Evaluation of an infrared light absorption method for objective assessment of oral mucosal dryness

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The aim of this study was to evaluate an infrared light absorption (ILA) method for registration of dryness of the oral mucosa. Measurements were performed in the buccal and in the lip mucosa immediately before and every 30 min after submucosal injection of 1.0 ml methylscopolamine nitrate in nine healthy subjects. For comparison, a dental mirror sliding friction test was used. About 1.5 h after injection the ILA method showed statistically significant ($P < 0.01$) decreases of values in both the buccal and the lip mucosa. However, in the individual subjects the deviations from initial values showed only slight agreement when measured with the ILA method and the mirror friction test. Thus, the ILA method does not seem to be suitable for registration of individual variations in oral mucosal dryness. □ *Saliva; xerostomia; methods*

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The properties of the oral mucosal surface are of great importance for patients' comfort during activities such as chewing and swallowing. The surface is normally covered by a thin layer, a pellicle, which is mainly composed of glycoproteins and water. Disturbances of this pellicle, such as severe mouth dryness, may give rise to symptoms associated with infections and ulcerations of the oral mucosa. Further, changes of the pellicle quality may be involved in the penetration mechanisms of various antigenic substances, thereby having an impact on oral manifestations of various allergic and immunologic conditions (1–3).

The quality of the surface film is affected in xerostomia (dry mouth). Investigations of xerostomia have almost exclusively used salivary flow measurements and patient interviews as evaluation factors (4–6). However, there is no absolute consistency between these methods in the assessment of xerostomia (7), and they are rather unreliable for accurate estimation of dry mouth. There is therefore a need for methods that may serve as routine means of objectively assessing oral mucosal dryness. In a previous series of trials, some electric methods have been explored to ascertain whether they could possibly fulfill the requirements of an objective method. However, none of them has proven suitable for assessing dry mouth on an individual basis (8).

Since dry mouth is probably associated with the water content of the oral mucosal surface, infrared light absorption (ILA) could possibly be a suitable objective method. This method has previously been used to assess the water content of the stratum corneum of human skin (9).

The aim of this study was thus to evaluate infrared light absorption for the objective assessment of oral mucosal dryness.

Materials and methods

A conventional instrument for humidity measurements from Pier Electronic, Germany (AB Liros Electronic, Malmö, Sweden) was used. The instrument works as follows: water absorbs infrared light at a maximum at two wavelengths: 1940 nm, at which comparatively small amounts of moist-

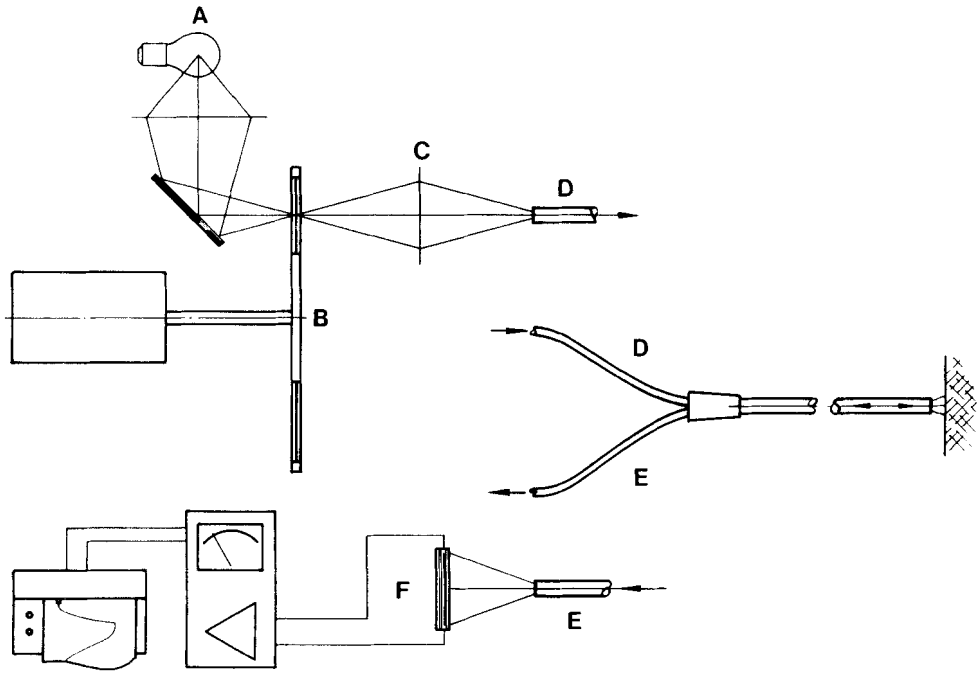

Fig. 1. Experimental set-up for measuring infrared light absorption.

ure (up to about 7% water) can be measured in good resolution and with good reliability, and 1450 nm, at which somewhat greater amounts of moisture (up to about 20% water) can be accurately measured. Light of wavelengths 1800 and 1300 nm is used as reference light, of which only a relatively small fraction is absorbed by water. In the present study, a wavelength of 1450 nm was used to assess the water content of oral mucosa with 1300 nm as the reference wavelength.

The commercially available equipment has been modified for clinical use. A sketch showing the principles of this experimental set-up is shown in Fig. 1. The optical fiber bundle, with a length of 1.2 m, is supplementary equipment to the original instrument. The bundle is at one end divided into two arms (D and E) with a length of 0.2 m and a diameter of 3.5 mm each. In the common fiber bundle part they are randomly mixed. This fiber bundle has a diameter of 5 mm and with a diameter of 70 μm for each fiber. The fibers transmit infrared light with a wavelength of 1900 nm with an absorption less than 40%. The optical fibers are shielded in their total length with a flexible metal piping covered by polyvinyl chloride. Light of different wavelengths is produced by a light source (A). The light passes through two optical filters mounted on a glass filter wheel (B) rotating at 3000 rpm. The beams are sent through a collector lens (C), which focuses the light into the optical fiber bundle (D). Some light is reflected at the measuring point and then back to the bundles of fibers D and E. The light reflected through bundle E is received by a photocollector (F) and converted into corresponding current pulses. These pulses pass through the signal conditioner and amplifier system. The ratio between the reflected light of the two wavelengths is displayed. A quantitative estimate of moisture is obtained and expressed as a 'unit' with values varying on an arbitrary scale of 0–100, where 0 is maximal light reflection, and 100 maximal light absorption. All values are registered on a Siemens Compensograph III recorder.

Table 1. Friction grade values registered in the cheek mucosa after sliding with a dental mirror and estimated on a three-point scale. Values in nine subjects before and after injection of 1.0 ml methylscopolamine nitrate

Subject no.	Time, h												
	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1	1	2	2	3	2	2	2	2	2	2	1	1	1
2	1	3	3	3	3	–	2	2	2	2	2	2	2
3	1	2	2	2	2	2	2	2	2	2	2	2	2
4	1	2	3	2	2	2	2	2	2	2	2	2	2
5	1	2	2	2	2	2	2	2	2	2	2	2	1
6	1	2	2	2	2	2	2	2	2	2	2	1	–
7	1	2	3	3	2	2	2	2	2	2	2	2	1
8	1	3	2	2	2	2	2	1	1	1	–	–	–
9	1	3	3	3	3	3	2	3	2	2	2	2	2
Mean	1.0	2.3	2.4	2.4	2.2	2.1	2.0	2.0	1.9	1.9	1.9	1.9	1.6

– = Not registered for practical reasons.

Test subjects and procedures

Mirror test. A dental mirror sliding test was used to assess the validity of the ILA method when registering dryness of the oral mucosa. The back of a mouth mirror was drawn along the buccal mucosa on the right and left side, and the friction was registered in accordance with a three-point scale. Grade 1: no obvious friction—that is, the mouth mirror slides easily along the bucca. Grade 2: some friction is registered. Grade 3: high friction—that is, the mouth mirror is almost stuck to the mucosa. The highest friction value in each subject is chosen.

ILA test. To produce a state of oral mucosal dryness, the following procedure was carried out: nine healthy volunteers, three men and six women with a mean age of 24 years (range, 20–27 years) and with no symptoms of xerostomia, were selected for the study. Methylscopolamine nitrate, 1.0 ml (Skopyl®, 0.5 mg/ml, Pharmacia AB, Uppsala, Sweden), was injected submucosally in the labial sulcus. Each subject refrained from eating or drinking for 1 h before the start of the experiment.

The mirror test and the measurements with the ILA method were performed in the buccal and lip mucosa immediately before injection and then after each 30-min period up to 6 h.

Statistics. Wilcoxon's signed-rank sum test was used to analyze differences between test values registered with the ILA method at various time intervals after injection.

Results

Mirror test

Friction values of all nine subjects are shown in Table 1. All of them showed at least grade-2 values—that is, increased friction—half an hour after injection. A return to grade 1, to normal, was registered within the experimental period in five subjects. In four of them some dryness remained even after 6 h, but all of them later returned to normal.

Infrared light absorption test

The ILA values measured in the buccal and the lip mucosa are shown in Figs. 2 and 3, respectively. A statistically significant decrease ($P < 0.01$) was registered in both locations 1.5 h after injection. However, there was insufficient individual agreement between registered values and dryness scores estimated with the mirror test. For instance, in subjects 2 and 9 extreme dryness was registered with the mirror test (grade 3) but relatively moderate changes of ILA values.

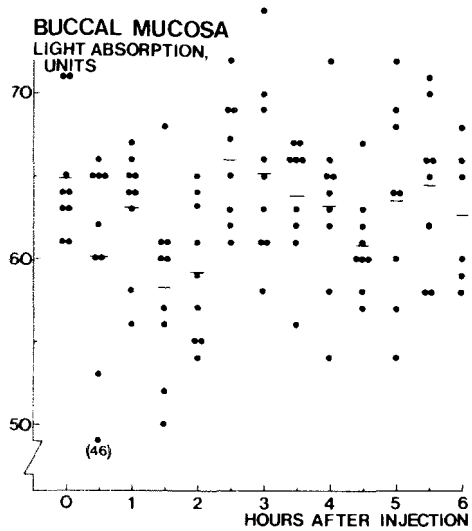

Fig. 2. Infrared light absorption values measured in the buccal mucosa in nine subjects before and after injection of methylscopolamine nitrate. Mean values indicated by bars.

Further, subject 5 showed relatively large changes of ILA values but moderate clinical dryness (grade 2). The inconsistency between the two methods is further illustrated in Fig. 4. It is obvious that large

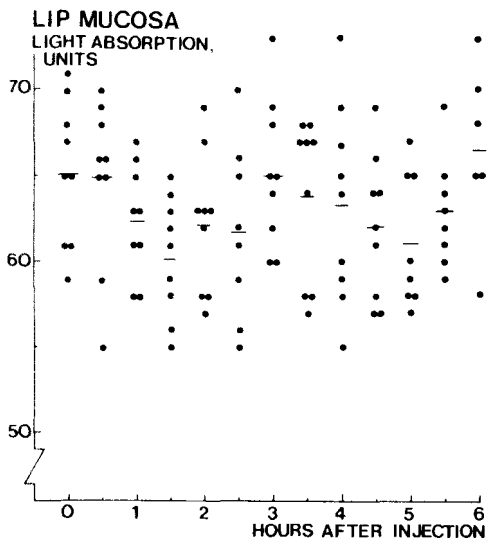

Fig. 3. Infrared light absorption values measured in the lip mucosa in nine subjects before and after injection of methylscopolamine nitrate. Mean values indicated by bars.

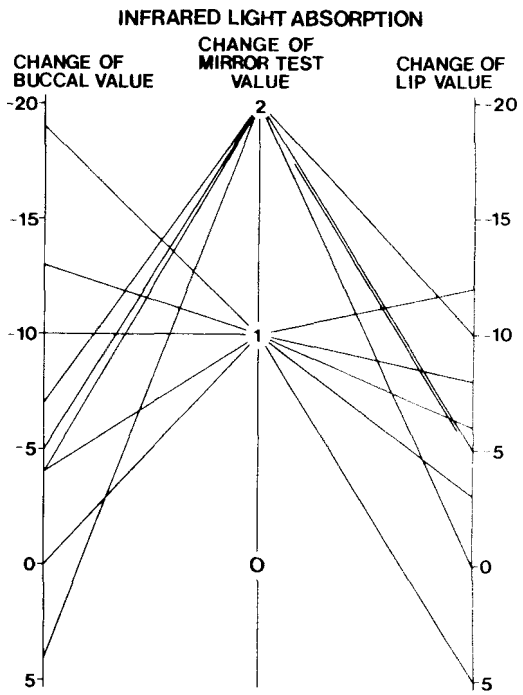

Fig. 4. Comparisons of changes in infrared light absorption and mirror test values 1.5 h after injection of methylscopolamine nitrate in buccal and lip mucosa.

changes of friction estimated by the mirror test in most cases correspond to only minor reductions of light absorption values or, in one case, even an increased value.

For practical reasons, one subject could not attend on the measuring occasion 2.5 h after injection, and one subject could not attend after 5 h. Another subject did not attend on the measuring occasion 6 h after injection, and because of technical failure there was one dropout at the same measuring time.

Discussion

In comparison with previously tested electric methods (8), the present ILA method probably has negligible influence on the mucosa. However, when measuring on the oral mucosal surface, some factors must be considered. The most important one is probably

the fact that light penetrates through the superficial pellicle and also the epithelial layer. Hence, the values obtained may partly reflect the water contents in deeper tissue layers. This disadvantage may not be decisive when measuring in the skin because of superficially present components that may absorb relatively large fractions of light. Measurements of the moisture on the surface of the skin (9) therefore give more valid results than corresponding measurements in the oral mucosa.

Furthermore, the contents of superficial proteins or glycoproteins may influence the light absorption pattern. As shown by Baier & Glantz (10), however, the protein component or its absorption properties are physically rather stable. Thus, variations obtained through the design of this study should hardly be influenced by variations in the protein absorption properties. Alternatively, a possibly low validity may be related to a high proportion of water in oral mucosal tissues in various tissues strata, but other elements may also influence the values obtained.

According to the description of the instrument, the measurement limits within which high resolution and reliability prevail should not exceed a water content of 20%. However, in-vitro tests point to a linear correlation with increasing contents of water from an absolutely dry to an absolutely wet filter disc.

In this study, an overall decrease of infrared light absorption was observed in the study group after about 1 h. As shown, this was not individually correlated to oral mucosal surface dryness. The pharmacologic action could possibly be exerted on the vascularity of the connective tissues, and this effect may co-vary with the oral soft tissue water content.

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