Effect of Salivary Flow Rate on Masticatory Efficiency

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Purpose*:** Saliva is a complex secretion that plays an important role in stomatognathic system activities, and its absence may lead to damaged functions such as mastication. Thus, the aim of this study was to investigate the effect of salivary flow rate on masticatory efficiency. ***Materials and Methods: Sixty dentate subjects were divided into three groups (n = 20) according to salivary flow rate: control (group 1), hyposalivation (group 2), and hypersalivation (group 3). All subjects from group 2 were under dermatologic treatment and taking systemic oral isotretinoin. Subjects from groups 1 and 3 were not taking any systemic medication and hypersalivation was induced in group 3 subjects by using a 6% citric acid solution. Masticatory efficiency was evaluated using an artificial test material (Optosil) and a sieving method. Masticatory efficiency was calculated as the weight percentage of the fragmented test food that passed through the 10-mesh (2-mm aperture) sieve. Data were analyzed using analysis of variance ($P < .05$). ***Results:*** The masticatory efficiency values (%) under normal, hypo-, and hypersalivation were 6.40 (± 4.35), 7.63 (± 5.57), and 4.73 (± 4.85), respectively. However, no statistical differences were found among groups. ***Conclusion:*** Within the experimental design of this study, it could be concluded that patients with reduced or increased salivary flow do not present alterations in masticatory efficiency. *Int J Prosthodont 2009;22:168–172*

Saliva plays a vital role in stomatognathic system activities, such as the integrity of the oral tissues, ingestion, and the preparation of food for digestion.[1] Some components of saliva, such as water and mucins, coat the oral mucosa, providing lubrication and a selective permeable barrier against exogenous insult and desiccation,[1,2] facilitating motor activities like chewing and swallowing.[1]

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Hyposalivation, which is an objective reduction in salivary flow,[3] is usually caused by a general loss of body water, damage to the salivary glands, or an interference of the neural control of the salivary glands.[4] Some consequences of hyposalivation include: xerostomia (subjective sensation of dry mouth[3]); an increase in dental caries; sensation of burning in the mouth; dryness of the lips, throat, skin, nose, or eyes; poorly fitting dentures; and difficulty masticating, swallowing (dysphagia), and speaking (dysphonia).[1,3,5] Its prevalence increases with age and affects 25% to 30% of the population aged 65 years or older.[5,6]

Hundreds of medications have xerostomic potential,[1,4,7] including antihypertensives, antiparkinsonians, antidepressants, antinflamatories, analgesics, and retinoids.[7] The latter are derivates of vitamin A and are mostly prescribed to the young for the treatment of severe acne.[7] They are known to have nonoral as well as oral side effects, including increased damaged, missing, and filled teeth indices as a consequence of reduced salivary flow rate during treatment.[8] The most common side effects of these drugs are dryness of the mouth, lips, nose, eyes, and skin.[9]

Production of sufficient saliva is indispensable for good chewing,[10] since moistening and fragmentation of food are the main functions of mastication.[11] Saliva also has a prominent function in the retention of removable prostheses, which means that a lack of the oral secretion may lead to damaged mastication[12] as well as a deleterious influence on the denture-bearing tissue.[13] It was observed that 29% and 25% of dentate subjects complaining of xerostomia reported difficulty swallowing and chewing dry foods, respectively.[14] Moreover, the number of chewing strokes increased as well as the time food remained in the mouth until swallowing,[15] while the masticatory efficiency decreased[16] after experimentally induced oral dryness. However, it is not known whether a modified salivary flow rate due to a long use of medications has any effect on masticatory function. Thus, the aim of the present study was to investigate the masticatory efficiency under normal salivary flow rate, long-term hyposalivation, and induced hypersalivation.

Materials and Methods

Sixty subjects (34 males and 26 females) with ages ranging from 16 to 26 years participated in this study. Only healthy subjects with good oral hygiene who were free of caries lesions, periodontal disease, and malocclusion and had at least 10 occlusal units and no edentulous regions were included. One pair of occluding molars was counted as two occlusal units, whereas a canine pair was counted as only one. Moreover, to be included in the study subjects had to present no systemic disease and no signs or symptoms of temporomandibular dysfunction. Subjects were selected among the students and staff of Piracicaba Dental School, as well as among patients who had sought dental treatment in the same institution. Additionally, subjects were selected in medical offices among dermatologic patients taking systemic oral isotretinoin therapy according to medical recommendations. The Ethics Committee of Piracicaba Dental School from State University of Campinas approved the research protocol (no. 063/2006) and written consent was obtained from all participants or their caregivers, in the case of participants under 18 years of age.

The subjects were divided into three groups (n = 20): *(1)* normal salivary flow rate (mean age = 21.0 ± 2.2 years), considered to be the control; *(2)* hyposalivation (mean age = 21.2 ± 4.0 years); and *(3)* hypersalivation (mean age = 20.2 ± 2.6 years). Subjects who did not take any medication were randomly divided into groups 1 and 3. Subjects from group 2 (hyposalivation) were undergoing a systemic oral isotretinoin therapy for acne treatment, prescribed by a dermatologist at a dosage of 0.5 to 0.7 mg/kg/day, for at least one month.[9] All of these subjects presented xerostomia and dry lips, which are signs of hyposalivation. However, other conditions, such as dryness of the skin and eyes, were frequently reported. Saliva stimulation (hypersalivation) for subjects in group 3 consisted of dripping a 6% citric acid solution on the tongue's lateral borders.

In order to confirm the salivary flow prior to the evaluation of masticatory efficiency, saliva samples were collected from all subjects. Before collection, the mouth was emptied by an initial swallow. Subjects were instructed not to move their tongue or lips during the procedure, in which saliva was allowed to accumulate in the mouth and expectorated into preweighed containers. The collection period was 5 minutes and the flow rate was expressed in mL/min.[1,16] The saliva weight in grams was assumed to be equal to its quantity in milliliters because the density of saliva is close to 1.0.[17] Samples were collected in the morning between 7:30 and 10:30 with all subjects being instructed to fast and avoid smoking for at least 90 minutes before the sample collection. The salivary flow rate was considered normal when it ranged from 0.3 to 0.4 mL/min.[18] Collection of less than 0.3 mL/min was characterized as hyposalivation, while collections above 0.4 mL/min characterized hypersalivation.

Masticatory efficiency was evaluated using a sieve method after saliva collection. Subjects chewed an artificial test material made of silicone rubber (Optosil, Heraeus Kulzer) for 20 chewing strokes. The silicone was manipulated according to manufacturer's instructions and the test material was prepared in molds to form cubes with edges 5.6 mm in length.[19,20] After setting, the cubes were removed from the mold, weighed individually for standardization, and stored in an electric stove at 60°C for 16 hours to ensure complete reticulation.[19] The cubes were then removed from the stove, and after cooling, were disinfected in 2% glutaraldehyde solution for 30 minutes. After, they were washed, dried on absorbing paper, and weighed once again. Portions of 17 cubes (approximately 3 cm^3 or 3.4 g) were separated and stored in plastic containers until the test. Two portions were offered to each participant, since people are not used to chewing on an artificial material. Only the data from the second portion were used. The volunteers were instructed to chew the cubes in their habitual way while chewing cycles were counted by the operator.[20] The particles obtained after completion of 20 chewing strokes were expectorated on a paper filter sitting on a glass container. Mouth rinse with 200 mL of water was carried out for the complete cleansing of the oral cavity and expectorated on the same filter. Finally, subjects' mouths were examined for retained pieces of the test material. After the water was completely drained, the filter with the particles was stored in an electric stove at 80°C for

Table 1 Means and Standard Deviations of Masticatory Efficiency (%)

	Groups			
	Control	Hyposalivation	Hypersalivation	*P* value*
Masticatory efficiency	6.40 ± 4.35	7.63 ± 5.57	4.73 ± 4.85	.1872

*No significant differences were found among groups ($P > .05$).

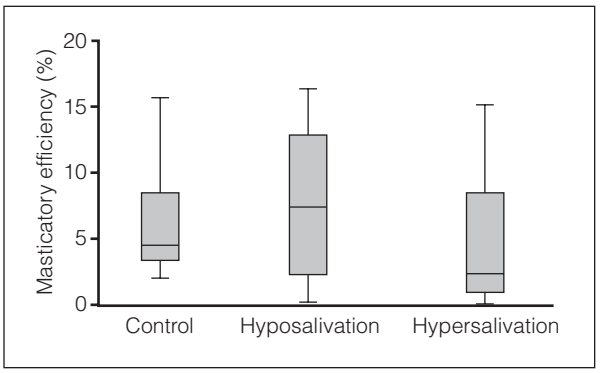

Fig 1 Box-plot of masticatory efficiency for control, hyposalivation, and hypersalivation groups.

25 minutes.[21] The particles were sieved through a stack of up to 10 sieves, with mesh sizes gradually decreasing from 5.6 to 0.5 mm and a bottom plate, in a sieving machine (Bertel Indústria Metalúrgica) for 20 minutes. The amount of test material on each sieve and the bottom plate was weighed on a 0.0001 g analytical balance (Mark 2060, Bel Engineering).[19,20] Masticatory efficiency was calculated as the weight percentage of the fractioned material that passed through the 10-mesh sieve (mesh size of 2 mm).[13,16]

Results were analyzed by analysis of variance at a 5% significance level (SAS/STAT 9.0 software).

Results

The mean flow rate of subjects from group 2 was 0.13 ± 0.07 mL/min (range 0.03 to 0.24 mL/min). Half of these subjects presented a flow rate of ≤ 0.1 mL/min, which is a clear sign of hyposalivation.[18] Saliva production of the subjects from group 1 was 0.34 ± 0.04 mL/min (range 0.3 to 0.4 mL/min), while the flow rate of group 3 subjects was 1.55 ± 0.7 mL/min (range 0.55 to 2.65 mL/min). These values characterize the three salivary flow rates.

Values from masticatory efficiency during 20 chewing cycles showed no statistical differences between groups ($P > .05$) (Table 1, Fig 1).

Discussion

The importance of saliva in oral function is well established[1,3,5] and changes in salivary flow can interfere with it. Saliva secretion was previously stimulated and reduced by orally administering pilocarpine hydrochloride and atropine sulfate to evaluate masticatory efficiency using peanuts as a test food.[16] In that study it was observed that, in spite of the absence of higher values of masticatory efficiency with increased salivary flow, hyposalivation led to a significantly lower chewing capacity. In a similar study by Liedberg and Owall,[15] hyposalivation and xerostomia were achieved by injecting methylscopolamine nitrate and masticatory capacity was measured using almonds, chewing gum, and an artificial material (Optosil). Masticatory efficiency was reduced with the almonds and Optosil. In the present study, masticatory efficiency was not affected by hyposalivation. The two referred clinical studies[15,16] were conducted within healthy, young individuals with normal salivary flow who did not use any medication. The anticholinergic drugs used to induce hyposalivation were administrated before the tests in one single visit, leading to an abrupt reduction of saliva secretion. In the present study, the volunteers had already been medicated by their doctors for at least one month, ie, they were part of the population who used xerostomic-potential drugs. It is suggested that the discrepancies in the outcomes between both of those studies[15,16] and this research occurred because individuals who had been taking xerostomic medications had already been used to having reduced salivary secretion. In contrast, in this study, subjects who underwent saliva stimulation did not present the altered masticatory efficiency in relation to normal flow rate subjects, which is in accordance with Ishijima et al.[16] Hypersalivation induced by means of pilocarpina hydrochloride[16] or 6% citric acid dripping promoted a sudden salivary flow increase, generating discomfort and an oromotor coordination deficiency during functions, as reported by the participants of this study.

On the other hand, it is well known that chewing capacity influences the production of saliva.[22] The presence of food in the mouth is a powerful stimulus to salivation and this can be attributed to gustatory stimulation and masticatory movements.[11,23] However, the effect of the gustatory stimulation of foods is considered more important than mechanical stimulation.[18,23] The salivary flow rates observed during chewing tests using natural foods, which are flavored, is much higher than those observed with unflavored materials due to taste stimuli.[17] The artificial material used in this study was tasteless and did not affect the salivary flow rate through gustatory stimuli. It is also important to consider that during mastication, it is likely that mechanoreceptors in the gingival tissues will be stimulated, which may result in an increased salivary flow.[24] The artificial material used in this study was not softened by saliva as natural foods are, and the force needed to crush it is much larger than the force used to knead natural foods usually used in masticatory tests, such as peanuts, almonds, and Melba toast.[17,25] Thus, following this reasoning, it can be suggested that the mastication of Optosil, a hydrophobic and hard material, caused an increased salivary flow, promoting similar conditions for all subject groups. These considerations may contribute to the explanation of why the salivary flow rate did not influence masticatory efficiency in the present study.

Hyposalivation and xerostomia cause discomfort and damage oral functions. Systemic diseases and the use of xerostomic medications are two of their most important etiologic factors.[1,4,14] Therefore, the senior population is most affected by the dry mouth condition.[11] In patients wearing complete or partial removable dentures, xerostomia was associated with soreness in denture-bearing tissues, and complete denture wearers complaining of dry mouth reported dissatisfaction with chewing and speaking.[12]

As a consequence of the continuous increase in the number of individuals belonging to the geriatric group[13] and the dissemination of xerostomic drug intake by the young, hyposalivation has become more common. The fact that hyposalivation induced by the use of xerostomic drug intake did not influence masticatory efficiency in this study does not diminish the importance of its control by clinicians, who should evaluate the need for stimulating saliva production, neutralizing the xerostomic effect by drug replacement when possible, restituting the oral secretion, and indicating oral treatments to prevent dental decay. These procedures aim to reduce oral signs of dry mouth and the damage caused by lack of saliva, reducing discomfort, dissatisfaction, and oral deterioration in denture wearers. Other studies are needed to elucidate how and to what extent the lack of saliva affects the quality of life of patients.

Conclusion

Within the limitations of this study, it is possible to conclude that salivary flow rate did not affect masticatory efficiency.

Acknowledgments

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Literature Abstract

Immediate rehabilitation of the completely edentulous jaw with fixed prostheses supported by either upright or tilted implants: A multicenter clinical study

The aim of this prospective clinical study was to investigate the treatment outcome with immediately loaded full-arch fixed prostheses supported by a combination of upright and tilted implants in patients with completely edentulous jaws up to 5 years and compare the outcomes for upright and tilted implants. This paper reports on the preliminary data of implant survival and peri-implant bone loss after up to 3 years of function. Sixty-five patients (43 women, 22 men) with a mean age of 59.2 years were enrolled. Ten patients were smokers. Twenty-four mandibles (96 implants) and 41 maxillae (246 implants) were reconstructed with immediately loaded full-arch fixed prostheses supported by both upright and tilted implants. In the mandible, two posterior implants were placed at a tilt of approximately 25 to 35 degrees. Two implants were placed upright in the interforamina anteriorly between the two posterior implants, giving a total of four implants in all mandibles. For the maxilla, the most posterior implant on each side was placed 3 to 4 mm from and parallel to the anterior sinus wall at a tilt of 30 to 35 degrees, with the posterior side 1 to 2 mm anterior to the medial sinus wall. Subsequently, two implants were placed upright in the anterior maxilla parallel to the midline. Finally, two implants were placed on each side in the available space between the implants already placed, giving a total of six implants in all maxillae. All implants were placed in a one-stage procedure, with angulated abutments used as healing abutments if implant inclination exceeded 30 degrees. Success criteria included: no clinical mobility; no peri-implant radiolucency or infection; no complaints of pain, neuropathy, or paresthesia; and crestal bone loss that did not exceed 1.5 mm at the end of the first year of function or 0.2 mm per year subsequently. Using a computer-aided radiographic technique, bone loss around tilted and upright implants was compared using the unpaired Student *t* test. Significance level was set at $P = .05$. Cumulative implant survival over time was assessed using Kaplan-Meier analysis. The maxillary cumulative implant survival rate was 97.59% up to 40 months, with a mean follow-up of 22.5 months of loading. There were no failures recorded in the mandible, yielding a 100% success rate. No prostheses failed in either jaw. At the 12-month follow-up, crestal bone loss for upright maxillary implants averaged 0.95 ± 0.44 mm compared with 0.88 ± 0.59 mm for tilted implants. For the mandible, bone loss averaged 0.82 ± 0.64 mm for upright implants and 0.75 ± 0.55 mm for tilted implants. There was no significant difference in crestal bone loss between tilted and upright implants in either jaw at 12 months. The authors concluded that immediate loading on combined upright and tilted implants could provide a predictable clinical outcome. They did, however, rightly recommend that this procedure be reserved for expert clinicians, in view of the highly technique-sensitive surgical procedures.

Capelli M, Zuffetti F, Del Fabbro M, Testori T. *Int J Oral Maxillofac Implants 2007;22:639–644.* **References:** 22. **Reprints:** Dr Matteo Capelli, Galeazzi Institute, Via R. Galeazzi 4, 20161 Milan, Italy. Email: matcap@dentalbrera.com—*Elvin W.J. Leong, Singapore*