*Original Article*

# Role of taste perception in white spot lesion formation during orthodontic treatment

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**ABSTRACT**

**Objectives:** To investigate the role of individual's taste sensitivity using 6-n-propylthiouracil (PROP) in the development of white spot lesions (WSLs) in adolescent orthodontic patients.

**Materials and Methods:** 44 healthy adolescents, aged 12 to 16 years old, who were in fixed-appliance orthodontic treatment for at least 6 months, consented to participate in this cross-sectional study. Data regarding participants' demographic information, oral hygiene practices, and dietary habits were obtained by a questionnaire. An oral clinical examination was performed to determine the oral hygiene status, the presence of WSLs and dental caries experience. The taste phenotype of the participants was evaluated through PROP test and they were accordingly divided into PROP nontasters and PROP tasters.

**Results:** The sample consisted of 24 subjects in the WSL group and 20 subjects in the WSL-free group. The WSL group demonstrated higher mean plaque score (48.2), mean decayed, missing, and filled surfaces (2.38), and mean decayed, missing, and filled teeth (1.96) scores compared to the WSL-free group (38.7, 0.85, and 0.55, respectively), but no significant differences were found. Most subjects in the WSL group were PROP nontasters (66.6%) whereas most subjects in the WSL-free group were PROP tasters (75%); a significant difference was observed between the groups ($P = .006$).

**Conclusions:** The prevalence of white spot lesions was significantly higher in adolescent orthodontic patients who were PROP nontasters compared to PROP tasters. A PROP taste perception could be a potential risk factor for the formation of WSLs during fixed orthodontic treatment that warrants further attention. (*Angle Orthod.* 2019;89:624–629.)

**KEY WORDS:** Taste perception; White spot lesion; Fixed orthodontic treatment; Adolescents

## INTRODUCTION

One of the most common side effects associated with fixed orthodontic treatment is the formation of white spot lesions (WSLs).[1] WSLs, defined as localized areas of enamel demineralization,[2] can occur as early as 4 weeks from the initiation of orthodontic treatment,[3] and can become fully recognized within the first 6 months.[4] WSLs can lead to an esthetic problem and, if not treated early, the lesion can progress to a frank cavitated lesion.[5] The prevalence of WSLs in orthodontic patients, reported in previous studies, ranged from 2% to 96%.[6]

There are various risk factors documented in the literature that contribute to the development of the WSLs. They include but are not limited to the following: poor oral hygiene before and during treatment, high previous caries experience, preexisting WSLs, duration of orthodontic treatment of more than 36 months.[2,6–8] Nevertheless, not all orthodontic patients develop WSLs. Individual host factors such as salivary flow and composition, enamel solubility, diet, and genetic susceptibility might play a role in the overall risk.[9] Early identification of WSLs in high-risk orthodontic patients is a matter of great clinical importance

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to implement effective prevention and halt the development of any preexisting demineralization.

The relationship between sugar consumption and dental caries has been researched for many years. One of the factors that might influence sugar intake is the sweet preference.[10] This preference has been linked to the bitter taste sensitivity of 6-n-propylthiouracil (PROP), which is an inheritable trait.[11,12] PROP is a medication used in the treatment of Grave's disease (hyperthyroidism) that is also used at low concentrations in taste research. PROP tastes bitter to some individuals (tasters) but is tasteless to others (nontasters).[12] Studies in taste psychophysics have further subclassified tasters into two groups, namely the supertasters, who recognize the extreme most bitterness from tasting PROP, and the medium tasters, who perceive the bitterness but not as intense as the supertasters.[13]

In recent years, several studies have been conducted to identify the association between individual bitter and sweet taste perception and dental caries experience.[14–17] It was found that the majority of PROP nontasters prefer sweet and strong-tasting food and were more likely to have high caries risk compared to PROP tasters.[14–17] No studies have examined the role of individual's PROP phenotype as a risk factor in the development of WSLs during orthodontic treatment. PROP nontaster orthodontic patients might be at a greater risk for the development of white spot lesions than PROP taster patients. Therefore, the purpose of this study was to investigate the association between the presence of WSLs among adolescent orthodontic patients and their different PROP taste phenotypes.

## MATERIALS AND METHODS

This study was a cross-sectional descriptive study and collaborative research between the Kuwait University Health Sciences Centre, Kuwait and the European University College, United Arab Emirates. The research protocol was approved by the ethical research committees of both institutions.

Participants were recruited from the European University College graduate orthodontic clinic. The recruits were adolescents, aged between 12 and 16 years old, with fixed orthodontic appliances for at least 6 months. Exclusion criteria included: (1) patients on a daily supplemental fluoride regimen, (2) patients on systemic medication for chronic diseases, (3) patients with known allergies/ history of adverse reaction to PROP, (4) patients with dental structural abnormalities, fluorosis, or restorations on anterior teeth, and (5) patients with WSLs preexisting to orthodontic treatment (as detected from the pretreatment intraoral photographs).

All participants must have had completed initial records and had received oral hygiene instructions as well as professional cleaning as part of their dental care before and during the orthodontic treatment. Routine clinical photographs were taken prior and during the treatment, based on the series recommended by the American Board of Orthodontics.[18] Informed consent was obtained from the parent or legal guardian, and the assent form was obtained from the participant.

The minimum required sample size ($n = 18$) for each group, WSL group vs. WSL-free group, was calculated based on the effect size equal to 0.50, a *P*-value of $<.05$, and a power equal to 0.8. Patients that had at least one WSL of grade 2, based on Gorelick et al. criteria,[19] were allocated to the WSL group, and patients that had no WSLs were allocated to the WSL-free group. Patients with only grade 1 WSLs were excluded since these lesions were not as discernible with visual examination as grade 2 or 3 lesions and were more difficult to be accurately graded.

### Questionnaire

A structured questionnaire was used for data collection and consisted of two main sections. Information on the demographics of the participants regarding their general health and the duration of orthodontic treatment were collected in the first section. The second section included questions about oral hygiene practices and dietary habits. The questionnaire was not expected to take longer than 10 minutes to complete.

### Clinical Examination

A single examiner performed the clinical examination of the study subjects to assess their oral hygiene status, presence of WSLs, and dental caries experience. All examinations were conducted using a mouth mirror and a fixed dental unit with ample dental light. Initially, the oral hygiene status was evaluated using the Plaque Control Record as described by O'Leary et al. (1972).[20] The presence of supragingival plaque was checked on the four surfaces of teeth (facial, lingual, and proximal surfaces) after staining the plaque with a disclosing agent. The plaque index (PI) was calculated by dividing the number of plaque covered surfaces by the total number of available surfaces. The result was multiplied by 100 to express the index as a percentage. Then, after the arch wire removal without debonding the brackets, all maxillary and mandibular teeth were cleaned, isolated with cotton rolls, and air-dried for 5 seconds. The presence or absence of WSLs was detected on the buccal surfaces of maxillary and mandibular teeth from the right second premolar to

the left second premolar, using the Gorelick Index.[19] The index scores were as follows: Grade 0 = no white spot lesion present; Grade 1 = visible white spots without surface interruption (mild WSL); Grade 2 = visible white spot lesion having a roughened surface but not requiring a restoration (moderate WSL); Grade 3 = visible white spot lesion with cavitation requiring restoration (severe WSL). If at least one WSL Grade 2 was present, the patient was included in the WSL group. Patients in the control group had no WSL of any grade. All teeth surfaces were visually examined to determine the number of decayed, missing, and filled surfaces (DMFS) and teeth (DMFT) in accordance with the WHO 2013 criteria.[21] The examiner was calibrated before the beginning of the study. For WSLs, the examiner evaluated 26 photographs of teeth with WSLs, and this was repeated once again with a 2-week interval. The intra-examiner agreement was 98.7%, and the weighted kappa coefficient was 0.95. For dental caries scoring, the examiner assessed 10 patients who were not involved in the study, and this was repeated once with a 1-week interval. The intra-examiner agreement was 97.2%, and the weighted kappa coefficient was 0.86.

### PROP Test

The PROP test was conducted by a single trained investigator who had no knowledge of the participants' clinical status. To determine the perceived taste sensitivity, a small piece of filter paper (3 cm circles of Whatman grade 1 filter paper) containing 1.6 mg of PROP was used. The participant was instructed to put the whole piece of filter paper in the mouth and moisten it thoroughly with saliva for 30 seconds. After removing the filter paper, the participant quantified the intensity of the bitter taste using the general labeled magnitude scale (gLMS); the 100 scale ranged from 0, denoting "no sensation," to 100 denoting "strongest imaginable sensation of any kind".[22,23] Subjects were categorized as PROP tasters (>22 on gLMS) and PROP nontasters (<22 on gLMS). PROP tasters were further classified to supertasters (>51) and medium tasters (>22 but <51).[23]

### Statistical Analysis

All data were analyzed using the Statistical Package for the Social Science 24.0 software (SPSS Inc, Chicago, Ill). Descriptive statistics were used to determine the distribution of demographic characteristics, oral hygiene factors, and dietary habits. Chi-square test was used to analyze the association between the presence/absence of WSLs and different risk factors as well as the PROP taste phenotype. Differences of means were evaluated using Student's *t*-test. The intra-examiner agreement was assessed using kappa statistics. A *P*-value of less than .05 was considered statistically significant.

**Table 1.** Distribution of Demographic Factors, Oral Hygiene Factors, and Dietary Habits Between Participants of White Spot Lesion (WSL) Group and WSL-free Group

| | All Participants | WSL Group | WSL-Free Group | *P* value |
|---|---|---|---|---|
| n | 44 | 24 | 20 | |
| Mean age, y ± SD | 13.9 ± 1.3 | 13.8 ± 1.4 | 14.0 ± 1.1 | .494 |
| Gender | | | | .741 |
| Male | 23 | 12 | 11 | |
| Female | 21 | 12 | 9 | |
| Frequency of tooth brushing | | | | .300 |
| Never/sometimes | 2 | 2 | 0 | |
| Once, d | 6 | 4 | 2 | |
| Twice or more, d | 36 | 18 | 18 | |
| Use of dental floss | | | | .915 |
| Never/rarely | 21 | 12 | 9 | |
| Occasionally | 14 | 7 | 7 | |
| Daily | 9 | 5 | 4 | |
| Use of interdental brush | | | | .206 |
| Never/rarely | 18 | 10 | 8 | |
| Occasionally | 7 | 3 | 4 | |
| Daily | 19 | 11 | 8 | |
| Use of fluoride mouthwash | | | | .956 |
| Yes | 24 | 13 | 11 | |
| No | 20 | 11 | 9 | |
| Professional topical fluoride | | | | .438 |
| Never/rarely | 8 | 6 | 2 | |
| Once, y | 16 | 8 | 8 | |
| Twice, y | 20 | 10 | 10 | |
| Frequency of sugary food | | | | .743 |
| Rarely | 14 | 8 | 6 | |
| <3, d | 24 | 12 | 12 | |
| ≥3, d | 6 | 4 | 2 | |
| Frequency of acidic beverages | | | | .408 |
| Rarely | 33 | 17 | 16 | |
| <3, d | 9 | 5 | 4 | |
| ≥3, d | 2 | 2 | 0 | |

## RESULTS

A total of 44 healthy adolescents (out of 70 subjects who met the inclusion criteria) participated in the study. The sample included 23 males and 21 females. The mean age of the participants was 13.9 years (±1.3). According to the presence or absence of WSLs, the sample was divided into two groups: WSL group (n = 24) and WSL-free group (n = 20). The mean duration of orthodontic treatment for the WSL group was 17.9 months (±9.4) whereas the mean length for the WSL-free group was 15.7 months (±9.3) with no statistically significant difference between the groups. Table 1 shows the distribution of demographic factors, oral hygiene factors, and dietary habits between the groups. No significant difference was found between the study groups regarding their mean age, gender, oral hygiene practices, and dietary habits. Most

**Table 2.** Differences in Mean ± SD Plaque Index (PI), Decayed, Missing, and Filled Surfaces and Teeth (DMFS, DMFT), White Spot Lesions (WSLs) and PROP Taste Phenotypes Among Study Groups[a]

| | All Participants | WSL Group | WSL-Free Group | *P* value |
|---|---|---|---|---|
| n | 44 | 24 | 20 | |
| Mean PI | 43.9 ± 21.3 | 48.2 ± 21.2 | 38.7 ± 20.9 | .144 |
| Mean WSLs | 0.86 ± 0.9 | 1.80 ± 0.3 | 0 | .000* |
| Mean DMFS | 1.68 ± 3.5 | 2.38 ± 4.2 | 0.85 ± 2.2 | .131 |
| Mean DMFT | 1.32 ± 2.8 | 1.96 ± 3.5 | 0.55 ± 1.4 | .079 |
| PROP phenotype | | | | .006* |
| Taster | 23 | 8 | 15 | |
| Non-taster | 21 | 16 | 5 | |

* Significant difference, $P < .05$.
[a] SD indicates standard deviation.

participants (81.8%) brushed their teeth with a fluoridated toothpaste twice a day, but only 20.5% used dental floss daily. Fewer than half (43.1%) used the interdental brush for cleaning around the brackets. Regarding fluoride exposure, 54.5% of participants reported the use of fluoride mouthwash and all subjects received professional topical fluoride twice a year. One-third of the participants (31.8%) claimed to consume sugary food rarely whereas more than half of the participants (54.5%) consumed sweet foods moderately, ie, less than three times daily. The majority of the participants (75%) stated that they rarely consumed acidic beverages.

The mean plaque index of the total sample was 43.9 (±21.3). The subjects of the WSL group demonstrated a high mean PI (48.2 ± 21.2) compared to that of the WSL-free group (38.7 ± 20.9), but the difference was not statistically significant ($P = .144$, Table 2). In the WSL group, the mean number of WSLs was 1.8 (±0.3). Fifteen subjects had between 1 and 3 WSLs whereas nine subjects had greater than or equal to 4 WSLs. The overall mean DMFS and DMFT scores for the participants were 1.68 (±3.5) and 1.32 (±2.8), respectively (Table 2). Although the mean DMFS (2.38 ± 4.2) and mean DMFT (1.96 ± 3.5) of the WSL group were higher than that of WSL-free group (0.85 ± 2.2 and 0.55 ± 1.4, respectively), no statistical significant differences were found between the two groups ($P = .131$, $P = .079$).

When the PROP taste phenotype of participants was evaluated, 23 were identified as PROP tasters and 21 as PROP nontasters (Table 2). Most of the PROP tasters were supertasters (n = 16) and the remaining were medium tasters (n = 7). The majority of the subjects in the WSL group were PROP nontasters (66.6%) whereas the majority of subjects in the WSL-free group were PROP tasters (75%, Figure 1). A significant relationship between the PROP taste and the presence of WSLs was found ($\chi^2$ [1] = 7.5, $P = .006$, Cramer's V = 0.415) with an odds ratio of 6 (95% CI: 1.6–22.4) for being a PROP nontaster. When the oral hygiene status (plaque index) controlled as a confounding factor, a significant association was also shown.

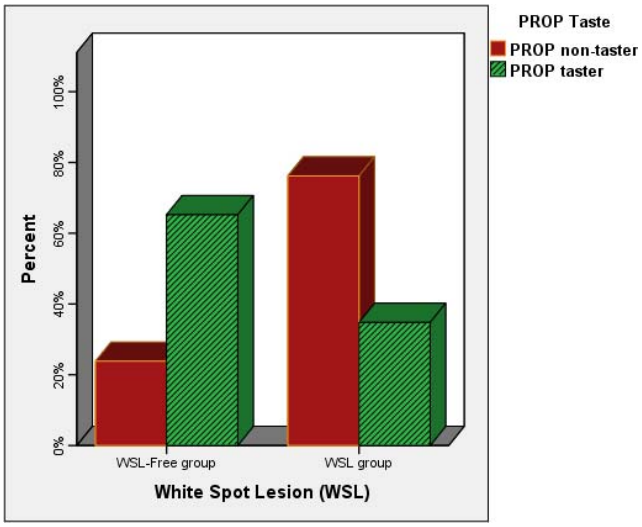


**Figure 1.** Histogram of the distribution of the participants according to their PROP taste phenotypes for the WSL group and WSL-free group.

## DISCUSSION

WSLs are one of the most common complications encountered in patients undergoing orthodontic treatment with fixed appliances. Despite the efforts for maintaining excellent oral hygiene during orthodontic treatment, WSLs are still seen in some patients.[9] A recent concept, genetic taste sensitivity to 6-n-propylthiouracil, has evolved and led to remarkable insights into food preferences and eating behavior.[24] PROP tasting has been used as a biomarker for the risk of obesity and dental caries.[14–17] No previous studies have examined the role of individual's taste sensitivity using PROP as a risk factor in the development of WSLs in orthodontic patients. Therefore, the current study investigated the relationship of the PROP taste phenotype and WSL development in a sample of adolescent orthodontic patients. Other potential confounding risk factors, such as caries experience, oral hygiene status, and practices, and dietary habits were also evaluated.

The present study found a significant association between the PROP taste sensitivity and the formation of WSLs. Two-thirds of the WSL group were identified as PROP nontasters whereas more than two-thirds of the WSL-free group were identified as PROP tasters. The odds of developing WSLs in the nontaster subjects were found to be six times higher than in the taster subjects. A possible explanation can be inferred from the findings of earlier studies that found that most of the

nontasters were sweet likers and had a higher frequency of sugar intake compared to supertasters, thus increasing their caries risk.[15–17] Several previous studies have also shown that the dental caries experience of 6-year-old to 15-year-old children was significantly higher for nontasters than supertasters.[14,17] In the present study, patients with WSLs exhibited two times higher DMFT/S scores compared to WSL-free patients, however, without any statistically significant difference. A higher DMFT/S score has been associated with a higher chance of developing WSLs.[8]

The increased accumulation of plaque around the orthodontic brackets has been linked to the increased risk of developing WSLs.[8] In the current study, although patients with WSLs demonstrated the highest plaque scores, the difference between patients with or without WSLs was not statistically significant, and the self-reported oral hygiene practices also did not differ between the study groups. Previous investigators assessing the oral hygiene level during the orthodontic therapy found that subjects with high plaque scores and inadequate oral hygiene were more likely to develop WSLs than those with adequate oral hygiene.[5,8]

Another risk indicator reported in the literature for WSL formation was diet. The role of high sugar consumption and low pH in the enamel demineralization and caries development has been well documented.[25] The present study investigated the frequency of sugary food intake, and the use of acidic beverages. No difference was found in the reported dietary habits between the study groups. These findings should be interpreted with caution since the participants can over- or under-report specific details related to their sugar consumption. Furthermore, the time of consumption during the day and the consistency of sugar-containing foods were not determined. In the sample, PROP nontaster subjects were found to have a higher frequency of sugar intake compared to PROP taster subjects, but it was not statistically significant.

The validity of PROP taste as a biomarker is based on ratings of the perceived intensity of PROP following stimulation using filter paper disks or solutions. A high reliability has been documented with the PROP test using filter paper disks ($r = 0.9$).[26] PROP test could be marketed or made available to be used for effective screening. Within the limits of this present study (eg, small sample, not all risks and protective factors were assessed), it may be concluded that PROP test could be a simple and valuable tool in the initial evaluations of orthodontic patients to assess their risk for developing WSLs. The findings of the present study will pave the way for other research in the field and allow this association to be studied more fully. Further longitudinal studies with larger sample sizes and diverse age groups are recommended.

## CONCLUSIONS

- The prevalence of white spot lesions was significantly higher in adolescent orthodontic patients with fixed appliances who were PROP nontasters compared to PROP tasters.
- PROP taste perception could be a potential risk factor for the formation of white spot lesions in orthodontic patients and warrants further attention.

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