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Original Article

Improvement of taste sensitivity of the nursed elderly by oral care

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It has been suggested that oral care is essential for improving the quality of life (QOL). The aim of oral care involves not only maintenance of oral health but also enhancement of mastication and appetite by means of improving taste sensitivity. There are, however, few studies that have investigated the effect of oral care on taste sensitivity. In the present study, we focused on tongue brushing among oral care and examined the changes in taste sensitivities by mild tongue brushing in the nursed elderly. Ninety subjects, over 64 years old with ability to communicate, were divided into 2 groups, one was the cared group (subject's tongue was brushed) and the other was the control group (not brushed but rinsed). The thresholds for four primary tastes such as saltiness, sourness, sweetness and bitterness were measured before and after treatments using the whole mouth method. The mean recognition thresholds for salty and sour tastes significantly decreased after tongue brushing in the cared group, while those for all four tastes were not changed after mouth rinsing in the control group. The present result suggests that mild tongue brushing may enhance taste sensitivity of saltiness and sourness in the nursed elderly.

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Introduction

One of major pleasures in daily life is eating. Many of the elderly are deprived of the pleasure of tasting delicious foods because their eating function decline with aging. Many researchers have investigated the influence of aging on taste sensitivities and most of them have reported that taste sensitivity somewhat declines with aging, although the affected taste qualities are not always consistent. Winkler et al.[1] reported that salty and bitter taste thresholds rise with aging, while no change in sweet or sour taste threshold was observed. Lassia et al.[2] reported that thresholds for all four primary tastes go up with aging. With respect to the cause of decreased taste sensitivity, ultrastructural changes of taste bud cells in aged mice have been reported[3].

Besides, basic goals of oral care include an improvement of the ability to taste a variety of foods as well as maintenance of oral hygiene. If oral care would improve an ability to taste, it would be especially important for elderly people with declined taste sensitivity. Enhancement of taste sensation by oral care, moreover, would greatly contribute to the maintenance of healthy lifestyle, because it would promote appetite, mastication and salivation. However, there are few reports studying the relation between oral care and taste sensitivity. Thus, we performed the present study to investigate influences of tongue brushing on

taste sensitivities in order to evaluate whether oral care is effective for improvement of taste sensation.

Materials and Methods

Subjects

The subjects were elderly persons over 64 years old with no problem in their ability to communicate, who were mildly nursed and attending nursing homes in Tokyo and Saitama. All of them were recognized that they had no dementia, because they marked over 20 points in the Hasegawa's Dementia Scale-Revised test (HDS-R). All subjects understood the purpose of the present study and gave their advised consent. We included only subjects who had lightly coated tongues by reference to the report by Kojima et al.[4], that is, thickness and area of fur coating is less than 1mm and 1/3 of the anterior tongue, respectively. The subjects having a subjective complaint of taste disorder, dry mouth and oral mucosa disease were excluded.

We interviewed the elderly persons and recorded their medical histories and their routinely taken drugs. Ikeda et al.[5,6], Schiffman et al.[7] and Miller et al.[8] reported on the influences of various drugs on the sensitivities of taste. Although it is reported that drug-induced taste disorder occupies the highest ratio, about 30%, among the taste disorders, a certain drug does not always cause taste disorder in all patients. Since about half of interviewed people had medications because of some chronic disease, we thought that it was inappropriate to exclude them all from a clinical viewpoint and the purpose of this study. We finally screened them by their taste sensitivity using the methods described later when the subjects had any possibilities of taste disorders due to diseases and medications. In case the people could not respond to at least one of the four primary tastes, we regarded them as having a taste disorder and excluded from the present experiment. Consequently, eleven people were excluded because they were regarded as having taste disorder.

As shown in Table 1, ninety subjects were selected for the present study and divided at random into 2 groups, one was the cared group (subject's tongue was brushed) which consisted of 50 subjects and the other was the control group (not brushed but only rinsed) which consisted of 40 subjects.

There were no statistically significant differences in age (*t*-test, $p > 0.05$) and gender (χ^2-test for independence, $\chi^2(0.05) = 3.84 > \chi_0^2 = 0.438$, df = 1) between two groups.

Taste perception tests

We measured the threshold for the four primary tastes. Sucrose, sodium chloride, tartaric acid and quinine hydrochloride solutions were used as sweet, salty, sour and bitter stimuli, respectively, and 13 serial concentrations of each taste solutions were prepared (Table 2). All taste substances were dissolved in distilled water and serially diluted. The solution of highest concentration of each taste was numbered 13 and the lowest one was numbered 1.

The recognition threshold, that is, the lowest concentration that subjects could recognize the taste quality correctly was measured by the whole mouth method. This method is simple and has a merit that the oral cavity can be measured as one unit. After rinsing mouth, 1ml of a test solution was placed on the medial dorsum of subject's tongue using a plastic syringe and held on the tongue for 3 sec, and then swallowed. The test solutions of each taste were applied in ascending order. When the test taste quality was changed, the subjects rinsed out their mouth twice for 10 sec with tap water and a 1 min interval was taken. The application order of the four primary tastes was randomly changed.

Table 1. Age and gender of subjects

	cared group	control group
mean age ± SD (year)	81.6 ± 1.0	81.4 ± 1.2
age range (year)	68-94	66-94
number	50	40
gender (male/female)	17/33	11/29

Table 2. Concentrations of taste solutions

concentration number	sweet (sucrose) M	salty (sodium chloride) M	sour (tartaric acid) mM	bitter (quinine hydrochloride) mM
13	1.1686	3.4223	106.6027	2.5194
12	0.5843	1.7112	53.3014	1.2597
11	0.2921	0.8556	26.6507	0.6299
10	0.1461	0.4278	13.3253	0.3149
9	0.0730	0.2139	6.6627	0.1575
8	0.0365	0.1070	3.3313	0.0787
7	0.0183	0.0535	1.6657	0.0394
6	0.0091	0.0267	0.8328	0.0197
5	0.0046	0.0134	0.4164	0.0098
4	0.0023	0.0067	0.2082	0.0049
3	0.0011	0.0033	0.1041	0.0025
2	0.0006	0.0017	0.0521	0.0012
1	0.0003	0.0008	0.0260	0.0006

Before examination all dentures were removed from subject's mouth, because some studies[9,10] suggested that wearing a denture with palatal plate may cause a rise in threshold of bitterness.

The examination was performed between 10:00 and 12:00 a. m. Therefore, the influences of meal and daily taken drugs were negligible.

Procedure and data analysis

First measurement of the recognition thresholds for the four primary tastes were carried out before treatments in both groups. In the cared group, the tongue was brushed with a Tongue Mate (Dent Care, Japan). The investigator scraped the subject's tongue gently in the direction from the root to the apex 10 times applying an equal pressure to the dorsal tongue surface. The brushed area covered most of anterior tongue that contains the fungiform and foliate papillae but not circumvallate papillae. After tongue brushing the subjects rinsed out their mouth. The appearance of their tongue surface was hardly changed after brushing by direct naked eye observation. In the control group, the subjects had a 1-minute interval after the first series of measurement and then merely rinsed out their mouth instead of tongue brushing. After these procedures, the thresholds for the four primary tastes were measured again in both groups.

Based on the results obtained from the tests mentioned above, taste thresholds for the four primary tastes before and after tongue brushing or mouth rinsing were compared in each group. The Wilcoxon matched-pair signed-rank sum test was used for statistical analysis of the differences between the mean thresholds. The *F*-test was used for statistical analysis of the distributions.

The present study complied with the principles of "the Helsinki Convention".

Results

No statistically significant differences in the distributions of the recognition thresholds for all four primary tastes were observed between the cared group and the control group ($p > 0.05$) in the measurement before treatments. Fig. 1 shows cumulative recognition

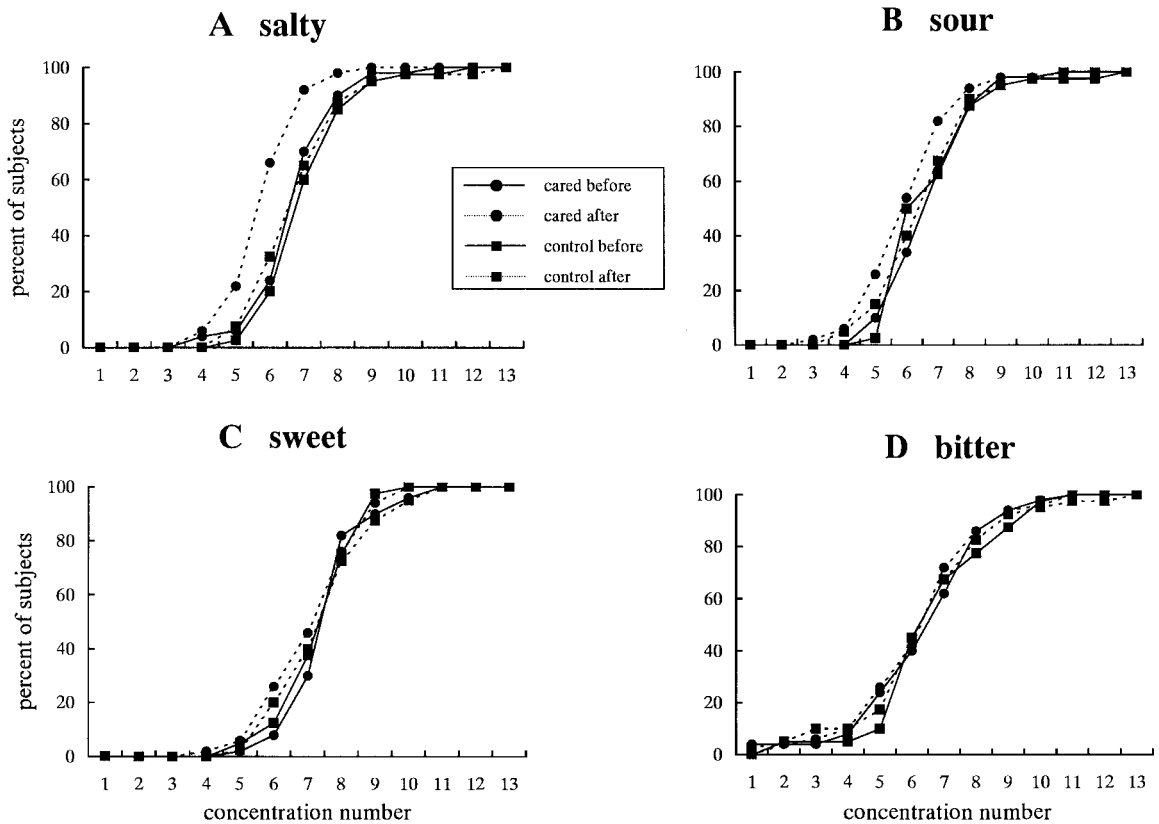

Fig. 1. Cumulative recognition threshold curves for the four primary tastes before (solid line) and after (dotted line) tongue brushing in the cared group (●) and mouth rinsing in the control group (■).

threshold curves for salty (A), sour (B), sweet (C) and bitter (D) tastes. The recognition thresholds in the abscissa are expressed in concentration number. The onset and the completion of the curves corresponds to the lowest threshold and the highest threshold, respectively, and the steepness of slopes inversely relates to range width of thresholds within each group.

The mean recognition thresholds of the four primary tastes obtained from the measurements before and after tongue brushing in the cared group and mouth rinsing in the control group are summarized in Fig. 2.

Saltiness

As seen in Fig. 1A, both onset and completion of the curve for salty taste became lower after tongue brushing (cared), while rinsing mouth (control) little affected the thresholds. In the cared group, the mean recognition threshold of sodium chloride changed to 6.16 $\pm$ 1.04 (mean $\pm$ S.D.) after brushing from 7.10 $\pm$ 1.22 before brushing (Fig. 2), showing a statistically significant difference ($p < 0.05$) between them. In the control group, no statistically significant difference ($p > 0.05$) of the mean thresholds was observed between before and after mouth rinsing.

Sourness

Among the cumulative threshold curves for sour taste in Fig. 1B, the curve after tongue brushing in the cared group was solely lower compared with other three curves. The mean recognition threshold of tartaric acid before and after tongue brushing was 7.08 $\pm$ 1.23 and 6.40 $\pm$ 1.43, respectively, demonstrating that there was a statistically significant difference ($p < 0.05$) between them (Fig. 2). On the other hand, there was no statistically significant difference ($p > 0.05$) between the two measurements in the control group.

Sweetness

As seen in Fig. 1C, all four curves of sweet taste thresholds had similar onset and completion. In the cared group, the mean recognition threshold of sucrose was 7.92 $\pm$ 1.16 before tongue brushing and 7.50 $\pm$ 1.37 after brushing. In the control group, the mean recognition threshold was 7.73 $\pm$ 1.13 and 7.83 $\pm$ 1.43 before and after mouth rinsing. There were no statistically significant differences ($p > 0.05$) between before and after treatments in both groups (Fig. 2).

Bitterness

The characteristic profile that the thresholds for bitter

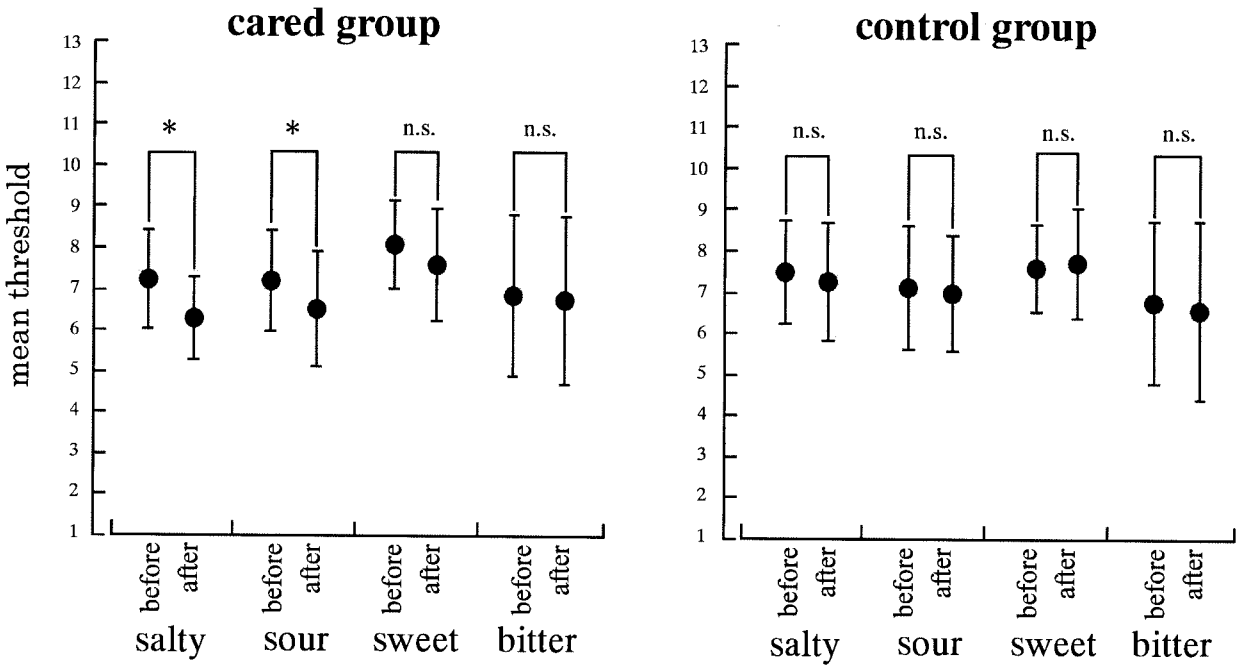

Fig. 2. Summary of the mean thresholds for the four primary tastes obtained from the measurements before and after tongue brushing in the cared group and mouth rinsing in the control group. The vertical bars represent the standard deviation of the mean. *: $p < 0.05$, n.s.: not significant.

taste widely dispersed in comparison with other tastes can be recognized from Fig. 1D. In each group, the cumulative threshold curves before and after treatments almost overlapped. As seen in Fig. 2, the mean recognition threshold for quinine hydrochloride in the cared group was 6.76 $\pm$ 1.97 and 6.68 $\pm$ 2.03 before and after tongue brushing, respectively. In the control group, the mean recognition threshold before and after mouth rinsing was 6.98 $\pm$ 1.99 and 6.78 $\pm$ 2.25. No statistically significant differences ($p > 0.05$) were observed between before and after treatments in both groups.

Discussion

We have investigated the effects of tongue brushing on taste sensitivity by measuring taste recognition thresholds and found that the sensitivities to salty and sour tastes were enhanced after tongue brushing in the nursed elderly.

Since the whole mouth method is suitable to measure subjective taste perception in short period, we adopted whole mouth method among popular methods such as the taste disc method and the drop method[11]. In order to make test time shorter, subjects did not rinse out their mouth after each application of test solution except when taste quality was changed. The total procedure of the present examination including tongue brushing took about 20 min, which is short enough to keep cooperation with elderly persons. Although precise evaluation of the effects needs to restrict the taste stimulation to the brushed area, this procedure requires more complicated operations and time. Thus, the protocol of the present study, which is in accord with the method used by Yamauchi et al.[12], is thought to be a reliable method to evaluate the effect of tongue brushing in the elderly for a short time examination.

The present results are not consistent with the results previously reported[13,14] in some points, probably due to difference in methods. Hyde et al.[13] brushed the tongue 40 times using toothbrush with or without toothpaste, which is stronger brushing protocol than the present one. They reported that only the threshold for bitterness in young subjects became lower after tongue brushing without toothpaste and that the thresholds for the other tastes showed no change or a rise irrespective of age or use of toothpaste. Since influences of flavors or sodium lauryl sulfate contained in toothpaste on the tongue have been reported[15], rises in taste thresholds could be caused by a strong stimulation by toothpaste. Moreover, there is a possibility that 40 times brushing with toothbrush might have caused damage of the tongue epithelium containing taste buds. Langan et al.[14] conducted oral hygiene program including tongue brushing 3 times a week for 5 weeks and measured the taste thresholds of four primary tastes at the beginning and the end of the program. They, therefore, left the daily and within-day variations in taste thresholds out of consideration. They reported statistically significant decreases in the detection thresholds for sweetness and saltiness at the end of the program but not in the recognition thresholds for all four primary tastes. In contrast, we completed measurements in a short period within the limited time (10:00-12:00 a.m.) of day and found a remarkable effect of tongue brushing on the improvement of salt sensitivity in the nursed elderly. In the cared group, the mean threshold of saltiness lowered to 6.16 in solution number (= 31.0 mM), which is approximate to that in the youth (6.24 = 33.2 mM) reported by Yamauchi et al.[12], where they adopted the same method of threshold measurement. This improving effect in the elderly may contribute to compensate for age-related decline in salt perception[16-24], which may in turn lead to decrease in salt consumption of daily foods and to healthy eating habits.

The taste bud have a small opening called taste pore, through which taste solutions reach the apical receptor membrane of taste cells, leading to activation of taste cells[25-27]. The saliva secreted to oral cavity also reaches the taste pore and the resting saliva contains high ratio of mucous substance such as muco-polysaccharide[28]. It is known that a certain type of cells in the taste bud also secrete muco-polysaccharide into the taste pore[29-31]. The mucous substances inside and over the taste pore may interfere with access of taste substances to the receptor membrane. Thus, there is a possibility that mild brushing of tongue surface has removed the mucous that may have not been removed only by mouth rinsing, resulting in an enhancement of the access of taste substances. The enhancement of the sensitivities to salty and sour stimuli observed in the present study may be caused by greater access of taste substances to receptor membranes.

Tongue brushing is also accompanied by mechanical stimulation of the tongue surface. There is a possibility that the stimulation might cause increases in blood flow within the papillae and saliva secretion and contribute to improvement of taste sensitivity. Since the influence of mechanical stimulation of the tongue on taste sensi-

tivities has not been examined, this issue needs further investigation.

The cumulative threshold curves for bitterness in Fig. 1D demonstrates that the thresholds of quinine ranged widely in comparison with the other tastes, which is consistent with the report by Mojet et al.[32]. They found that the standard deviation of the mean threshold for quinine was larger in the elderly than in the young. This may reflect the phenomenon that some of elderly subjects showed quite high threshold of bitterness.

The tongue brushing did not improve the sensitivities to bitter and sweet substances. Taste buds of the circumvallate papillae and soft palate greatly contribute to perception of bitter and sweet tastes[33-35]. These regions were not cleaned by brushing in the present study. This might be the reason that changes in the thresholds for sweetness and bitterness were not observed. There is, therefore, a possibility that brushing of soft palate and posterior tongue would improve the sensitivity to sweet and bitter tastes. In the present study, however, we did not brush these areas, because mechanical stimulation to these areas easily triggers the gag reflex.

The present study provided the basic evidence for the improving effect of tongue brushing on taste sensitivity. This effect is important especially for the elderly because the taste thresholds for all four primary tastes could rise with aging. The present study included only subjects with lightly coated tongues. If the tongue brushing would be applied to the subjects with heavily coated tongue for longer term, greater effects on taste sensitivities would be expected.

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