Dysphagia 6:211–213 (1991)

Dysphagia

Masticatory Ability in Experimentally Induced Xerostomia

Birgitta Liedberg, D.D.S.[1] and Bengt Öwall,[2] Odont. Dr.
[1]Department of Oral Diagnosis, Dental School of Malmö, Malmö, Sweden and
[2]Department of Prosthetic Dentistry and Stomatognathic Physiology, Royal Dental College, Aarhus C, Denmark

Abstract. The masticatory ability of 15 nondysphagic volunteers with complete natural dentition was tested using different chewing parameters including preparation of a two-color plastic chewing gum (bolus shape, and color mixture), particle reduction of a piece of silicone, and number of strokes before swallow of almonds. The tests were performed under conditions of normal salivation and experimental oral dryness caused by intramuscular injection of methylscopolamine. The chewing gum tests as well as the silicone particle reduction tests were not influenced by lack of salivation. The number of chewing strokes prior to the initiation of swallowing of almonds was significantly increased. Oral dryness seems to cause accumulation of particles in the oral cavity from friable food and the particulate material is not transported posteriorly into a "ready-to-swallow" positioning. The absorption of saliva by dry oral content such as an almond further impaired oral manipulation of food.

Key words: Experimental xerostomia — Chewing — Oral function — Swallowing — Deglutition — Deglutition disorders.

Oral dryness, or xerostomia, as occurs in Sjögren's syndrome, is associated with problems of chewing and swallowing [1–3]. According to Bertram, approximately 10% of patients with oral dryness have swallowing problems [1]. The mechanical effect of the saliva in relation to normal chewing and swallowing is to lubricate the mucosa and moisten dry food. The moistening of oral content during chewing has been considered in relation to the number of chewing strokes before swallow and the type of food [4]. Results from chewing studies support the concept that the dryness and viscosity of the food are more important than the particle size in determining the number of chewing strokes prior to swallow [4]. No correlation was found, however, between salivary flow rate from the major salivary glands and the duration of the oral phase of swallowing [5]. No study has evaluated the actual chewability of different types of food and other materials in relation to oral dryness.

The aim of this study was to compare the mastication of different types of material during normal oral conditions and experimentally induced oral dryness.

Material and Methods

Fifteen dental students with complete natural dentition volunteered for this study. There were 5 women and 10 men age 22–31 years, with a mean age of 25. None of them was taking any medication and all were nonsmokers.

Chewing Tests

Four different chewing tests were used. Chewing gum (specially prepared by A/S Alfred Benzon, Copenhagen) made from the same base as their SOR-BITS® was used for the evaluation of color mixing and bolus shape. The chewing gums had been stained blue and red by water-insoluble color. A test piece was made from one blue and one red piece, 10 × 10 × 5 mm each. They

Address reprint requests to: Bengt Öwall, Department of Prosthetic Dentistry and Stomatognathic Physiology, Royal Dental College, Vennelyst Boulevard, DK-8000 Aarhus C, Denmark

Table 1. Mean ± standard deviation for the results of different chewing tests during normal salivation and lack of salivation (mean ± SD)

	Normal salivation	Lack of salivation	p values and significance level
Chewing gum color mixture	2.45 ± 0.3	2.4 ± 0.4	$p = 0.569$ NS
Chewing gum shape	1.2 ± 0.5	1.0 ± 0.8	$p = 0.414$ NS
Optosil® particle reduction	54.0 ± 11.6	48.8 ± 14.3	$p = 0.0222$
Almonds: number of strokes	12.9 ± 3.6	22.2 ± 15.6	$p = 0.0007$

p values and significance levels are provided for comparisons.

were put together with the colors distinctly separated. The test piece was placed in the oral cavity in a standardized way. The subject then made 10 unrestricted chewing strokes. The chewing gum bolus was expectorated and then evaluated for color mixture and shape and categorized into one of five groups for each variable.

Particle size after chewing was evaluated by use of silicon dental impression material. Optosil® tablets (5 mm thick and 20 mm in diameter) were prepared from a silicone dental impression material (Bayer Dental, Leverkusen). They were used for a particle size evaluation according to the method of Edlund and Lamm [6]. The tablets were chewed for 20 strokes, expectorated, fractionated, and measured in a sieve system.

Blanched almonds of uniform size were chewed and swallowed and the number of strokes needed to the first swallow was counted by 2 independent observers, and the mean number was determined. A complete test series consisted of 3 chewing gums, 5 Optosil® tablets, and 3 almonds. The sequence of the test materials was randomized. The order between the test under normal conditions and lack of salivation was also randomized. They were separated by at least 1 day. Lack of salivation was achieved by injection of 0.5 ml methylscopolamine nitrate (Skopyl® Pharmacia, Sweden). The effect was checked with measurements of saliva stimulated by the chewing of paraffin [7].

Statistical Methods

Comparisons were made by Wilcoxon's assigned rank test and the level for significance was $p > 0.05$ (N.S.).

Results

Lack of Salivation

The cessation of salivation was very effective. Eight of 15 test subjects had no measurable saliva after injection of methylscopalamine. The saliva production under normal conditions was 2.71 ± 1.19 (mean ± SD) ml per min (range, 1.0–5.0) and 0.14 ± 0.21 (range, 0–0.6) under test conditions.

Chewing Tests

The results of the chewing test are presented in Table 1. Comments from the test subjects about chewing during lack of salivation were noted. Six persons reported spontaneously the same reaction about chewing the almonds: they felt as if the almond was readily fragmented for swallowing but they were unable to start the swallowing act. Four persons had almost identical comments on sensitivity of the oral mucosa. Their comments about Optosil® and almond chewing were that they had less accurate perception under conditions of lack of saliva and could not locate the particles in the oral cavity. Rinsing with water between the different tests had no effect on the sensation of dryness.

Discussion

Oral dryness is a common clinical complaint that may impair speech, chewing, swallowing, and taste. The dysfunction may be very uncomfortable and affects patients' quality of life in a negative way [1, 3, 8, 9]. A wide literature about chewing ability is available and many variables have been studied. For overviews, see work by Bates and colleagues [10] and Gunne [11].

This study is concerned with the contribution of saliva to chewing competence and to the subjective sense of swallow readiness. Our series documented only young healthy persons with good conditions of the oral mucosa, jaw muscles, and temporomandibular joints. Old or unhealthy persons are likely to show an even more reduced chewing ability in a similar condition of lack of salivation. Therefore, results of our study probably reveal the lowest degree of negative effect.

The experimental set up was based on lack of salivation induced by methylscopolamine nitrate, the effect of which was measured by whole salivary sampling. The reduction was drastic: all subjects had a secretion rate after cessation of salivation that is considered very low (i.e., below 0.7 ml/min) [12, 13]. The whole saliva flow predominantly reveals the secretion of serous saliva and not of mucous saliva, which may be more important for lubricating the mucosa. It has, however, been shown with a friction

surface test of oral mucosa that methylscopolamine nitrate also has a clear effect on buccal as well as lip mucosal wetting [14].

These varied substances and chewing routines test different aspects and variables of mastication. That there is no influence of oral dryness on the ability to chew chewing gum may be explained by the fact that the chewing gum incorporates no saliva and remains as one piece due to internal adhesiveness during chewing. The silicone also does not incorporate any saliva during chewing. It is friable and breaks and the particles are distributed in the oral cavity. Since the Optosil test does not include any swallowing, it is influenced by the difficulty in collecting the particles and locating them between the occluding teeth during chewing under conditions of lack of saliva. The almond test, which includes actual swallowing, is highly modified by lack of salivation. The reason for this may be that the almond, during chewing under conditions of normal salivation, takes up saliva like the Brazil nuts used in similar studies by Lucas and Luke [4]. During experimental xerostomia, the almonds dry out the oral cavity even more during chewing and the collection of the particles is made impossible, as in their transportation towards the pharynx. Månsson and Sandberg have shown that the capacity of repeated dry swallowing is significantly reduced when saliva secretion is inhibited [15].

This is probably due to a depression of the initiation of the pharyngeal swallow reflex. It seems as if the mechanism is related to the dryness as such and not the lack of anything to swallow, since the same situation occurs when particles from almonds are present. Lack of saliva may thus negatively influence chewing of certain types of food and the swallowing reflex directly.

Our study indicates that the type of chewing performance included in kneading a coherent pliable bolus is not influenced by experimental xerostomia. However, the collection of particles of a friable food that are spread in the oral cavity are crucially affected, as is their transportation toward the pharynx. The problems of xerostomia can thus be classified into problems of chewing, swallowing, and locating particles spread in the oral cavity during chewing.

The clinical implication of our results therefore seems to be that in patients with xerostomia hydrophilic foods that also break into particles, such as biscuits and almonds, might be unsuitable for mastication and swallowing and that foods that stick together as a single bolus may be more suitable for swallowing. Meat most probably can be handled almost in the same way during xerostomia as during normal salivary conditions.

The number of chews required to swallow an almond is a simple measure that could be used to grade the degree of oral dryness in patients with xerostomia.

References

1. Bertram U: Xerostomi. *Odontologi 77,* Munksgaard: Copenhagen, 1977, pp 31–42
2. Sreebny LM, Valtini A: Xerostomia. A neglected symptom. *Arch Intern Med 147:*1333–1337, 1987
3. Sessle BJ: How are mastication and swallowing programmed and regulated. In Sessle BJ, Hannam AG (eds): *Mastication and Swallowing.* Toronto: University of Toronto Press, 1976, pp 161–171
4. Lucas PW, Luke DA: Is food particle size a criteria for the initiation of swallowing? *J Oral Rehab 13:*127–136, 1986
5. Sonies BC, Ship JA, Baum BJ: Relationship between saliva production and oropharyngeal swallow in healthy, different-aged adults. *Dysphagia 4:*85–89, 1989
6. Edlund J, Lamm CJ: Masticatory efficiency. *J Oral Rehab 17:*123–130, 1980
7. Ericsson Y: Clinical investigation of the salivary buffering action. *Acta Odontol Scand 17:*131–165, 1959
8. Fox PC, van der Ven PF, Sonies BC, Weiffenbach JM, Baum BJ: Xerostomia: evaluation of a symptom with increasing significance. *J Am Dent Assoc 110:*519–525, 1985
9. Ettinger R: Xerostomia: a complication of aging. *Aust Dent J 26:*365–371, 1981
10. Bates JF, Stafford GD, Harrison A: Masticatory function—a review of the literature III. Masticatory performance and efficiency. *J Oral Rehab 3:*57–67, 1976
11. Gunne HSJ: Masticatory efficiency and dental state. *Acta Odont Scand 43:*139–146, 1985
12. Ericsson Y, Hardwick L: Individual diagnosis, prognosis and counselling for caries prevention. *Caries Res 12* (Suppl 1): 94–102, 1978
13. Heintze U, Frostell G, Lindgärde F, Trell E: Secretion rate and buffer effect of resting and stimulated whole saliva in relation to general health. *Swed Dent J 10:*213–219, 1986
14. Henricsson V, Svensson A, Axell T: Device for measuring dryness of the oral mucosa. *Scand J Rheumatol Suppl 61:* 190–193, 1986
15. Månsson I, Sandberg N: Salivary stimulus and swallowing reflex in man. *Acta Otolaryngol 79:*445–450, 1975