Prevalence of white-spot lesions before and during orthodontic treatment with fixed appliances

Alessandra Lucchese*, Enrico Gherlone**

*Department of Medical-Surgical Sciences of Communication and Behavior, School of Dentistry, University of Ferrara, **Department of Dentistry, Vita Salute University, San Raffaele Hospital, Milan, Italy

Correspondence to: Alessandra Lucchese, School of Dentistry, Vita Salute University, San Raffaele Hospital, Via Olgettina 48, Milan, Italy. E-mail: lcclsn@unife.it

SUMMARY The aim of the study was to determine the prevalence of white-spot lesions (WSLs) in patients with fixed orthodontic appliances. The cross-sectional study sample consisted of three groups of patients: group I, 59 patients treated orthodontically for 6 months; group II, 64 patients treated for 12 months; group 0 (control), 68 patients examined immediately before appliance placement. All groups were treated with a 0.022-inch slot preadjusted appliance and they wore a functional fixed appliance. The presence of WSLs was evaluated by visual examination using the scoring system proposed by Gorelick. The groups were evaluated for differences in the prevalence of at least one WSL using Fisher’s exact test, followed by Bonferroni pairwise comparisons. The prevalence of WSLs by tooth type was evaluated with logistic regression ($P < 0.05$). Intraobserver agreement was assessed by means of the Cohen $\kappa$ statistical method. There were no significant differences in the prevalence of WSLs between patients treated for 6 and 12 months ($P = 0.855$); however, there were significantly more WSLs in groups I and II than in group 0 ($P = 0.000$). No significant differences were found between girls and boys ($P = 1.000$). The mandibular first molars and maxillary lateral incisors were the most affected teeth, in both the treated and untreated groups. The study revealed significant decalcification at 6 months after orthodontic bonding. Considering how quickly these lesions can develop and become irreversible, early diagnosis is of critical importance.

Introduction

Decalcification and the morphological characteristics of the enamel surface have been studied extensively. The main aims of research in this area include (1) to develop a scale of enamel lesions, (2) to define the aetiology of lesions and differential diagnosis of such lesions, and (3) to develop methods of preventing lesions from becoming cavities (Boj et al., 2004; Hong and Lew, 1995; Lucchese and Storti, 2011; Lucchese et al., 2012). Among enamel lesions, white-spot lesions (WSLs) are the main iatrogenic effect of orthodontic therapy with fixed appliances (Zachrisson and Zachrisson, 1971). The first clinical evidence of demineralization of the surface enamel can be seen as a WSL, which represents the first stage of caries formation. Patients are informed that it is their own responsibility to prevent the formation of WSLs (Maxfield et al., 2012); consequently, optimal oral hygiene and prevention with fluoride are crucial (Pasini et al., 2006).

Several types of dental appliance may enhance the risk of plaque aggregation despite good oral hygiene by the patient. Complicated appliances are often prescribed to preadolescent patients who require both orthodontic and functional fixed appliances to correct severe skeletal class II and III malocclusions. Fixed orthodontic appliances contribute to the adhesion of oral bacteria due to their complex design, which prevents proper cleaning around orthodontic brackets and may result in enamel demineralization (Chatterjee and Kleinberg, 1979; O’Reilly and Featherstone, 1987). Some studies have shown that the introduction of fixed orthodontic appliances induces a rapid increase in the volume of dental plaque and that such plaque has a lower pH than that found in non-orthodontic patients (Chatterjee and Kleinberg, 1979). Furthermore, there is a rapid shift in the composition of the bacterial flora in plaque following the placement of orthodontic appliances. Specifically, the levels of acidogenic bacteria, such as Streptococcus mutans and lactobacilli, increase significantly in orthodontic patients (Lundström and Krasse, 1987). Consequently, cavities progress more rapidly in patients who are bonded with full orthodontic appliances than in subjects with no orthodontic appliance.

WSLs can become noticeable around the brackets of fixed appliances within 1 month of bracket placement, although the formation of regular cavities usually takes at least 6 months (Øgaard, 2008). These lesions are commonly seen on the buccal surfaces of the teeth, around the brackets, especially in the gingival area (Gorelick et al., 1982; Øgaard et al., 1988). Although WSLs that are left untreated after removal of a fixed orthodontic appliance can reduce in size naturally without intervention, they often persist, which
causes aesthetic concerns (Artun and Thyrlstrup, 1989; Benson et al., 2005; Willmot, 2008). Nearly one-third of orthodontic patients develop at least one WSL as a result of poor oral hygiene and the retention of plaque around orthodontic appliances (Lovrov et al., 2007).

The extent of WSLs varies from 4.9 to 84% of the tooth surface, depending on the examination technique used (Gorelick et al., 1982; Mizrahi, 1982; Artun and Brobakken, 1986; Øgaard, 1989; Mitchell, 1992; Boersma et al., 2005; Chapman et al., 2010).

Even though WSLs can develop within 1 month of placement of the appliance, most previous investigations on the prevalence of WSLs have been carried out at the end of orthodontic treatment. The formation of these lesions and their prevalence at different times during orthodontic and orthopaedic treatment has received little attention from researchers. The main driver of the present study was the diverging opinions in the literature about the prevalence of WSLs. In the study, we focused on the analysis and quantification of WSLs observed in our clinical practice. We determined the prevalence of WSLs in preadolescent children with fixed orthodontic and orthopaedic appliances by visual inspection, before and 6 and 12 months after treatment.

Subjects and methods

Study sample

The cross-sectional study sample was selected from patients who attended the private practice of the author and initially consisted of 216 patients who required orthodontic treatment with fixed appliances. From this sample, 191 patients were selected, who fulfilled the following criteria: no history of previous orthodontic treatment or surgery, absence of congenital anomalies, Caucasian origin, medium socioeconomic status, and from the same geographical area (Mediterranean). Patients with any systemic disease, cysts, clefts, or any congenital malformations, generalized dental problems, or ongoing medication for a chronic disease, or who wore a removable appliance were excluded from the study. Each patient’s parent or guardian signed an informed consent form before treatment.

Study design

The patients were divided into three groups and were examined for the presence of WSLs. Group I consisted of 59 patients (28 girls and 31 boys) with an average age of 9±1.3, who had been undergoing orthodontic treatment for 6 months (± 3 weeks). Group II comprised 64 patients (36 girls and 28 boys) with an average age of 10±1.4, who had started orthodontic treatment 12 months (± 4 weeks) previously. The control group, group 0, consisted of 68 patients (36 girls and 32 boys) with an mean age of 9±1.5, who were examined for WSLs immediately before placement of the appliance on their teeth. For all groups, the total treatment time was 13±0.9 months.

Patients in all the groups were bonded with a 0.022-inch slot preadjusted appliance (MBT Prescription; 3M Unitek, Monrovia, CA, USA) and they wore a functional fixed appliance. Metal brackets were bonded using a light-cured composite resin and adhesive (Transbond XT; 3M Unitek) in accordance with the manufacturer’s instructions. Each patient was given the same instructions with respect to oral hygiene. One week after bracket placement, all patients received thorough prophylaxis.

The WSL index (Gorelick et al., 1982) was used for visual evaluation of the buccal surfaces of the anterior teeth, premolars, and first molars in the maxilla and mandible. The scoring was as follows: 0: no visible white spot or surface disruption (no demineralization); 1: visible WSL that covered less than one-third of the surface, without surface disruption (mild demineralization); 2: visible WSL that covered more than one-third of the surface, with a roughened surface but not requiring restoration (moderate demineralization); and 3: visible cavitation, requiring restoration (severe demineralization). Teeth with a score of 0 were considered not to have WSLs, and teeth with a score of 1 or 2 were considered to have mild and moderate WSLs. The scoring was performed under direct illumination using a dental lamp after light pumicing and drying with compressed air for 5 seconds. Measurements were performed on all patients who were enrolled in the study by the same operator. The clinician was blinded to the time frame for orthodontic therapy and evaluated the subject patients only after another assistant had removed the wires from the appliance.

Statistical analysis

The three groups (6 months, 12 months, and control) were evaluated for differences in the prevalence of at least one WSL by Fisher’s exact test followed by Bonferroni pairwise comparisons. Logistic regression was used to evaluate the multiple effects of group (time in therapy) and gender on the prevalence of WSLs and to determine interactions between groups and gender. In addition, the prevalence of WSLs according to tooth type was evaluated with logistic regression, with the significance level set at P < 0.05. To determine the validity of the method, intraobserver agreement was assessed by means of Cohen’s κ coefficient. Fifteen patients were selected randomly and reevaluated by the same observer within 15 days from the first assessment. All data were processed using SPSS version 17.0 (Chicago, IL, USA).

Results

The numbers of patients in each group with a WSL upon visual examination are shown in Table 1. In group I (6 months), 24 of 59 patients (40%) had at least one visible WSL and 35 (59%) had no WSLs (score 0).
Ten of the patients (16%) had WSLs with a visual score of 1 and 14 (23%) had WSLs with a visual score of 2.

In group II (12 months), 28 of 64 patients (43%) had at least one visible WSL and 36 (56%) had no WSLs (score 0). Twelve of the patients (18%) were assigned a score of 1 and 16 (25%) a score of 2. There was no significant difference in the number of WSLs between groups I and II ($P = 0.855$). The scores did not differ significantly between groups I and II, even though there was a greater proportion of patients with score 2 in the 12-month group.

In group 0 (control), only 9 of 68 patients (13%) had at least one WSL. Six of the patients (9%) were assigned a score of 1 and three (4%) a score of 2.

The number of patients with WSLs was significantly higher in group I ($P = 0.001$) and group II ($P = 0.000$) than in group 0.

WSL scores in girls and boys are compared in Table 2. There was no significant difference in the number of patients affected by lesions between girls and boys in group I or in group 0 ($P = 1.000$, Fisher’s exact test). In group I, 13 of 31 boys (41%) and 11 of 28 girls (39%) had at least one WSL. In group 0, 5 of 32 boys (15%) and 4 of 36 girls (11%) had at least one WSL. In contrast, there was a significant difference ($P = 0.009$, Fisher’s exact test) in the prevalence of WSLs between boys and girls in group II: 16 of 28 boys (57%) had at least one WSL, as opposed to only 12 of 36 girls (33%). Overall, 55% of patients who had at least one visible WSL were boys and 44% were girls.

The prevalence of WSLs on different types of teeth is shown in Figures 1 and 2. For each tooth type in both the maxilla (Figure 1) and mandible (Figure 2), the frequency of WSLs was greater in patients who had undergone orthodontic treatment than in patients in the control group. Among the treated patients, the greatest prevalence of WSLs was found in the mandibular first molars (30%), followed by the maxillary lateral incisors (29%) and the mandibular second premolars (20%). In the untreated patients, the greatest prevalence was observed with the lower first molars (8%), followed by the lower and upper second premolars (3%), and the upper lateral incisors (3%).

### Table 1: Frequency of patients with WSLs.

<table>
<thead>
<tr>
<th>Group</th>
<th>No WSL N (%)</th>
<th>WSL present N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (6 months; n=59)</td>
<td>35 (59)</td>
<td>24 (40)</td>
</tr>
<tr>
<td>II (12 months; n=64)</td>
<td>36 (56)</td>
<td>28 (43)</td>
</tr>
<tr>
<td>0 (Control; n=68)</td>
<td>59 (87)</td>
<td>9 (13)</td>
</tr>
<tr>
<td>Total (191)</td>
<td>130 (68)</td>
<td>61 (31.9)</td>
</tr>
</tbody>
</table>

The control group had a lower prevalence of WSLs than had the 6-month group ($P = 0.001$, Fisher’s exact test) and the 12-month group ($P = 0.000$, Fisher’s exact test). The 6- and 12-month groups did not differ significantly from each other ($P = 0.855$, Fisher’s exact test). WSL = white-spot lesion.

### Table 2: Differences between male and female patients in relation to WSL formation.

<table>
<thead>
<tr>
<th>Group</th>
<th>Boys with WSLs N (%)</th>
<th>Girls with WSLs N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (6 months; n=24)</td>
<td>13 (41)</td>
<td>11 (39)</td>
</tr>
<tr>
<td>II (12 months; n=28)</td>
<td>16 (57)</td>
<td>12 (33)</td>
</tr>
<tr>
<td>0 (Control; n=9)</td>
<td>5 (15)</td>
<td>4 (11)</td>
</tr>
<tr>
<td>Total (61)</td>
<td>34 (55)</td>
<td>27 (44)</td>
</tr>
</tbody>
</table>

WSL = white-spot lesion.

### Discussion

The results of the present study revealed the presence of significant decalcification among child patients at 6 months after orthodontic bonding. Twenty-four of 59 patients (40%) had a visible WSL, which indicated that WSLs are undoubtedly a major clinical problem in relation to treatment with fixed orthodontic appliances. This percentage increased to 43% (28/64 patients) among patients who had been treated for 12 months. In contrast, only 13% of the control group...
(9/68 patients) showed at least one WSL. The high incidence of WSLs at 6 months after active orthodontic treatment shows that demineralization can rapidly become a concern with fixed appliances when oral hygiene is poor. Fixed appliances become sites of plaque retention, and without good oral hygiene, plaque accumulates and acidogenic bacteria cause marked demineralization.

Our results are in line with the study by the formation of regular caries usually Øgaard et al. (1988), who reported that WSLs can become visible around the orthodontic appliance within 1 month of bonding. Chapman et al. (2010) showed similar results, with 36% of patients having visible WSLs, which increased to 46% in the 12-month treatment group, as compared with only 11% in the control group. However, our results disagree with previous investigations that showed a higher prevalence of WSLs. Gorelick et al. (1982) reported a prevalence of approximately 50% for WSLs at the end of orthodontic treatment. Using quantitative light fluoroscopy, Boersma et al. (2005) reported that 97% of patients had one or more lesions at the end of orthodontic treatment. The higher prevalence in these previous studies might have been due to the length of the orthodontic treatment (~24 months), as compared with our evaluations at 6 and 12 months after the beginning of treatment. It is also possible that the technological advances and new composite materials that are now available for bonding, and their different chemistry, might have contributed to the lower prevalence of WSLs in the present study.

We found no significant difference in the number of patients with WSLs between girls and boys in either the six-month group or control group. However, in accordance with Øgaard (1989), a significant difference was identified in the prevalence of WSLs between boys and girls in the 12-month group. Overall, 55% of patients in the present study who had at least one visible WSL were male and 44% were female. Our results disagree with those of Gorelick et al. (1982), who found a prevalence of 44% for boys and 54% for girls, but they agree with those of Boersma et al. (2005), who reported a prevalence of 40% in male and 22% in female patients.

There is still some controversy about the frequency of WSLs on different types of teeth. In the present study, there was a high prevalence of WSLs on mandibular first molars and second premolars, followed in decreasing order by first premolars, canines, lateral incisors, and central incisors. In the maxilla, in the treated group, a high prevalence of WSLs was observed on lateral incisors and canines, followed by central incisors, second premolars, first molars, and finally first premolars. Our analysis supports the results of Gorelick et al. (1982), who reported that the most commonly affected teeth were maxillary lateral incisors and mandibular first molars, and the results of Chapman et al. (2010), who showed that the order of incidence was lateral incisors, canines, premolars, and central incisors. The results of Geiger et al. (1988) also agree with our conclusions, showing that lesions occurred most frequently on maxillary lateral incisors, mandibular first molars, and canines. In contrast, Mizrahi (1983) and Øgaard (1989) concluded that maxillary and mandibular first molars were the most commonly affected teeth.

The higher percentage of WSLs on maxillary first molars that was reported by other authors might have been due to the fact that the upper first molars were banded and not bonded in the previous studies, whereas the teeth in most of our patients were bonded. Although the bands are tight fitting and cemented, there is always a risk that a small niche might occur between the band and the gingival enamel surface as a result of a crack in the cement layer (Mizrahi, 1983). It has been reported that the development of lesions under orthodontic bands is an extremely rapid process, even when cement that contains fluoride is used.

To date, clinical detection of WSLs has been carried out primarily by means of traditional methods such as visual inspection after air drying and tactile examination by dental probing. We chose to use this approach in the present study. However, the subjectivity and lack of reproducibility of these approaches, together with the prerequisite of the presence of a significantly advanced lesion, have led to the introduction of several optical techniques during recent decades: the optical caries monitor, use of quantitative laser and light-induced fluorescence, digital imaging with fibre-optic transillumination, laser fluorescence, and computer analysis of digital photographs. Despite the availability of these techniques, we consider that visual inspection was appropriate in the present case.

The present study showed that significant decalcification occurred within only 6 months after orthodontic bonding. Considering how quickly these lesions can develop and become irreversible, early diagnosis is of critical importance. Given the high number of lesions that were found at 6 months, it is crucial to evaluate the oral hygiene status of patients during the first months of orthodontic treatment, and if necessary, to implement preventive actions immediately, in order to prevent demineralization.

Conclusion

In the present study, we demonstrated that the tendency of plaque to accumulate around fixed orthodontic appliances can result in rapid demineralization. Despite recent advances, prevention of demineralization during orthodontic treatment is one of the greatest challenges faced by clinicians. For each patient, there is a need to develop an oral hygiene protocol that should be followed both at home and at the dental practice. This protocol should be individualized for patients wearing fixed orthodontic appliances and it should aim to prevent the formation of WSLs during treatment, as well as to provide early treatment. Vigilant home hygiene, including the use of a fluoride mouthwash, is effective in preventing WSLs, but this requires unusual levels of patient compliance. We suggest following a preventive regime at the dental practice with
periodic applications of fluoride varnish, and educating and motivating patients to take care of their own oral hygiene.

In cases of WSL formation, early diagnosis and treatment are crucial to prevent these lesions from becoming cavities. Communication among patients, parents, orthodontists, and general dentists needs to improve to decrease the incidence of WSLs in the orthodontic population.

References