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Original Article

# Taste Perception in Patients Wearing Upper Removable Orthodontic Appliances with Posterior Bite Planes

**Sarawan Siripanthana D.D.S.**[1]
**Chidsanu Changsiripun D.D.S., Ph.D.**[2]

[1]Postgraduate Student, Department of Orthodontics, Faculty of Dentistry, Chulalongkorn University
[2]Department of Orthodontics, Faculty of Dentistry, Chulalongkorn University

## Abstract

***Objectives*** To compare the recognition threshold of the four taste qualities in patients wearing upper removable orthodontic appliances with posterior bite planes before and after insertion.

***Material and Methods*** Subjects who received upper removable orthodontic appliances with posterior bite planes were recruited in the study. Recognition threshold for salty, sweet, bitter and sour was measured using a Modified Harris-Kalmus test. The tests were conducted on three different occasions; T0-one month before appliance insertion; T1-on the day of appliance insertion; T2-one month after appliance insertion. The retest was additionally performed on T1, prior to appliance insertion. Friedman test was used to statistically compare the recognition thresholds between different testing time and taste qualities. Test-retest reliability was assessed using intraclass correlation coefficient. P-values less than 0.05 were considered significant for all statistical analyses.

***Results*** Eighteen young orthodontic patients (12 males, 6 females), whose ages ranged from 8-14 years old (mean ± SD, 10.89 ± 1.57) were included in the present study. The within-subject reliability proved to be reasonably reliable with intraclass correlation = 0.690. The results showed that recognition threshold increased immediately after insertion of appliances (T1) for all the tastes except for sweet and decreased at T2 compared to T1, however the differences were not significant. When investigating the threshold changes among taste qualities at specific period of time, the results showed no significant differences.

***Conclusion*** Short-term treatment of upper removable orthodontic appliances with posterior bite planes may not affect the taste recognition threshold of the four taste qualities.

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***Key words:*** *orthodontics; posterior bite planes; removable orthodontic appliance; taste perception; threshold change*

***Correspondence*** to Sarawan Siripanthana, poker_z@hotmail.com

## Introduction

Among many of the orthodontic treatment approaches, removable appliances are widely used for growth modification and also for correcting minor malocclusions such as anterior and posterior dental crossbite or deep overbite. Removable orthodontic appliances with bite planes have to be worn all the time even during meals in order to correct the malocclusion. Many patients often complain about their taste change during wearing these appliances. Taste receptors within taste buds are known to locate not only on the tongue but also on the palate as well (Witt et al, 2003). Removable orthodontic appliances consist of acrylic portion cover considerable area of the palate and oral mucosa. These changes in oral environments may affect the patients' gustatory sensitivity. Loss of adequate gustatory function may induce poor appetite, reduced dietary intake and weight loss (Sasano et al, 2012). The patients may refuse to wear the appliances as they feel these appliances interfere with their taste sensation, and this could result in unfavorable treatment outcome.

Previous studies (Har-Zion et al, 2004; Hegde and Dwivedi, 2007) have shown no significant effect of removable orthodontic appliances on taste and flavor, indicating that upper removable appliances do not influence the patients' ability to detect and identify taste and flavor sensations. However, their evaluations were based on subjective verbal description and semi-quantitative rating of the intensity of the stimuli. To the best of our knowledge, no studies have ever been done to evaluate the effect of upper removable orthodontic appliances with posterior bite planes on quantitative outcome such as taste threshold.

Therefore, the aim of the present study was to evaluate the effect of wearing upper removable orthodontic appliances with posterior bite planes on the taste recognition thresholds of the four basic tastes.

## Materials and methods

Sample size calculation was based on previous study (Murphy, 1971). The calculated sample size was 23. Twenty-five subjects who were treatment planned to receive upper removable orthodontic appliances with posterior bite planes during their orthodontic treatment in the Department of Orthodontics, Faculty of Dentistry, Chulalongkorn University, were recruited for this study. All subjects had no systemic disease, no previous orthodontic treatment and did not suffer from any acute problems or diseases in their upper respiratory tract or use any kind of drugs. Research protocol was approved by the Human Research Ethics Committee of the Faculty of Dentistry, Chulalongkorn University.

### Removable appliances

The removable orthodontic appliances were constructed using self-curing acrylic resin (Orthocryl, Dentaurum, Germany) and stainless steel wires. The polymer:monomer ratio was 3:1 with the spray-on method. Each appliance was prepared approximately 1 week before delivery and soaked in water for 24 hours before insertion.

### Taste materials

Stimuli representing the four basic tastes were 1) sodium chloride for salty, 2) sucrose for sweet, 3) citric acid for sour, 4) caffeine for bitter. For each taste, 5 concentrations were prepared in successive 0.2 log dilutions with deionized water to avoid differences in salt levels. The total range of concentrations was chosen on the basis of threshold values reported in previous literatures (Weiffenbach et al, 1982; Bartoshuk et al, 1986; Cowart, 1989; Mojet et al, 2001; Mojet et al, 2005): sodium chloride 120-19.02 mM; sucrose 103-20.60 mM; citric acid 3-0.48 mM; caffeine 4-0.63 mM. The solutions were prepared less than 1 week in advance of use, stored under refrigeration (4°C)

and brought to room temperature one hour before use.

**Testing procedure**

The subjects were asked to refrain from chewing gum, brushing their teeth, or consuming anything except water at least an hour before beginning of the tests.

At the first session, the subjects took a screening test, to which they received the suprathreshold sample of the four taste qualities in randomized sequence. They had to correctly identify the taste qualities in order to ensure that they had functioning sense of taste. In addition, the psychological status was indirectly evaluated by a researcher during this session. The cognitive and attentive abilities of the subject were evaluated. The subject who cannot understand or follow the instructions was excluded.

The recognition threshold was measured using a Modified Harris-Kalmus test (Wise et al, 2007). The test began with the lowest concentration. During each trial, the subjects received a cup containing 10 ml of sample solution and held the sample in their mouths for at least 5 seconds (whole mouth, sip-and-spit method), then expectorated. The subjects had to identify the quality of the taste samples using 5 forced-choice labeled cards; sweet, sour, bitter, salty, or water. Between each of the sample, the subjects rinsed their mouths with deionized water. The subjects sampled each concentration once, in ascending order, until they were able to identify the taste quality correctly. Then they were presented with a sorting task composed of six cups, three containing deionized water and three containing the target solution at the concentration previously identified as having the taste. The subjects' task was to sort the cups into "taste" and "water". If they could correctly sort the samples, that concentration served as their recognition threshold. If subjects failed the sorting task, the test would be continued at the next higher concentration. The example of the testing procedure is shown in Fig 1.

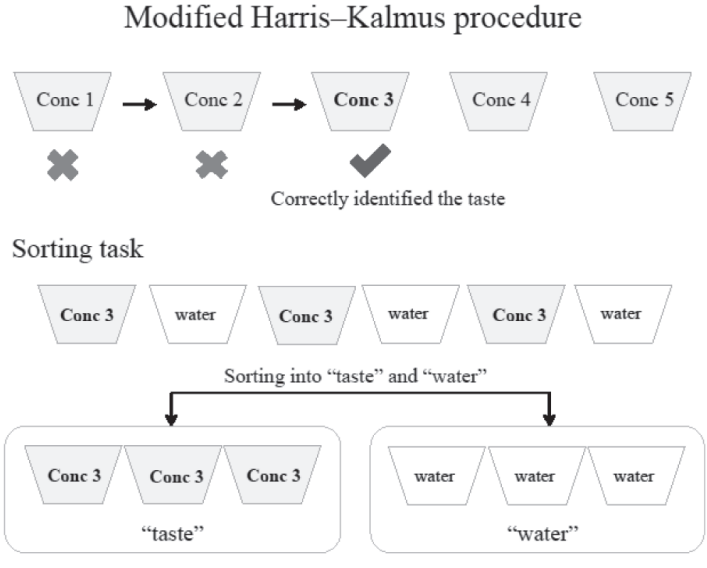


**Fig. 1** Example of a Modified Harris-Kalmus test. The subject received the sample solution in ascending order, beginning with the lowest concentration and attempted to identify the taste. In the example here, the subject identified the correct taste quality at solution "Conc 3". Then the subject proceeded with the sorting task composed of six cups, three containing water and three containing the solution previously identified as having the taste (Conc 3). The subject's task was to group the solutions in two sets and identify those that contained the taste. If the subject succeeded in sorting the solutions, "Conc 3" was labeled as taste recognition threshold.

The testing procedures were conducted on 3 different sessions: T0-1 month before appliance insertion; T1-on the day of appliance insertion; T2-1 month after appliance insertion.

To evaluate within-subject reliability, the retest was performed prior to appliance insertion on insertion day and focused on salty taste.

### Statistical analysis

The threshold concentration values were log transformed to reduce skew, and then these data were used for statistical analysis. The Friedman test was used to compare the recognition thresholds among T0, T1 and T2 in each taste. In addition, the threshold change among taste qualities was evaluated by the same statistical test. Moreover, to show the threshold data in molar concentration unit, geometric mean recognition threshold for each taste was calculated. The test-retest reliability was assessed using intraclass correlation coefficient. The analyses were conducted using SPSS software version 17. P-values less than 0.05 were considered significant for all statistical analyses.

## Results

Of all the subjects recruited, seven subjects were excluded. Three subjects did not pass the screening test, one subject had developed a cold during treatment, two subjects missed the appointment, and the other one discontinued the appliance. The final subjects included in the study were 18 (12 males and 6 females), whose ages ranged from 8 to 14 years old (mean ± SD, 10.89 ± 1.57). All were school-aged children and were able to understand and follow the instruction. Since 7 subjects were excluded, the drop-out rate was 28% and the statistical power of the 18 sample size was 0.632.

The test-retest for within-subject reliability proved to be reasonably reliable (intraclass correlation coefficient = 0.690). The geometric mean recognition thresholds for each taste are presented in Table 1. The recognition threshold increased immediately after insertion of appliances (T1) for all the taste stimuli except sucrose and decreased at T2 compared to T1. However, none of them showed statistically significant differences (Table 2). When investigating the

**Table 1** Geometric mean recognition threshold for each taste quality

| Taste Stimuli | Geometric mean recognition threshold (mM) | | |
|---|---|---|---|
| | T0 | T1 | T2 |
| Sucrose (sweet) | 52.61 | 47.50 | 55.37 |
| NaCl (salty) | 41.05 | 50.37 | 43.21 |
| Citric acid (sour) | 0.74 | 1.01 | 0.86 |
| Caffeine (bitter) | 1.47 | 1.90 | 1.67 |

**Table 2** Comparison of recognition threshold at different testing sessions

| Taste Stimuli | Recognition threshold (Mean ± SD in log mM unit) | | | *P-value* |
|---|---|---|---|---|
| | T0 | T1 | T2 | |
| Sucrose (sweet) | 1.72 ± 0.19 | 1.68 ± 0.22 | 1.74 ± 0.18 | 0.219 |
| NaCl (salty) | 1.61 ± 0.23 | 1.70 ± 0.27 | 1.64 ± 0.25 | 0.607 |
| Citric acid (sour) | -0.13 ± 0.24 | 0.00 ± 0.28 | -0.06 ± 0.26 | 0.052 |
| Caffeine (bitter) | 0.17 ± 0.30 | 0.28 ± 0.25 | 0.22 ± 0.36 | 0.052 |

T0-1 month before appliance insertion; T1-on the day of appliance insertion; T2-1 month after appliance insertion. *P-value* < 0.05 was considered statistically significant (Friedman test).

threshold changes among taste qualities at specific period of time (T0-T1, T1-T2, T0-T2), the change in threshold was highest in sour taste at T0-T1 and T0-T2 but no significant difference was found.

## Discussion

Orthodontic treatment with a removable appliance relies solely on the patient's cooperation and motivation. According to Schott & Göz (Schott and Goz, 2010), a majority of the young patients preferred wearing their removable appliances overnight only. Inadequate wearing time makes the treatment more difficult to achieve. Removable orthodontic appliances occasionally cause many discomforts including the feelings of tension, pain, increased saliva, disturbed swallowing and tongue mobility (Doll et al, 2000). Some patients even complain about their taste alterations. Basically, taste sensations induce the feelings of satiety and are primary reinforcers of eating (Schiffman, 1983) which in turn affect the patient's quality of life. So far, the effect of orthodontic removable appliances on the gustatory sensitivity has not been well clarified.

To compare the present result with other studies on this relevant issue, we found only two investigations (Har-Zion et al, 2004; Hegde and Dwivedi, 2007) which focused on the suprathreshold intensity and palatability using visual analogue scale (VAS). They concluded that upper removable appliances do not affect the taste and flavor sensations. The participants were able to differentiate between the low and the high concentrations. Nevertheless, from our point of view, the use of only low and high concentrations in their evaluations might not be able to detect a slight amount of change in taste sensitivity. On the contrary, the taste threshold can provide a more physiologic measure and appears to be free from the subjective units of rating scales (Lawless and Heymann, 2010). Therefore, we chose to use the threshold measure in our study. Moreover, we focused only in those with the upper removable orthodontic appliances with posterior bite planes, which require the patients to eat with the appliances in their mouths. The results from former studies (Har-Zion et al, 2004; Hegde and Dwivedi, 2007) showed that at times an appliance made a transient alteration in taste perception but was not statistically significant which agree to our study regardless the difference of the method.

One of important factors affecting taste function that needs to be considered is saliva. Saliva has been linked to taste sensitivity, as it is the principal component in the external environment of taste receptor cells

(Klasser et al, 2008). Patients reported increased salivary flow immediately after appliance insertion, which tended to decline overtime (Stewart et al, 1997). This increased saliva might as well be responsible for the increase in the taste threshold at T1 and its decline at T2 that we found in our study.

The idea of increased saliva was supported by Murphy (Murphy, 1971) whose study was done on complete dentures and found that dentures interfered with taste perception. His explanation was that dentures stimulated saliva which diluted the solution and this effect may persist up to 3 weeks until the patients adapted to the dentures. He also suggested another explanation that denture might alter touch, temperature and pain receptors in the oral mucosa and thus changing the perceived taste. In the present study, the salivary flow rate was not monitored which was one of our limitations. However, all the subjects participated in the study had no medications or diseases that affect salivary flow.

In the light of knowing that the late release of self-curing acrylic monomer could affect taste sensation (Baker et al, 1988). It was proved that the amount of monomer released from orthodontic acrylic resins is high in the first 24 hours and began to decline after the first day (Stafford and Brooks, 1985; Ica et al, 2014). So, in our protocol, the appliance fabrication was done 1 week in advance and we immersed the appliance in a water bath for at least 24 hours before delivery.

Until now, the study regarding the relationship between removable orthodontic appliance and taste sensation has been very limited. Here, we studied solely on the threshold aspect of the four taste qualities (sweet, sour, salty, and bitter). Recently, umami has been introduced as the fifth taste that is believed to play an important role in the taste palatability and acceptability of foods (Yamaguchi and Ninomiya, 2000). Hence, further investigation is required for more information of all the five taste qualities and the effect of removable orthodontic appliances on taste threshold as well as taste palatability.

According to Laing et al, by 5 years of age, children can identify the four common tastes that describe gustatory function (Laing et al, 2008). In this study, the reliability of the subjects which were young school-aged children (8-14 years old) was evaluated by the test-retest reliability, conducted 1 month apart with no appliance. The subjects reliability was acceptably high.

Due to the limitation of this clinical study, we were able to recruit only 25 subjects and 7 subjects were later dropped-out of the trial, which left 18 subjects for the final evaluation. The drop-out rate was 28%. Further studies should recruit more subjects to improve the statistical power and therefore could relate the results to the population. Moreover, there was no control group without appliances in this study but the retest without appliances at a period of 1 month showed that the threshold was not significantly altered in such a short duration.

Another limitation was the short follow-up period after appliance insertion. Future studies should be carried out in a longer period which will represent appliance wearing in orthodontic practice. To date, there is no reference threshold in Thai population available. The results from this study might serve as a preliminary in threshold study in Thai children.

## Conclusions

The result indicated that short-term treatment of upper removable orthodontic appliances with posterior bite planes may not affect the taste recognition threshold. Therefore orthodontists should use this information to explain and motivate the patients to wear the appliances all the time including during meals which will be helpful in the treatment outcome.

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