学 位 論 文

高齢者における口唇閉鎖訓練，もしくは音波ブラシによる唾液流量への影響

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松本歯科大学大学院歯学独立研究科博士（歯学）学位申請論文

The effect on salivary flow of lip trainers and sonic toothbrushes in older Japanese patients

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［目的と背景］

唾液分泌の減少は、口腔内の乾燥を惹起し、咀嚼、嚥下、発音にも影響する。それに伴い口腔内常在菌が増殖すると歯周炎やう蝕の誘発に繋がる。それゆえ、口腔乾燥感をもつ高齢者の唾液量を上げることは重要である。今回の研究目的は、口唇筋力固定装置および音波歯ブラシによる機械的刺激の唾液の流出状態と口腔内湿潤状態改善に対する効果を検討した。

［方法］

松本歯科大学病院歯周病科に通院する26人の口腔乾燥の自覚のある患者がこの研究に登録した。すべての患者は 20 本以上の歯を有しており、年齢は60歳以上である。被験者を、無作為に13人ずつの2群に分けた。パタカラ群（P 群）では、被験者はパタカラ®を使用し、1 日 3 回、3 分のトレーニングを 6 か月間行った。ソニッケアー群（S 群）では、被験者は音波歯ブラシのソニッケアー®を 1 日 3 回、2 分、6 か月間使用した。刺激時唾液量、安静時唾液流量、口腔湿潤性と唇閉鎖力を、訓練開始前、1 か月後、6 か月後に測定した。また、歯周組織検査（プロービング深さ、臨床アタッチメントレベル、プロービング時の出血）を訓練開始前とベースラインの6か月時点で行った。

［結果］

刺激時唾液量と安静時唾液量について、両群とも 1 か月、6 か月の時点で増加しており、S 群よりも P 群のほうがより唾液量が増加した。さらに、P 群は口腔内湿潤度においても S 群より増加していた。P 群における口唇閉鎖力は 1 か月後と 6 か月後ともに向上した。臨床パラメーターは、両群で改善が認められたが、S 群でより改善された。

［結論］

高齢患者における口腔乾燥度は、口唇筋力トレーニングとソニッケアー®でブラッシングしたことによって向上した。

ABSTRACT

Aim and Background: Oral dryness causes various problems such as difficulty in swallowing and speaking. It also causes oral bacterial imbalance and increases risk of caries. Therefore, it is important to examine the effect of stimulation of the saliva flow by devices in an aged population with complaint of oral dryness sensation. The aim of this study was to improve and maintain the saliva flow and the oral wetness in Japanese elderly patients by facial mimetic muscle training using the lip trainer device or by using the sonic electric tooth brushing.

Methods: Twenty-six patients were referred to the Department of Periodontology, Matsumoto Dental University Hospital, with complaints of oral dryness were enrolled in this study. All the patients had 20 or more teeth and were aged 60 years and above. They were randomly divided into two groups (P and S) of 13 each. In group P, subjects used the Patakara® lip trainer for 3 minutes, 3 times per day for 6 months. In group S, subjects used the Sonicare® sonic toothbrush for 2 minutes, 3 times per day for 6 months. Unstimulated and stimulated salivary flow rates, oral wettability and lip closing force were measured at baseline, and after 1 and 6 months. Clinical periodontal parameters: probing depth (PD), clinical attachment level (CAL) and bleeding on probing (BOP) were checked at baseline and 6 months.

Results: Both of the groups showed increased stimulated and unstimulated salivary flow rates, with group P showing better results than group S at 1 and 6 months. Group P also recorded better results for wettability than group S. Lip closing force was improved by facial muscle mimetic training at 1 and 6 months in group P. Clinical periodontal parameters were improved in both groups, but more in group S than group P.

Conclusion: It is indicated that the salivary flow in the older Japanese patients was improved by facial mimetic muscle training and brushing with a sonic toothbrush.

INTRODUCTION

Worldwide healthcare systems in developed countries ensure that health promotion programs are in place and with ever increasing health problems in all age groups, the low-cost is probably not easy to sustain. Measures taken in the right direction at a right time enables to address those issues in advance to prevent the later arising difficulty which would pose as a health burden. It is highly commendable how health professionals including dentists work towards development of measures that focuses on attaining the definitions of epidemiology with early diagnosis and prompt treatment, to implement preventive measures and to explore ready solutions that can be offered to those patient populations at risk. This has considerable impact on health status and future costs.

Japanese average life expectancy is very high with males ranking fifth in the world at 80.21 years and females ranking highest in the world at 86.61 years[1)]. However, healthy life expectancy is 71.19 years in males and 74.21 years in females[2)]. Because of healthy lifestyle and dietary habits, senior citizen accounts for 26% of the population[3)]. Impacts of population aging on health care system can be fairly anticipated. Having realized the major health burden, Japanese health policy makers are well aware that it is paramount to devise methods to combat the health issues in the geriatric population.

Work is being done to modify the life style of elderly. They are encouraged to adopt an active way of life for physical and mental health. For this reason, many physical exercises are part of daily routine in residents of old people home to ensure healthy aging. Effect of aging on stimulated salivary flow in adults has been discussed repeatedly in literature but still there is not clarity of data for implementation of measures to overcome this serious health problem. Older patients come to dentists with chief complaints of dryness of mouth, discomfort, frustration, mood swings and frequent respiratory infections. Cluster of these concomitant problems including dental caries and masticatory issues are not infrequent in this population and mostly pertains to a single common factor: Dryness of mouth.

Oral dryness sensation or xerostomia is a significant health problem. Oral dryness sensation is caused by low saliva output by salivary glands, old age and mouth breathing habit. Those suffering from dry mouth find it difficult to maintain good oral hygiene, several studies have shown that the discomfort of xerostomia may influence scores on the Oral Health Related Quality of Life[4-6)]. It has been reported that xerostomia is closely related to age[7-12]. Aging is defined as the alteration in the form, function of a tissue or organ as a result of biological activity associated with a minor disturbance of normal cellular turnover[13]. Therefore, diminished microcirculation, cellular reproduction, tissue repair and degeneration of elastic and nervous tissue leads to hypo function of body organs with age. Hence, low salivary gland function and weak facial muscles in older people could be potential causes of xerostomia.

Saliva is an important body fluid secreted by three major salivary glands (parotid, submandibular and sublingual) and numerous minor salivary glands. More saliva is secreted each day than any other body fluid. The functions of saliva is that it constantly bathes the oral cavity's soft and hard tissues and keeps bacterial life under control to counter opportunistic infections as oral candidiasis. It has a lubricative function for wetting food and initiation of swallowing and protecting the mucosal surfaces of the oral cavity. It contains antimicrobial enzymes that kill bacteria such as lysozyme, salivary lactoperoxidase, lactoferrin and immunoglobulin A. It also regulates the mouth's mineral balance to maintain dental enamel integrity. The washing effect of saliva removes food debris and plaque, thus preventing dental caries and halitosis.

In response to the diverse needs of oral health in elderly people, it is important to recognize methods that could give relief and would have implications on future health status of the elderly patients. Many salivary flow enhancing products which provide some relief for dry mouth are now available. They include saliva substitute, saliva stimulants (also called sialagogues), dentifrices and pilocarpine medication. Mastication exercises such as gum chewing[14] have been shown to increase saliva flow, and the use of sonic toothbrushes help to diminish oral dryness[15].

In this study, we hypothesized that facial mimetic muscle training using a device, or stimulation of the gingiva by using a sonic toothbrush, could increase salivation and improve periodontal health and be used therapeutically for older patients complaining of oral dryness.

MATERIAL AND METHODS

Twenty-six patients referred to the Department of Periodontology (from April 2013 to April 2015) at Matsumoto Dental University Hospital with complaints of oral dryness were enrolled in this study. All patients were 60 years of age and above and had at least 20 teeth. All were undergoing supportive periodontal therapy (SPT). Subjects had received routine periodontal therapy and only the sensation of oral dryness remained. Patients affected by Sjögren's syndrome, smokers, unmotivated patients and those on medications that affect salivary flow were excluded from this study.

Subjects were randomly divided into two groups, group P (n = 13) and group S (n = 13). In group P, patients undertook facial mimetic muscle training using the Patakara® lip trainer device (Patakara Ltd., Tokyo, Japan) 3 times per day for 3 minutes for 6 months. In group S, subjects used the Sonicare® sonic toothbrush (Diamond Clean, Phillips Electronic Ltd, Amsterdam, The Netherlands) 3 times per day for 2 minutes for 6 months, following the manual instructions. Volume of saliva collected, oral wetness and oral muscle force were measured at baseline, 1 and 6 months. Periodontal parameters, including probing depth (PD), clinical attachment level (CAL) and bleeding on probing (BOP), were recorded at baseline and 6 months.

Patient appointments were kept between 9 am and midday to avoid salivary circadian effects. Subjects were also advised to have an early breakfast routinely, and not to drink any liquid at least 60 to 90 min prior to the saliva collection. They were also advised not to drink alcohol for at least one night before the collection day. The purpose and procedure were explained to all patients and, following the ethical guideline, a signed consent was obtained. This study was designed and presented to the ethical committee review board of Matsumoto Dental University. After obtaining the approval (number: 0181) from the ethical committee, the process of subject recruitment was initiated.

1. Unstimulated saliva flow

Unstimulated saliva flow collection at rest was performed using the passive drool method[16]. Subjects were instructed to clean their oral cavity and swallow the residual saliva in their mouths. After clearing their saliva, subjects were instructed to adopt a slightly head down position. A container was provided and subjects were told to allow saliva to pool in mouth and perform gentle spitting maneuver to collect the saliva for 10 minutes.

The subjects were monitored and advised to keep the movement of the tongue and oral musculature to a minimum to avoid any stimulation of salivary production. The normal range was determined at over 1 ml / 10 m.

2. Stimulated salivary flow

Stimulated salivary flow rate was measured using the Saxon method[17]. Sterile gauze 7.5 × 7.5 cm was placed in a container and weighed. Subjects were advised to clean their oral cavity and swallow the residual saliva to remove all pre-existing oral fluid. Subjects were then advised to chew on the gauze piece for exactly 2 minutes (at their own eating pace) using a digital timer, and to spit out the gauze with saliva into a container. The difference in container weight was calculated using an electronic scale (KP103, Tanita, Tokyo, Japan). The normal range was determined at over 2 g / 2 m.

3. Wettability

Wettability was measured by using an oral moisture meter (MUCUS®, Life Co. Ltd, Saitama, Japan). It is a very handy device for measuring the oral wetness. It has a sensor at one end and handle with a display screen and button to operate on the other. This device is provided with plastic sleeves which are used on sensor for prevention of saliva contamination. Patients were advised to sit in a comfortable position and the sensor was placed with gentle pressure of 200 g on the dorsal surface of tongue 10 mm from the tip, and on the buccal mucosa 10 mm from the angle of the mouth. Measurements were taken three times and the average value was taken as the final result. The normal range of oral wettability was set at 25% and above.

4. Lip closing force

A multidirectional lip closing force measurement system was used[18]. The measurement probe was made up of eight phosphor-bronze plates each holding a strain gauge surrounding a plastic octagonal prism, and was capable of determining directional forces in eight directions. Before the measurements were taken, the subjects were given brief instructions about the apparatus. The head of each subject was fixed so that the Camper plane line was parallel to the measurement probe. The metallic plates of the measurement probe were covered by a thin plastic cover to prevent salivary contamination and provide infection control. In each recording session, three sets of measurements were taken, with 3 minutes intervals between each set of measurements to avoid oral muscle fatigue.

5. Periodontal examination

Clinical parameters were recorded in both groups at baseline and 6 months. All data were measured at six points per tooth to the nearest 0.5 mm using a periodontal probe (UNC-15, Hu-Friedy Mfg. Co., Chicago, USA).

6. Statistical analysis

All data were expressed as mean ± standard deviation (SD). Statistical Package for Social Science for Windows (Ver.15.0, SPSS, Tokyo, Japan) was used. For saliva flow rate (unstimulated and stimulated) and wettability, repeated analysis of variance (ANOVA) was used to calculate statistical differences among baseline, 1 and 6 months. Groups P and S at each time point was compared using an un-paired t-test. Lip closing force was calculated by repeated ANOVA among values at baseline, 1 and 6 months.

For clinical parameters (PD, CAL and BOP), repeated ANOVA was used to calculate statistical differences between the baseline and 6 months. Groups P and S at each time points were compared using an un-paired t-test. P value was set at $p < 0.05$.

RESULTS

All 26 patients completed the study. Demographic features are shown in Table 1. Although the average value of unstimulated saliva secretion in both groups was above the normal range, 53.8% of subjects in group P and 30.8% of subjects in group S had saliva secretion below the normal range at baseline. The unstimulated saliva secretion increased in both groups during the study; with group P scoring better than group S. Group P at baseline (1.7 ± 1.4 ml / 10 m) increased by 43.5% to 2.4 ± 1.4 ml / 10 m) at 1 month and by 42.9% to 2.4 ± 1.2 ml / 10 m at 6 months. In group S, resting saliva secretion was 1.8 ± 0.9 ml / 10 m at baseline and increased by 38.8% to 2.5 ± 1.4 ml / 10 m at 1 month and by 25.7% to 2.3 ± 1.8 ml / 10 m) at 6 months. However, the difference was not statistically significant (Fig. 1a).

At baseline, values below the normal range for stimulated saliva secretion were seen in 76.9% of subjects in group P and 15.4% of subjects in group S. Stimulated saliva secretion was also increased in both groups, with group P recording superior results compared to group S. In group P, salivary flow rate was 1.5 ± 0.9 g / 2 m at baseline and increased by 39.2% to 2.1 ± 0.9 g / 2 m at 1 month, and maintained a 34.0% increase (2.1 ± 0.6 g / 2 m) at 6 months compared with baseline. In group S, stimulated saliva secretion was 2.1 ± 0.7 g / 2 m at baseline and improved by 26.1% to 2.6 ± 1.1 g / 2 m) at 1 month; however, the improved saliva flow decreased by 4.2% to 2.2 ± 0.7 g / 2 m at 6 months. These results were also not statistically significant (Fig. 1b).

At baseline, values below the normal range for wettability were seen in 30.8% of subjects on the tongue and by none on the buccal mucosa in group P. In group S, values below the normal range were seen in 15.4% of subjects on the tongue and in 46.2% of subjects on the buccal mucosa. In group P, the tongue wettability score was 25.7 ± 4.0% at baseline, improving by 8.6% (27.9 ± 2.3%) at 1 month and by 3.9% (28.4 ± 1.5%) at 6 months compared to baseline. Group S recorded wettability scores of 26.7 ± 2.2% at baseline, decreasing slightly to 26.5 ± 1.6% (-0.5%) at 1 month, and increasing fractionally by 0.5% to 26.7 ± 1.8% at 6 months compared to baseline. Inter group comparison showed significant differences between group P and group S at 6 months($p < 0.05$) and a tendency was seen at 1 month ($p = 0.081$) (Fig. 2a).

In group P, buccal mucosa wettability scores were 28.3 ± 1.5% at baseline, improving by 4.1% (29.5 ± 1.1%) at 1 month and 3.1% (29.3 ± 0.9%) at 6 months. In group S, wettability was 26.2 ± 2.3% at baseline, with a minor improvement of 1.7% (26.6 ± 2.6%) at 1 month, but a decline of −1.5% to 25.8 ± 3.1% at 6 months compared to baseline. Inter group comparison showed significant differences in wettability between group P and group S at baseline, 1 and 6 months ($p < 0.05$) (Fig. 2b).

Lip closing force was measured only in group P. Results of lip closing force were calculated at the start of the experiment to be 3.8 ± 1.7N.s and increased by 100.2% (7.5 ± 5.5N.s) after 1 month ($p < 0.05$). At 6 months the improvement rate was 63.6% (6.2 ± 2.6N.s) compared with the baseline (Fig. 3).

Clinical parameters in group P increased fractionally from 2.4 ± 0.2 mm to 2.5 ± 0.2 mm (PD) and from 2.9 ± 0.3 mm to 3.0 ± 0.3 mm (CAL), whereas BOP decreased from a baseline of 7.3 ± 8.2% to 5.4 ± 4.5% at 6 months. In group S, all clinical parameters decreased. PD decreased from 2.4 ± 0.3 mm to 2.3 ± 0.3 mm, CAL decreased from 2.7 ± 0.4 mm to 2.6 ± 0.3 mm ($p < 0.05$) and BOP decreased from 7.8 ± 6.3% to 3.7 ± 3.1% ($p < 0.05$) from baseline to 6 months, respectively. Inter group comparison showed significant differences in CAL between both groups at 6 months (Fig. 4).

DISCUSSION

This study was carried out in a small population of older people with complaints of dry mouth living in the Japanese country side. The people living in country side have a very stable life style. Their work and leisure activity is planned and often do not change on yearly basis. They lead a very active life and are capable of their daily life work. Previous studies have demonstrated the association of self-reported dry mouth with aging populations[7)] and have investigated factors associated with dry mouth in older Japanese[19)]. With a rapidly aging population and high life expectancy, the potential incidence of oral dryness is very high in this population. Therefore, it is important to develop different techniques to treat oral dryness and to test their efficacy. It is also important to design these techniques to be easy to use, easy to maintain, cost effective and could be done properly without assistance.

Loss of cells from the motor nervous system causing a reduction in the complement of motor neurons and nerve fibers are a part of aging[20)]. Loss of skeletal muscle mass, quality and strength related to aging are a phenomenon known as sarcopenia. Previous studies have shown the efficacy of health promotion programs with facial mimetic muscle training for older adults[21)]. It has been established that salivation is controlled by three components of the reflex arch (afferent receptors and nerves, central connection and nucleus, and the efferent arm) [22)]. Repeated movement of facial muscles with a lip trainer is assumed to trigger stimulation in afferent receptors in the facial muscles resulting in increased salivation.

The facial muscles and two of the three major salivary glands are innervated by branches of the facial nerve (CN VII). Therefore, it may also be assumed that induced activity in the facial muscles may be responsible for activation of the superior salivatory nucleus and the submandibular ganglion leading to increased salivary flow. It could also be assumed that facial muscle training and stretching during chewing acts to rehabilitate the deglutition organ and activate salivation. However, long-term use of a training device can lead to desensitization to stimulation, and the exercises are also inconvenient to perform. Therefore, our experiment was designed to test short-term facial muscle training.

Earlier reports have found that sonic toothbrush stimulate saliva flow in a xerostomic population[15)]. Our findings are consistent with this; however, the exact mechanism is still not understood. It could be assumed that the sonic toothbrush provides vibrotactile stimulation for the gingiva. It has also been reported that facial vibrotactile stimulation activates parasympathetic activity[23)] in the parotid or submandibular region, stimulating saliva flow. Our results show that the repeated use of a sonic toothbrush could provide repetitive vibrotactile stimulus on the gingiva, leading to an improvement in saliva flow. The movement of the tooth brush bristles on the gums could also be perceived as massage by the user. It could be assumed that this feeling may also play a part in stimulation in addition to vibrotactile stimulation. It should also considered as and merit that sonic tooth brushing three times a day had a good impact on oral hygiene. This could be the reason that clinical parameter results were better in group S than group P. Therefore, this should be considered as an added advantage.

Both the devices used in our experiment were effective but the different modes of stimulation in both groups showed different results. However, better results were seen in group P which recorded improvement in lip closing force. It has been reported that older patients on medication are more prone to develop hyposalivation, and that the chances of hyposalivation increases with the number of medications taken at any time[24)]. This fact highlights the need to develop a technique for stimulating salivary flow without the use of pharmaceutical products. Keeping this in mind, our experiment did not include any patient who used any type of medication. This was done to avoid any possibility of medication impact on results.

As we have mentioned that oral dryness rapidly deteriorates the oral health. The inspection of clinical parameter was necessary to check if oral health was maintained after saliva secretion was enhanced by stimulation therapies. The results of our experiments showed that the clinical parameters (CAL and BOP) were improved or maintained in both groups. This shows the positive effect of stimulation therapies on oral health.

It is also important to acknowledge the limitations of this study. We used a small group of older Japanese patients living in specific weather conditions and eating Japanese food. Previous studies have reported that meat-based diets, which are harder to chew, cause more salivation than vegetarian diets[25)]. It is also know that saliva secretion varies from hot to cold environments. Therefore, the results of this study should be used with caution when comparing them with studies involving other racial and cultural backgrounds. There is also capacity for having control group and combined group using both Patakara® and Sonicare® devices. It is hoped that these groups would be used in our future research projects.

CONCLUSION

The findings of our research experiment suggests that amount of saliva could be increased by using lip training device and sonic electric toothbrush. Both procedures are effective in maintaining the wetness of the oral cavity. It aims to use the stimulating a natural mechanisms for increasing the saliva production by rehabilitation exercises using either device in the market. The results showed that using the Patakara® or Sonicare® could be helpful for older patients with oral dryness sensations. Similarly, periodontal health was also maintained as shown by periodontal parameters. Results of this study indicate the need to strengthen the preventive program of muscular aging by facial muscle exercises and using sonic tooth brush.

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CONFLICT OF INTERESTS

The author declares no conflict of interest.

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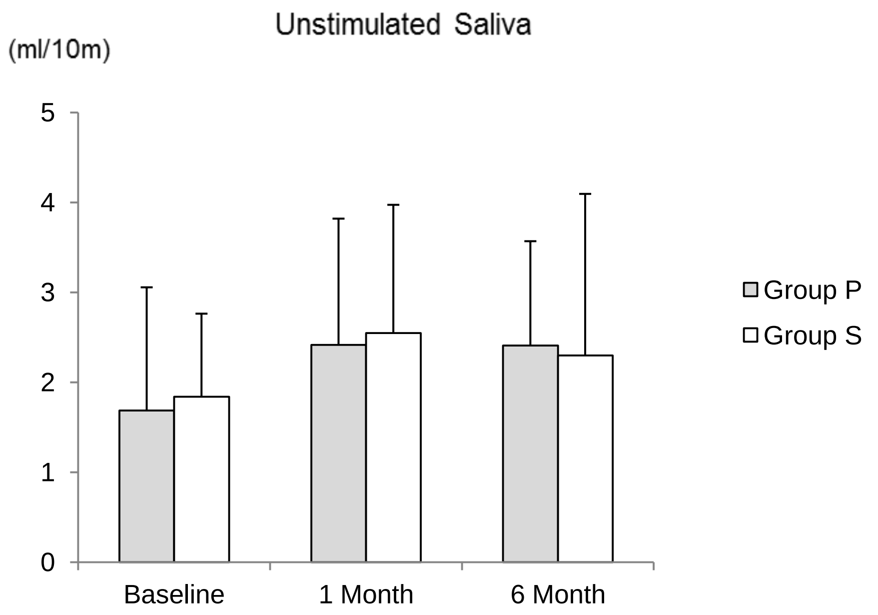
FIGURE LEGENDS

Figure 1. (a) Unstimulated saliva secretion in both groups (b) Stimulated saliva secretion in both groups.

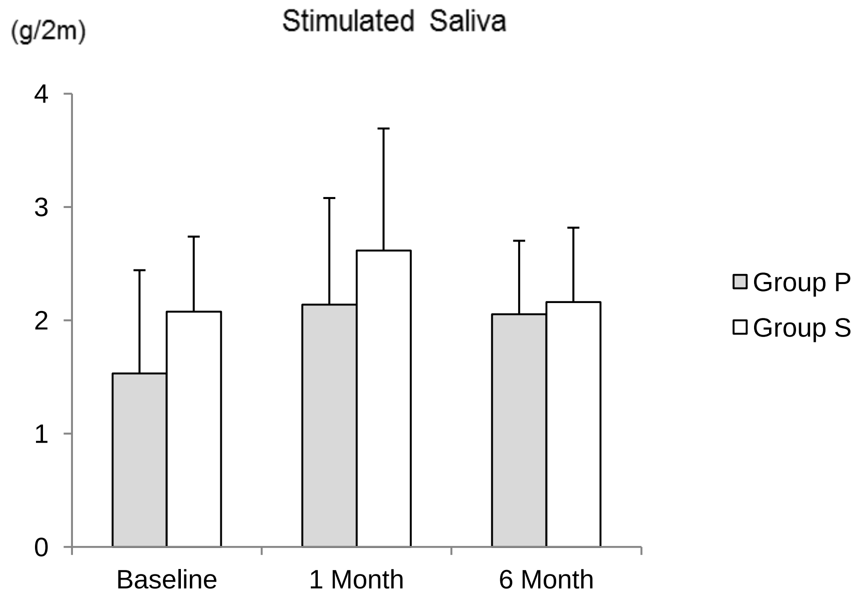
Figure 2. (a) Wettability on the tongue in both groups (b) Wettability on the buccal mucosa in both groups. *p<0.05

Figure 3. Lip closing force test. *p<0.05

Figure 4. Clinical parameters in both groups at baseline and after 6 months. (a) Mean probing depth (PD), (b) Mean clinical attachment levels (CAL)(*repeated ANOVA, **unpaired t-test) and (c) Mean bleeding on probing (BOP).

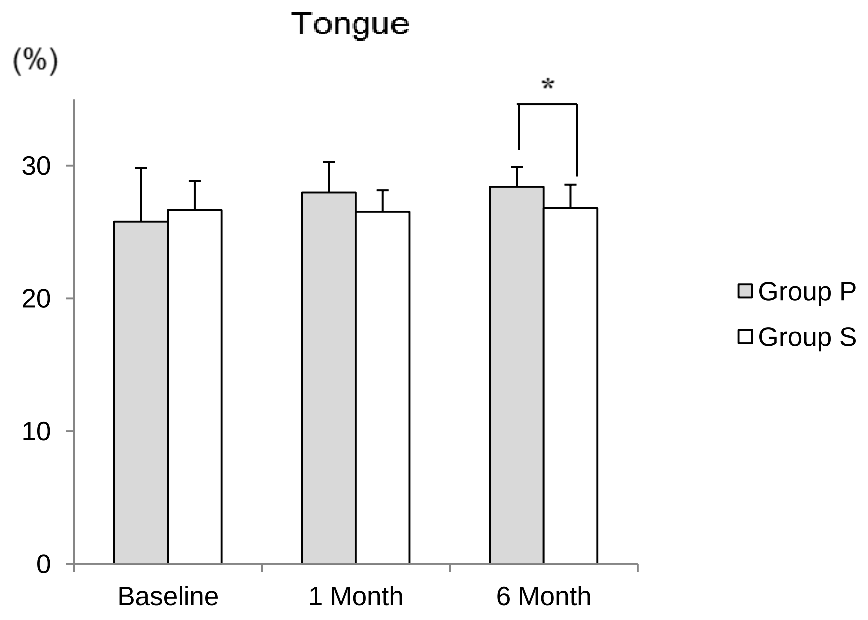

Unstimulated Saliva
(ml/10m)
5
4
3
2
1
0
Baseline
1 Month
6 Month
Group P
Group S

a

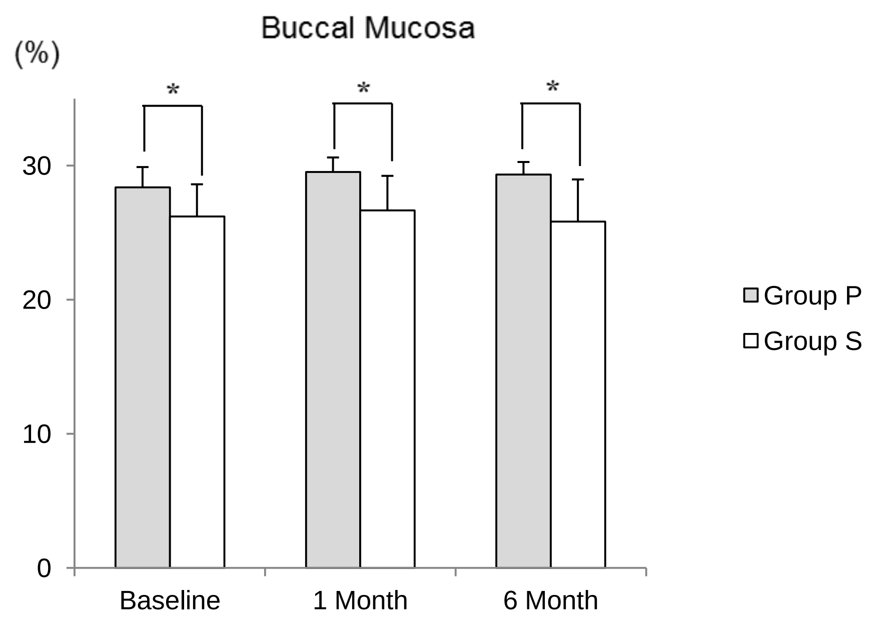

Stimulated Saliva
(g/2m)
4
3
2
1
0
Baseline
1 Month
6 Month
Group P
Group S

b

Figure 1.


Tongue
(%)
30
20
10
0
*
Baseline
1 Month
6 Month
Group P
Group S

a


Buccal Mucosa
(%)
30
20
10
0
*
*
*
Baseline
1 Month
6 Month
Group P
Group S

b

Figure 2.

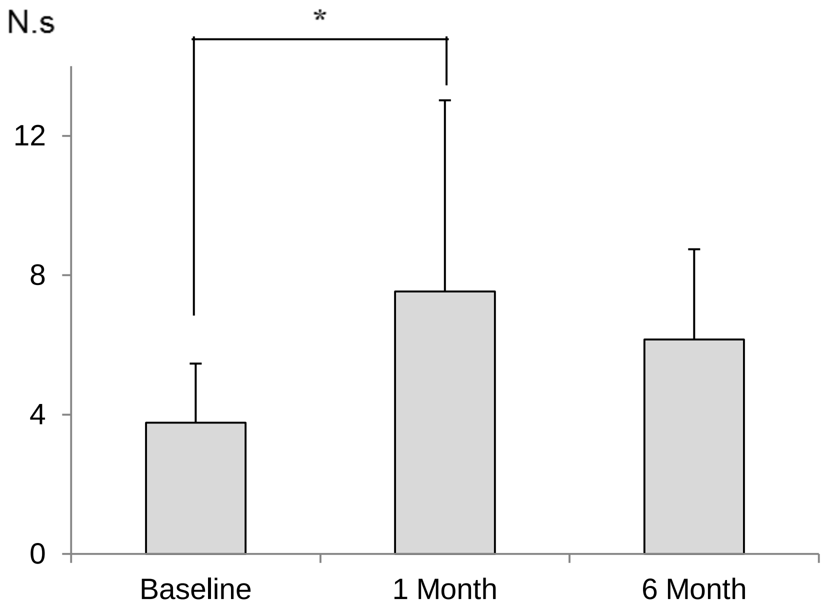
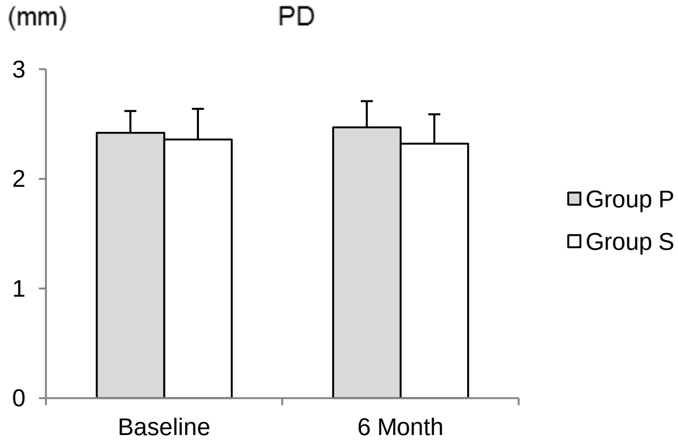
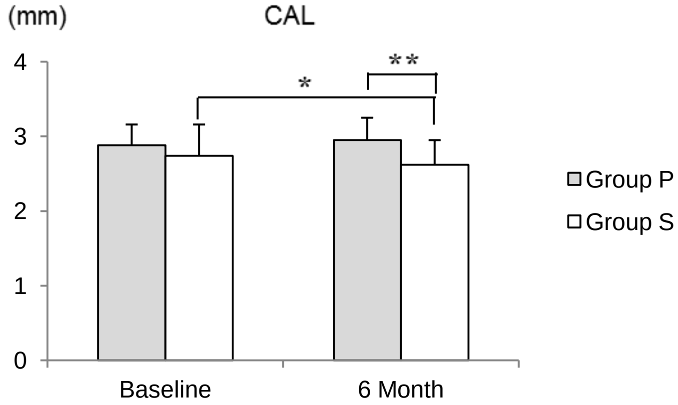


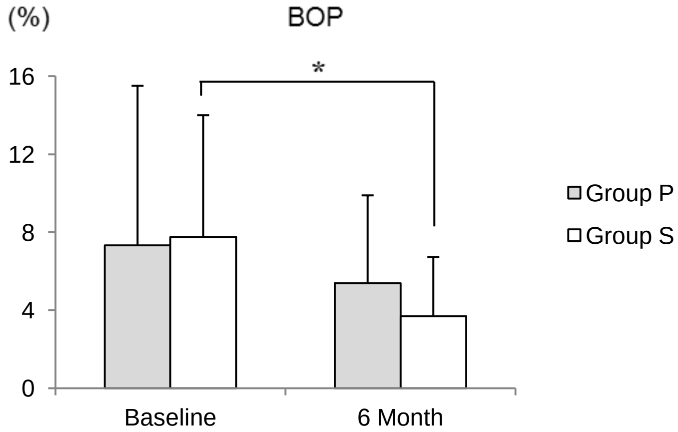
Figure 3.


(mm)
PD
3
2
1
0
Baseline
6 Month
Group P
Group S

a


(mm)
CAL
4
3
2
1
0
**
*
Baseline
6 Month
Group P
Group S

b


(%)
BOP
16
12
8
4
0
*
Baseline
6 Month
Group P
Group S

c

Figure 4.

Table 1.

	Group P	Group S
Number of subjects (n)	13	13
Sex		
Male (%)	4 (30.7)	7 (53.8)
Female (%)	9 (69.3)	6 (46.2)
Age (years)		
Average ± SD	71.3 ± 5.8	67.4 ± 3.5
60 – 70 years	6	11
71 or more	7	2
Number of teeth		
Average ± SD	24.6 ± 2.5	25.3 ± 3.2
20 – 25	7	6
26 or more	6	7