and Surgical Sciences, Faculty of Dental Science, Kyushu University, Fukuoka, Japan
[b] Section of Oral and Maxillofacial Surgery, Division of Maxillofacial Diagnostic and Surgical Sciences, Faculty of Dental Science, Kyushu University, Fukuoka, Japan
[c] OBT Research Center, Faculty of Dental Science, Kyushu University, Fukuoka, Japan
[d] Faculty of Dental Science, Kyushu University, Fukuoka, Japan

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ABSTRACT

Objectives: To investigate the use of an oral moisture meter to aid in the diagnosis of Sjögren's syndrome (SS) by measuring the moisture values and salivary flow rate (SFR) simultaneously.
Methods: The SFR and moisture values of the dorsum of the tongue and buccal mucosa were measured in 40 patients with SS and 29 healthy controls using an oral moisture meter. In addition, a visual analogue scale (VAS) was used to determine the degree of subjective oral symptoms (xerostomia, decreased saliva production, drinking during eating, oral pain, dysphagia, and dysgeusia).
Results: The moisture values of the dorsum of the tongue and buccal mucosa were significantly lower in SS patients than in healthy subjects (both $p < 0.01$). SFR, especially when measured by the spitting test, correlated positively with the moisture values of the dorsum of the tongue ($p < 0.0001$) and buccal mucosa ($p < 0.0003$). Furthermore, the sensitivity, specificity, and accuracy of the oral moisture meter measurements of the dorsum of the tongue and buccal mucosa were 92.5%, 68.9%, and 82.6%, and 70.0%, 82.8%, and 73.9%, respectively. The moisture values of the dorsum of the tongue had a moderate negative correlation with the VAS scores of secondary subjective oral symptoms of xerostomia (oral pain, dysphagia, and dysgeusia), whereas a weak negative correlation was observed for subjective oral symptoms directly related to xerostomia (xerostomia and decreased saliva production).
Conclusions: The oral moisture meter accurately reflected the results of the SFR tests and chronic subjective oral symptoms, and therefore might be a diagnostic criterion for SS.

1. Introduction

Sjögren's syndrome (SS) is a long-term autoimmune disease characterized by the lymphocytic infiltration of secretory glands. Its main symptoms are dry eyes and dry mouth. The mechanisms involved in the pathogenesis of SS are unclear, and therefore, no definitive treatment has been established[1].

A diagnosis of SS is achieved through a combination of oral examinations, ocular examinations, serological tests, imaging tests, and histopathological examinations, some of which are invasive and require significant time to make a diagnosis. Oral examinations primarily use measurements of salivary secretion, such as the stimulated salivary flow rate (SFR) (Saxon test and gum test) and unstimulated SFR (spitting test). However, these evaluations are time-consuming, and SFR is susceptible to diurnal variation, leading to poor reproducibility[2,3]. Recently, an oral moisture meter (Mucus, Japan Life Co., Saitama, Japan) has been used as an evaluation item for oral dryness in the diagnostic criteria for xerostomia and oral hypofunction[4]. The oral moisture meter can quantify the water content of the oral mucosa in seconds, and therefore, it might aid the measurement of oral moisture in

* Correspondence to: Section of Oral and Maxillofacial Surgery, Division of Maxillofacial Diagnostic and Surgical Sciences, Faculty of Dental Science, Kyushu University, 3-1-1 Maidashi, Higashi-ku, Fukuoka 812–8582, Japan.
E-mail address: moriyama@dent.kyushu-u.ac.jp (M. Moriyama).
[1] These authors contributed equally to this work.

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cases with mastication difficulty or a poor general condition. Several studies have demonstrated its usefulness in determining the degree of oral mucosal moisture in patients with radiation-induced[5] or drug-induced xerostomia[4], as well as in maxillofacial surgery[6,7]. However, the correlation between SFR and oral mucosal moisture in patients with SS is unclear.

Therefore, this study examined the correlation between SFR and oral mucosal moisture by measuring both parameters simultaneously to determine the usefulness of the oral moisture meter for the diagnosis of SS.

2. Methods

2.1. Study design

Forty patients with SS (38 females and 2 males; mean age ± standard deviation (SD), 62.3 ± 15.1 years) and 29 healthy controls (28 females and a male; mean age ± SD, 43.2 ± 7.9 years) were referred to the Department of Oral and Maxillofacial Surgery, Kyushu University Hospital between 2019 and 2021 and were included in this prospective study.

SS was diagnosed according to the 1999 Research Committee on SS of the Ministry of Health, Labour and Welfare of the Japanese Government[8] and the American College of Rheumatology/European Alliance of Associations for Rheumatology 2016 classification criteria for primary SS[9]. All patients with SS had lymphocytic infiltration in the salivary glands and had never been treated with steroids or any other immunosuppressants. There was no documented history of HIV, human T lymphotropic virus type 1, hepatitis B virus, or hepatitis C virus infection in any of the patients. None of the patients had evidence of malignant lymphoma at the time of the study. The controls consisted of 29 healthy subjects who had no sicca, no history of radiotherapy, and who had not taken steroids or immunosuppressive drugs. Table 1 shows the clinical findings in both groups.

Table 1
Demographic characteristics between patients with Sjögren's syndrome (SS) and healthy controls.

	SS (n = 40)	Healthy controls (n = 29)	*P*-value
Age (years)	62.3 ± 15.1	43.2 ± 7.9	0.0005 *
Sex			
Female	38	28	
Male	2	1	0.6203 §
Stimulated SFR			
Saxon test (g/2 min)	1.84 ± 1.67	4.94 ± 2.42	0.0327 *
Gum test (ml/10 min)	8.12 ± 7.40	23.54 ± 8.05	0.0141 *
Unstimulated SFR			
Spitting test (ml/15 min)	0.91 ± 1.95	8.06 ± 3.91	< 0.0001 †
Moisture values measured by oral moisture meter			
Dorsum of tongue	24.2 ± 3.24	28.53 ± 1.27	< 0.0001 †
Buccal mucosa	27.40 ± 2.46	29.46 ± 2.49	0.0226 *
VAS of subjective oral symptoms (mm)			
Xerostomia	64.55 ± 25.40	31.97 ± 34.23	< 0.0001 *
Feeling hyposalivation	63.33 ± 25.69	22.83 ± 32.95	< 0.0001 *
Water-drinking at meals	51.7 ± 33.24	37.69 ± 38.44	0.1103 *
Oral pain	26.25 ± 27.23	10.41 ± 22.71	0.0129 *
Difficulty in swallowing	25.15 ± 25.95	9.03 ± 20.16	0.0069 *
Taste abnormality	17.3 ± 20.02	5.34 ± 16.93	0.0107 *

SFR, salivary flow rate; VAS, Visual Analogue Scale; Mean value ± standard deviation. Significant differences between the groups were determined by * Student's t test, § Fisher's exact test, and † Mann–Whitney U-test.

2.2. Measurement of the SFR

Stimulated SFR was measured by the Saxon test and gum test. The Saxon test was performed by having subjects chew a Surgeon Type IV Gauze Sponge (Hakuzo Medical Corporation, Osaka, Japan) once a second for 2 min and measuring the weight of the gauze. If the increase in weight of the gauze was ≤ 2 g, the subject was classified as "decreased"[10]. The gum test was performed by having subjects chew gum (Free Zone; Lotte Co. Ltd., Tokyo, Japan) and keep spitting saliva into a beaker for 10 min, after which the total amount of saliva was measured. If the volume of saliva was ≤ 10 ml, the subject was classified as "decreased"[11]. This mint-flavor, plate-like gum can also be used for patients with dentures because it seldom sticks to the teeth.

The unstimulated SFR was measured using the spitting test. This test was carried out by asking subjects to spit saliva into a paper cup for 15 min. The amount of saliva under the unstimulated conditions (sitting on a chair and not moving) was measured. If the volume of saliva was ≤ 1.5 ml, the subject was classified as "decreased"[12].

2.3. Oral moisture meter (Mucus III)

The oral moisture meter Mucus III (Life Co. Ltd.) was used to measure the moisture content (moisture values) of the oral mucosa under resting conditions. As shown in Fig. 1, the probe, which was covered with a sterile sensor cover (thickness, 12 μm) was placed on the central part of the dorsum of the tongue and buccal mucosa about 10 mm from the tip for approximately 5 s. An alarm provided a signal for the end of the measurement. A digital display provided objective data, measurements were performed three times, and the mean data were used for analyses [13].

Moisture values ≥ 30.0% are considered normal; moisture values of 27.0–29.9% are borderline (generally not treated), and moisture values ≤ 26.9% are low. In this study, patients with moisture values > 27.0% were classified as the "normal moisture group" and those with moisture values ≤ 26.9% were classified as the "dry group"[4].

2.4. Subjective oral symptoms

The subjective symptoms and major complaints of dry mouth were collected from patients at a medical interview. A visual analogue scale (VAS) was used to quantify the subjective oral symptoms of dry mouth. The scale ranged from 0 mm to 100 mm. A reading of 0 mm was designated as "do not feel any symptoms" and that of 100 mm as "feel significant symptoms." Patients were asked to mark their subjective feelings between these two points arbitrarily, and the distance from 0 mm to their mark was measured. Using this VAS method, six subjective oral symptoms (xerostomia, feeling hyposalivation, drinking water with meals, oral pain, difficulty in swallowing, and taste abnormality) were assessed (Supplementary Figure 1)[3,12].

The measurements were carried out in the afternoon, 1–2 h after lunch at each time point, and in the following order: 1) dry mouth questionnaire; 2) measurement of oral moisture with Mucus III; 3) resting saliva test; 4) Saxon test after 10 min; and 5) gum test after 10 min. Patients did not eat or drink for at least 60 min before measurements, nor did they smoke after the diagnosis.

2.5. Statistical analysis

All statistical analyses were performed using GraphPad Prism 9 (GraphPad Software, San Diego, CA, USA). The Student's *t*-test, Mann-Whitney *U*-test, Fisher's exact test, and Pearson's correlation coefficients were used for comparisons of independent groups. A *P*-value < 0.05 was considered statistically significant.

The correlation coefficient (*r*) ranged from negative (−1) to positive (+1). A positive correlation was measured on a scale from 0 to 1.0: a "weak positive correlation" ranged from 0.2 to 0.4, a "moderate positive

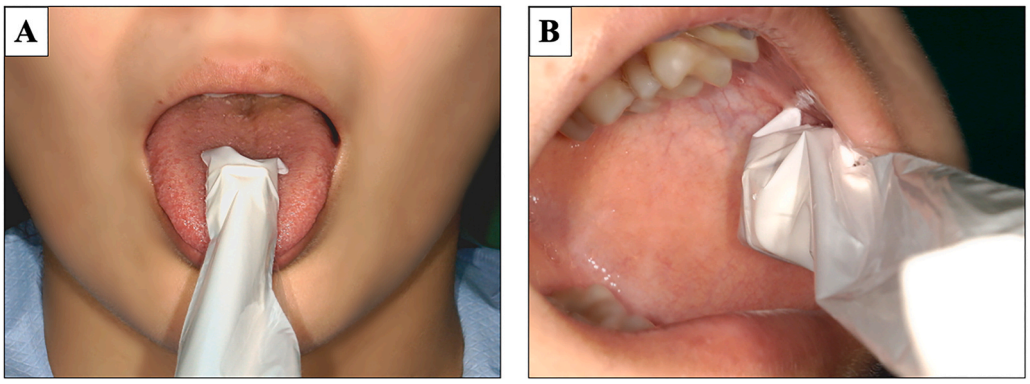

Fig. 1. Measurement of moisture using an oral moisture meter on the dorsum of the tongue (A) and buccal mucosa lingual mucosa (B).

correlation" ranged from 0.4 to 0.6, and a "strong positive correlation" was between 0.6 and 1.0. Conversely, a negative correlation was measured on a scale from 0 to − 1.0: a "weak negative correlation" ranged from − 0.2 to − 0.4, a "moderate negative correlation" from − 0.4 to − 0.6, and a "strong negative correlation" from − 0.6 to − 1.0.

3. Results

3.1. Differences in VAS, SFR, and moisture values between SS and healthy controls

VAS of xerostomia, feeling hyposalivation, oral pain, difficulty in swallowing, and taste abnormality was significantly higher in SS patients than that in healthy subjects, while VAS of drinking water with meals was not significant difference between them (Table 1). The stimulated SFR (Saxon test and gum test) and unstimulated SFR (spitting test) values for SS patients were significantly decreased compared with those of healthy controls (Table 1, Fig. 2A). In addition, the moisture values on the dorsum of the tongue and buccal mucosa of SS patients were significantly decreased compared with those of healthy controls (Table 1, Fig. 2B).

As shown in Table 2, the diagnostic usefulness of SS screening using SFR and moisture values was investigated. Based on the frequency of the "low" (Saxon 2.0 g/2 min or less; Gum test, 10 ml/10 min or less; spitting test, 1.5 ml/15 min) or "dry" group (moisture value ≤ 26.9%) in patients with SS and healthy controls, the sensitivity, specificity, and accuracy of the Saxon test, the gum test, and the spitting test were 65.0%, 93.1%, and 76.8%; 70.0%, 93.1%, and 78.3%; and 87.5%,

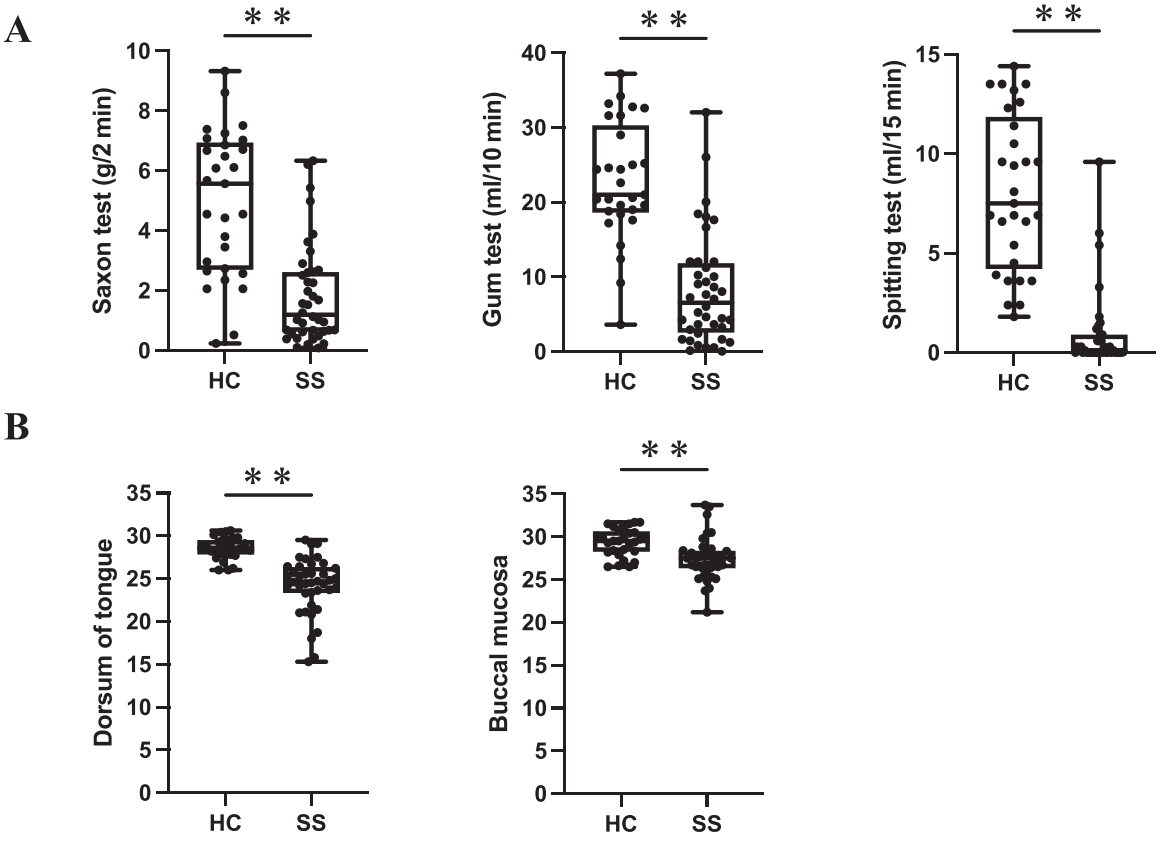

Fig. 2. Comparison of oral moisture meter (A) and salivary flow rate (SFR) tests (B) between patients with Sjögren's syndrome (SS) and healthy controls. Data are shown as box plots. Each box represents the upper and lower interquartile range. Lines inside the boxes represent the median. Symbols represent individual subjects. ** $p < 0.01$ (Mann-Whitney *U*-test).

Table 2
Sensitivity, specificity, and accuracy of the Saxon test, gum test, spitting test, and moisture values.

	Sensitivity	Specificity	Accuracy
Stimulated SFR			
Saxon test	65.0%	93.1%	76.8%
Gum test	70.0%	93.1%	78.3%
Unstimulated SFR			
Spitting test	87.5%	100.0%	82.6%
Moisture values measured by oral moisture meter (based on the classifications)			
Dorsum of the tongue	92.5%	68.9%	82.6%
Buccal mucosa	70.0%	82.8%	73.9%
Moisture values measured by oral moisture meter (based on the ROC curves)			
Dorsum of the tongue (Cut-off point = 27.5)	92.5%	82.8%	88.4%
Buccal mucosa (Cut-off point = 28.1)	72.5%	79.3%	75.4%

SFR, salivary flow rate; ROC, receiver operated characteristic.

100%, and 82.6%, respectively. Those of moisture value measurements on the tongue dorsum and buccal mucosa were 92.5%, 68.9%, and 82.6%; and 70.0%, 82.8%, and 73.9%, respectively.

In addition, to set a cut-off point for screening hyposalivation in oral moisture values, data were plotted on a receiver-operating characteristic (ROC) curve (Supplementary Figure 2), and sensitivity, specificity, and accuracy were calculated at each measurement site. Buccal mucosa water values were 72.5%, 79.3%, and 75.4%, respectively, and the cut-off point was 28.1 for water values. Moreover, the highest sensitivity (92.5%), specificity (82.8%), and accuracy (88.4%) were obtained from the tongue dorsum, with a cut-off point of 27.5.

3.2. Relationship between the SFR and moisture values

The moisture values of the dorsum of the tongue had a moderate positive correlation with the stimulated SFR (Saxon test, $r = 0.4875$; gum test, $r = 0.5878$) and a strong positive correlation with the unstimulated SFR (spitting test, $r = 0.6378$) (Fig. 3A). However, the moisture values of the buccal mucosa had a weak positive correlation with the stimulated SFR (Saxon test, $r = 0.3416$; gum test, $r = 0.3824$) and a moderate positive correlation with the unstimulated SFR (spitting tests, $r = 0.4193$) (Fig. 3B).

3.3. Correlation of the subjective oral symptoms with the SFR and moisture values

Next, we examined the correlation of the subjective oral symptoms (xerostomia, feeling hyposalivation, drinking water with meals, oral pain, difficulty in swallowing, and taste abnormality) with stimulated and unstimulated SFR and moisture values of the dorsum of the tongue and buccal mucosa. As shown in Table 3 and Supplementary Table 1, the stimulated and unstimulated SFR values had a strong negative correlation with xerostomia and hyposalivation, whereas there was a weak negative correlation with drinking water with meals, difficulty in swallowing, and taste abnormality.

The moisture values of the dorsum of the tongue had a moderate negative correlation with drinking water with meals, difficulty in swallowing, and taste abnormality, and a weak negative correlation with xerostomia and hyposalivation. The moisture values of buccal mucosa had a moderate negative correlation with difficulty in swallowing and a weak negative correlation with the other subjective oral symptoms.

4. Discussion

The age of onset for SS is often in the 50 s, and there are many cases in the elderly. Especially in patients with poor overall health, conventional SFR tests can be time-consuming and difficult to perform. Therefore, a simple method is required to evaluate oral dryness without being influenced by an individual's oral function or overall condition. The oral moisture meter Mucus III can easily measure the moisture of the oral mucosa in less than two seconds[14] and is not influenced by the oral function or the overall health of the individual. Recently, it was used to evaluate oral dryness in various populations, such as elderly residents in nursing homes, patients in intensive care units, and stroke patients, because the results are not influenced by oral function or overall condition[15].

In the current study, the oral moisture meter had a significant positive correlation with the conventional SFR tests including the Saxon test, gum test, and spitting test (Fig. 3). Moreover, the diagnostic ability of moisture values of the dorsum of the tongue measured by the oral moisture meter was superior to that of the conventional SFR tests. With

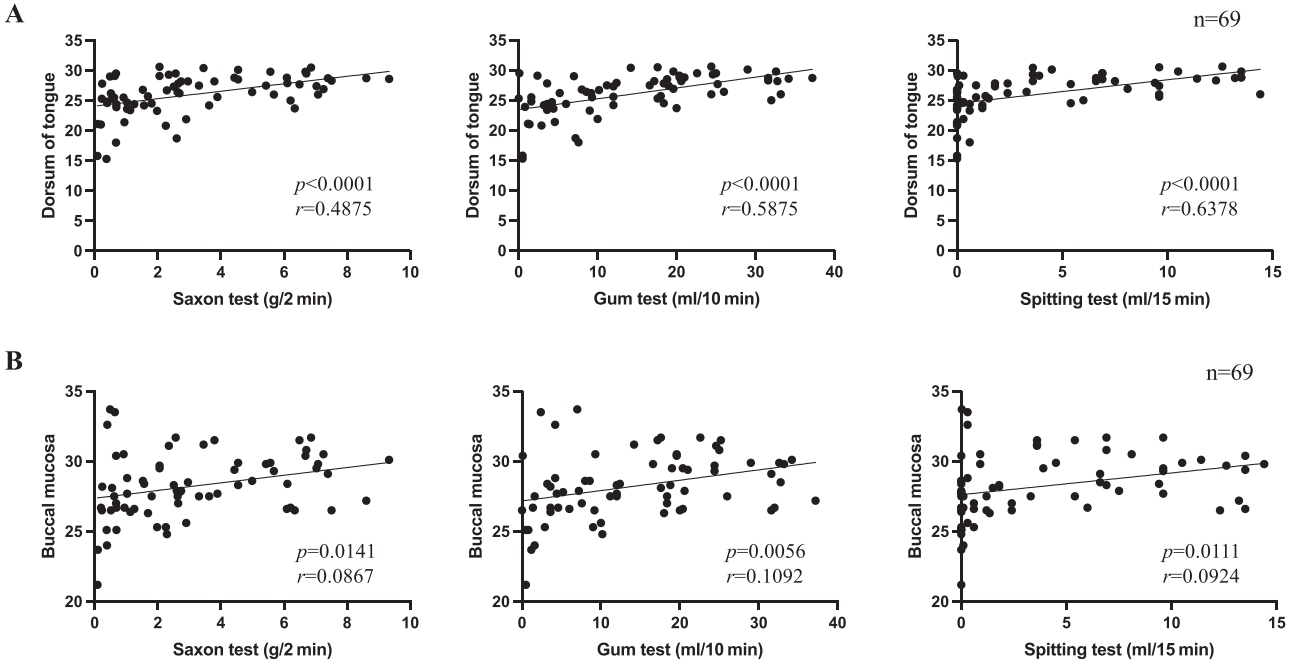

Fig. 3. Relationship between oral moisture meter and SFR tests. Significant differences between the groups were determined by Pearson's correlation coefficients.

Table 3
Correlation of subjective oral symptoms assessed by the Saxon test, gum test, spitting test, and oral moisture values (at the dorsum of the tongue and buccal mucosa).

	VAS of subjective oral symptoms					
	Xerostomia	Feeling hyposalivation	Water-drinking at meals	Oral pain	Difficulty in swallowing	Taste abnormality
Stimulated SFR						
Saxon test	$r = -0.5669$	$r = -0.6242$	$r = -0.3277$	$r = -0.3093$	$r = -0.3388$	$r = -0.2972$
Gum test	$r = -0.5673$	$r = -0.6397$	$r = -0.2649$	$r = -0.3633$	$r = -0.3892$	$r = -0.3365$
Unstimulated SFR						
Spitting test	$r = -0.5878$	$r = -0.6426$	$r = -0.2617$	$r = -0.3269$	$r = -0.3367$	$r = -0.2554$
Moisture values						
Dorsum of tongue	$r = -0.3398$	$r = -0.3827$	$r = -0.2272$	$r = -0.4276$	$r = -0.4632$	$r = -0.4407$
Buccal mucosa	$r = -0.2039$	$r = -0.2311$	$r = -0.1915$	$r = -0.3454$	$r = -0.4032$	$r = -0.3605$
		$r = 0.0$	0.2	0.4	0.6	0.8

Significant differences between the groups were determined by Pearson's correlation coefficients. The classification of the correlation coefficient (r) was described in the Methods section.

regard to cut-off values, there was no significant difference in diagnostic performance between the current Mucus standard of 27% and the ROC values calculated in this study. From these results, the oral moisture confirmed to be useful for screening based on the current standard values (Table 2). In general, oral moisture is measured at the lingual and buccal mucosa. Mizuhashi et al. [16] suggested that oral moisture can be uniformly assessed by measuring it at the dorsum of the tongue and comparing it with that at the buccal mucosa. In another previous study, unstimulated SFR and oral moisture values using Mucus III were measured at ten specific times during the evaluation period: before going to bed (the1st night), just after getting up (the next morning), before and after each meal (breakfast, lunch, dinner), before going to bed (2nd night) and again just after getting up (2nd morning). They have concluded that the diurnal fluctuations of unstimulated SFR were significantly greater than those of oral moisture values (dorsum of the tongue and buccal mucosa). Moreover, the diurnal fluctuations of the moisture values on the buccal mucosa were significantly greater than those on the dorsum of the tongue[17]. The results of the present study regarding site-specific accuracy are consistent with that report. Compared to the dorsum of the tongue, the buccal mucosa has a thinner epithelium, and its anatomical structure makes it difficult to retain water, making it more susceptible to external influences. This is supported by the large diurnal fluctuations and lack of reproducibility of the buccal mucosa.

Interestingly, the stimulated and unstimulated SFR accurately reflected the subjective oral symptoms directly related to xerostomia, whereas the moisture values of the dorsum of the tongue accurately reflected the secondary subjective oral symptoms of xerostomia (Fig. 3).

This study has some limitations. The one, this study was not a large multi-center analysis, and there is not enough evidence to confirm that oral moisture is a diagnostic standard equivalent to SFR. Another, there was no monitoring before and after treatment with a M3 muscarinic acetylcholine receptor (M3R) agonist. From a practical viewpoint, we performed a continuous follow-up of SS by evaluating the change in the water content of the oral mucosa, salivary production, and subjective symptoms after treatment with an M3R agonist, which could be applicable for monitoring the effects of treatment on SS patients.

5. Conclusions

This study demonstrated that the use of an oral moisture meter on the dorsum of the tongue might be a convenient and quick screening test for SS, equivalent to SFR tests.

Ethics approval

The study design and methods were approved by the Institutional Review Board of the Center for Clinical and Translational Research of Kyushu University Hospital (IRB serial number: 2019–307). All patients or their relatives gave written informed consent at admission and prior to their inclusion in the study.

Funding

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Conflict of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ajoms.2024.02.007.

References

[1] Moriyama M, Tanaka A, Maehara T, Furukawa S, Nakashima H, Nakamura S. T helper subsets in Sjögren's syndrome and IgG4-related dacryoadenitis and sialoadenitis: a critical review. J Autoimmun 2014;51:81–8.
[2] Longman LP, McCracken CF, Higham SM, Field EA. The clinical assessment of oral dryness is a significant predictor of salivary gland hypofunction. Oral Dis 2000;6:366–70.
[3] Hayashida J-N, Minami S, Moriyama M, Toyoshima T, Shinozaki S, Tanaka A, et al. Differences of stimulated and unstimulated salivary flow rates in patients with dry mouth. J Oral Maxillofac Surg Med Pathol 2015;27:96–101.
[4] Okamoto A, Miyachi H, Tanaka K, Chikazu D, Miyaoka H. Relationship between xerostomia and psychotropic drugs in patients with schizophrenia: evaluation using an oral moisture meter. J Clin Pharm Ther 2016;41:684–8.
[5] Fujimaki Y, Tsunoda K, Ishimoto S, Okada K, Kinoshita M, Igaki H, et al. Non-invasive objective evaluation of radiotherapy-induced dry mouth. J Oral Pathol Med 2014;43:97–102.
[6] Nishii M, Akashi M, Kakei Y, Hasegawa T, Minamikawa T, Furudoi S, et al. Sequential changes in oral dryness evaluated by a moisture-checking device in patients with oropharyngeal cancer during chemoradiotherapy: a pilot study. Oral Health Dent Manag 2014;13:507–11.
[7] Murakami M, Nishi Y, Kamashita Y, Nagaoka E. Relationship between symptoms of dryness and moisture levels in patients with maxillofacial prostheses. J Prosthodont Res 2010;54:65–9.
[8] Fujibayashi T, Sugai S, Miyasaka N, Hayashi Y, Tsubota K. Revised Japanese criteria for Sjögren's syndrome (1999): availability and validity. Mod Rheuma 2004;14:425–34.
[9] Shiboski CH, Shiboski SC, Seror R, Criswell LA, Labetoulle M, Lietman TM, et al. 2016 American college of rheumatology/European league against rheumatism classification criteria for primary sjögren's syndrome: a consensus and data-driven methodology involving three international patient cohorts. Arthritis Rheuma 2017;69:35–45.
[10] Kohler PF, Winter ME. A quantitative test for xerostomia. The Saxon test, an oral equivalent of the Schirmer test. Arthritis Rheum 1985;28:1128–32.
[11] Olsson H, Spak CJ, Axéll T. The effect of a chewing gum on salivary secretion, oral mucosal friction, and the feeling of dry mouth in xerostomic patients. Acta Odontol Scand 1991;49:273–9.

[12] Vitali C, Bombardieri S, Jonsson R, Moutsopoulos HM, Alexander EL, Carsons SE, et al. Classification criteria for Sjögren's syndrome: a revised version of the European criteria proposed by the American-European Consensus Group. Ann Rheum Dis 2002;61:554–8.
[13] Sugiura Y, Soga Y, Nishide S, Kono K, Takahashi K, Fujii N, et al. Evaluation of xerostomia in hematopoietic cell transplantation by a simple capacitance method device. Support Care Cancer 2008;16:1197–200.
[14] Takahashi F, Takahashi M, Toya S, Morita O. Relationship between medicine and stimulated saliva and oral moisture. Nihon Hotetsu Shika Gakkai Zasshi 2008;52:537–42.
[15] Takahashi F, Takahashi M, Toya S, Koji T, Morita O. Clinical usefulness of an oral moisture checking device (Mucus®). Prosthodont Res Pract 2006;5:214–8.
[16] Mizuhashi F, Takahashi M, Mizuhashi R, Toya S, Morita O, Koide K. Influence of swallowing saliva repeatedly on oral moisture. J Prosthodont Res 2010;54:128–32.
[17] Okane M, Kitamura Y, Sato Y, Kitagawa K, Mashimo J. Objective assessment of the subjective sensation of oral dryness. Jpn Gerodontol 2007;22:298–308.

Supplementary Table 1. Correlation of subjective oral symptoms assessed by the Saxon test, gum test, spitting test, and oral moisture values (at the dorsum of the tongue and buccal mucosa).

	VAS of subjective oral symptoms					
	Xerostomia	Feeling hyposalivation	Water-drinking at meals	Oral pain	Difficulty in swallowing	Taste abnormality
Stimulated SFR						
Saxon test	$p < 0.0001$	$p < 0.0001$	$p = 0.0060$	$p = 0.0097$	$p = 0.0044$	$p = 0.0013$
Gum test	$p < 0.0001$	$p < 0.0001$	$p = 0.0279$	$p = 0.0022$	$p = 0.0009$	$p = 0.0047$
Unstimulated SFR						
Spitting test	$p < 0.0001$	$p < 0.0001$	$p = 0.0298$	$p = 0.0061$	$p = 0.0047$	$p = 0.0341$
Moisture values						
Dorsum of tongue	$p = 0.0043$	$p = 0.0012$	$p = 0.1149$	$p = 0.0037$	$p = 0.0006$	$p = 0.0023$
Buccal mucosa	$p = 0.0928$	$p = 0.0560$	$p = 0.0605$	$p = 0.0002$	$p<0.0001$	$p = 0.0002$

Significant differences between the groups were determined by Pearson’s correlation coefficients.

A

口腔自覚症状のアンケート

氏名：

年齢：　歳

性別：

記入方法
質問項目について御自分の感覚で適当な場所に**×印**をつけてください。

例　非常によく乾く ― ほとんど気にならない

1. 口の渇き　非常によく乾く ― ほとんど気にならない
2. 唾液減少　高度に減少 ― ほとんど気にならない
3. 摂食時の飲水　常に必要 ― パンも問題なし
4. 口腔の痛み　常に自覚する ― ほとんど気にならない
5. 嚥下困難感　非常に困難 ― さほど支障なし
6. 味覚異常　無味覚 ― 変化なし

実施者：

B

Questionnaire for subjective oral symptoms

Name：

Age：

Sex：

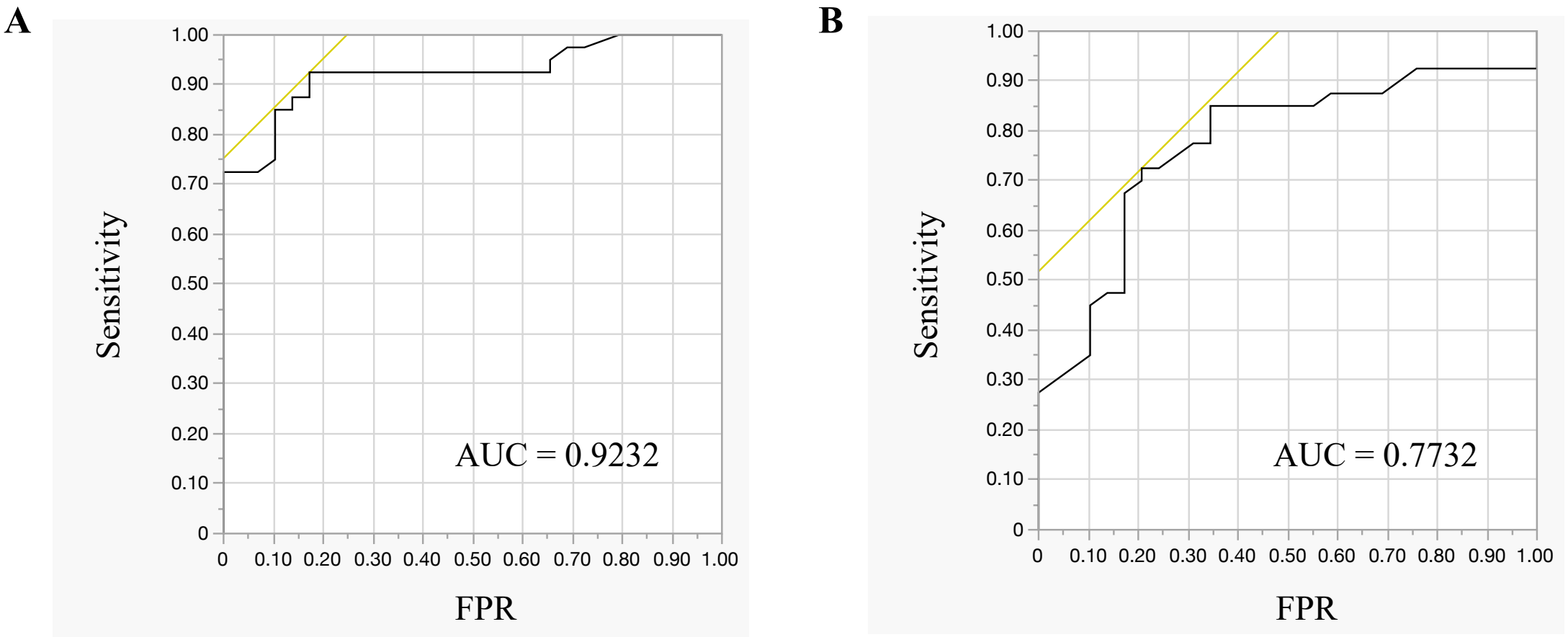
<How to fill>
Please mark an X in the appropriate place for each question item according to your own feeling.

Example：　Dries very well ― Hardly Noticeable

1. Xerostomia　Dries very well ― Hardly Noticeable
2. Feeling hyposalivation　Highly decreasing ― Hardly Noticeable
3. Drinking water with meals　Always necessary ― No problem with bread
4. Oral pain　Always aware ― Hardly Noticeable
5. Difficulty in swallowing　Very difficult ― Not much of a problem
6. Taste abnormality　Lacking taste ― No change

Implementor：

Supplementary figure 1. Questionnaire for subjective oral symptoms. Japanese (A), English (B). The scale was from 0 mm to 100 mm. Patients were asked to mark their subjective feeling between these two points arbitrarily, and the distance from 0 mm to their mark was measured.



Supplementary figure 2. Receiver operated characteristic (ROC) curves from oral moisture value of the dorsum of the tongue (A) and buccal mucosa (B). AUC, area under the ROC curve; FPR, false positive rate.