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Is it possible to completely eliminate new white spot lesions during orthodontic treatment?

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ABSTRACT

Introduction: Orthodontists prevent and treat dental, occlusal, and facial abnormalities and improve aesthetics. Despite this, orthodontists continue to struggle with the persistent problem of impaired oral hygiene during orthodontic treatment. Although patient awareness is growing, new white spot lesions (WSLs) after the insertion of fixed appliances are still observed.

The aim of the study was to evaluate the relationship between oral hygiene status and the development of new WSLs in orthodontically treated teenagers undergoing a regular oral hygiene regimen and motivation.

Materials and methods: A group of 144 teenagers aged 12–18 years was examined. Participants were divided into 2 groups – orthodontically treated and control. Oral hygiene status, based on the approximal plaque index (API), and the number of WSLs were measured at 3 time points: baseline (0), 1 month from baseline (1), and 6 months from baseline (2).

Results: The API values in the group treated with fixed appliances increased over time, indicating that the oral hygiene of orthodontic patients deteriorated over time. The distribution of the API after 6 months differed significantly between the group with new decalcifications and the group without new decalcifications ($p < 0.05$).

Conclusions: Despite intense oral hygiene instructions, motivation, and fluoride prevention, there remains a group of patients with disturbed oral hygiene that significantly influences the development of new WSLs after 6 months of fixed appliance therapy. There is a need for intense oral hygiene education and motivation in early childhood to develop proper oral hygiene habits for a lifetime, as a 6-month period proved to be insufficient for some patients.

Keywords: caries; fixed appliances; oral hygiene; orthodontic treatment; white spot lesions; WSL prevention.

INTRODUCTION

For years, increased interest in orthodontic treatment has been observed. Orthodontists prevent and treat dental, occlusal, and facial abnormalities. Furthermore, one of the goals of orthodontic treatment is the improvement of aesthetics, and as such, the popularity of orthodontics continues to rise.

Although orthodontic therapy is intended to improve aesthetics, orthodontists are still struggling with the problem of new enamel decalcifications, mainly caused by impaired oral hygiene after the insertion of fixed orthodontic appliances (FOA).

The human organism includes a microbiome. The balance established between the microbial species and the host favors the state of health. The loss of this balance is associated with disease [1, 2, 3]. The balance between different microbial communities can be altered by: growth, hormones, diet, smoking, and poor oral hygiene [4, 5, 6].

Fixed orthodontic appliances may influence the oral microbiome composition, as they increase plaque accumulation and impede proper oral hygiene. Furthermore, the oral microbiota can be affected by metal corrosion as well as tooth movement [7].

Insufficient oral hygiene leads to the creation of a metabolically active biofilm, which disturbs the balance of demineralization and remineralization processes, leading to the formation of white spot lesions (WSLs) on the vestibular tooth surfaces.

A large percentage of patients undergoing orthodontic treatment are children under 18 years of age. In this age group, problems with maintaining proper oral hygiene have been noted. A sharp increase in the number of WSLs during the first 6 months of treatment was observed [8]. Therefore, during the first months of therapy, a critical evaluation of oral hygiene status should be carried out.

Enamel demineralization usually occurs asymmetrically in places with difficult access to hygienic procedures. Risk factors for the development of enamel decalcification during orthodontic treatment include the presence of WSLs before orthodontic therapy, decayed or filled molars, disturbed oral hygiene, excess bonding material, long etching time (>15 s), duration of therapy, excessive drinking, and frequent use of fermentable carbohydrates [9]. White spot lesions are prevented primarily by establishing good oral hygiene habits and prophylaxis with fluorides. Patient education and motivation for compliance with a non-cariogenic diet are also essential [10].

Nevertheless, despite growing patient awareness and caregiver attention in caries prevention, studies carried out over the years indicate the continuous problem of the presence of white carious spots during therapy with FOA. Their frequency has been reported to vary widely, 2–97% in different epidemiological studies [11, 12, 13].

The aim of the study was to evaluate the relationship between oral hygiene status and the development of new WSLs in orthodontically treated teenagers under regular motivation and oral hygiene regimen.

MATERIALS AND METHODS

Sample characteristics

A group of 165 individuals was assessed for eligibility; 21 of them were excluded from the examination, and 144 teenagers aged 12–18 years were analyzed. Participants were divided into 2 groups – those treated with a FOA (60 patients) and a control group (84 individuals).

The FOA-treated group consisted of patients qualified for therapy with conventional metal brackets. The control group included pupils attending schools in the Lublin Voivodeship, Poland.

The research was approved by the Bioethical Committee of the Medical University of Lublin (No. KE-0254/169/2011), and consent was obtained from pupils, their parents, teachers, school directors, and dentists.

Inclusion criteria were good general health, full permanent dentition, and treatment with traditional fixed appliances.

Patients with carious or non-carious enamel lesions and previous orthodontic or surgical treatment were excluded from the study.

The control group was formed to match the study group.

Data collection

Each measurement was assessed at 3-time points:

1. beginning (baseline),
2. short-term (1 month from baseline),
3. long-term (6 months from baseline).

As a WSL can become experimentally visible after 1 month and during the first 6 months of FOA therapy a rapid increase in a number of WSLs was noted, the observation was carried out over a period of 6 months.

Oral hygiene status was assessed as a primary outcome and was measured using the approximal plaque index (API). The number of WSLs was measured as a secondary outcome. The visual assessment of WSLs was performed using the International Caries Detection and Assessment System (ICDAS).

The API was used to assess the amount of plaque in the interdental spaces.

International Caries Detection and Assessment System Code 1 (the presence of white carious spots on enamel surfaces after drying) and Code 2 (the presence of white carious spots on enamel surfaces without drying) were considered a positive result.

The measurements were carried out in accordance with World Health Organization (WHO) recommendations – in a dental office, under a shadeless lamp, using a flat mirror and a WHO-621 periodontal probe.

The number of WSLs detected after tooth brushing was considered final.

Patients received extensive oral hygiene instruction before the start of the trial. During follow-up visits, patients' oral hygiene status was assessed and they were motivated to effectively maintain oral hygiene during therapy.

Statistical analysis

The obtained results were analyzed statistically and presented as descriptive analysis and U-test relations.

A typical level of statistical significance of $p = 0.05$ was assumed for the analysis.

The main calculations were performed in Statistica 8.0, PL.

RESULTS

In the first study, the average value of the API in the orthodontically treated group was 11.67 in the group with new decalcifications and 16.44 in the group without new WSLs. In the first study, the average value of the API in the control group was 10.20 in the group with new decalcifications and 15.25 in the group without new WSLs.

The API values in the group treated with FOA increased over time, indicating that the oral hygiene of orthodontic patients deteriorated over time.

The API values in the control group decreased after 1 month, indicating a positive impact of hygiene instruction on the API level in this group. However, after 6 months of observation, the hygiene of patients in the control group also deteriorated (Tab. 1).

Based on the Mann–Whitney U-test (Tab. 2), it can be observed that the distribution of the API in the third study in the group with new decalcifications and in the group without new decalcifications for the orthodontic treatment group differed significantly ($p = 0.0085$).

Based on the values of relevant descriptive statistics, it can be observed that the values of the API in the third study were significantly higher in the group with new WSLs than in the group without new decalcifications in the study group.

DISCUSSION

As studies indicate, the development of WSLs can be related to many factors. Genetics and peri- and postnatal factors should be mentioned here. Brackets, wires, and other additional attachments provide new retentive places for the development and retention of dental biofilm. As the components of the appliance disturb oral hygiene and thus significantly increase the risk of new enamel decalcifications, orthodontists have been paying attention to the oral hygiene of their patients for years. Each new orthodontic patient is educated in the principles of WSL prevention.

The classic method of preventing enamel demineralization includes fluoride-based agents. The use of fluoride is the gold standard in the prevention and management of caries. Fluoride prevents WSL development by inhibiting acid production, decreasing demineralization, and promoting remineralization. No evidence is available regarding any strategy that can effectively replace the use of fluoride [10].

TABLE 1. Descriptive statistics for the approximal plaque index taking into account new enamel white spot lesions

Group	New WSL	API	n	M	SD	V	Min.	Max.	Q1	Me	Q3
Orthodontically treated group	yes	API1	3	11.67	3.21	27.6%	8.0	14.0	8.0	13.0	14.0
		API2	3	24.33	11.50	47.3%	13.0	36.0	13.0	24.0	36.0
		API3	3	67.33	18.15	27.0%	54.0	88.0	54.0	60.0	88.0
	no	API1	57	16.44	13.53	82.3%	0.0	50.0	7.0	13.0	25.0
		API2	57	23.53	16.62	70.7%	0.0	75.0	13.0	18.0	31.0
		API3	57	32.35	15.58	48.2%	0.0	73.0	21.0	33.0	42.0
Control group	yes	API1	5	10.20	5.63	55.2%	7.0	20.0	7.0	7.0	10.0
		API2	5	10.60	5.55	52.4%	3.0	17.0	7.0	13.0	13.0
		API3	5	20.60	13.09	63.5%	10.0	43.0	13.0	17.0	20.0
	no	API1	79	15.27	12.08	79.1%	0.0	83.0	7.0	13.0	20.0
		API2	79	12.76	14.30	112.0%	0.0	90.0	3.0	10.0	17.0
		API3	79	20.84	20.46	98.2%	0.0	97.0	7.0	13.0	27.0

WSL – white spot lesion; API – approximal plaque index; API1 – approximal plaque index values at baseline; API2 – approximal plaque index 1 month from baseline; API3 – approximal plaque index values 6 months from baseline; n – sample size; M – arithmetic mean; SD – standard deviation; V – coefficient of variation; Q1 – quartile 1; Me – median; Q3 – quartile 3

TABLE 2. Mann–Whitney U-test values for the approximal plaque index including new enamel decalcifications

Group	Comparison	API	U	Z	p
Orthodontically treated group	group with and without WSL	API1	76.0	–0.3059	0.7597
		API2	75.0	0.3399	0.7339
		API3	7.5	2.6315	0.0085
Control group	group with and without WSL	API1	131.0	–1.2590	0.2080
		API2	184.5	0.2386	0.8114
		API3	165.5	0.5980	0.5499

WSL – white spot lesion; API – approximal plaque index; API1 – approximal plaque index values at baseline; API2 – approximal plaque index 1 month from baseline; API3 – approximal plaque index values 6 months from baseline; U – the statistic of the Mann–Whitney U-test; Z – standard descriptive statistics; p – probability

Regular, proper oral hygiene is the basis for the prevention of WSLs in orthodontically treated patients. The principle of daily hygiene should be mechanical plaque control by brushing using a toothpaste with a standard or high concentration of fluoride after every meal or even a snack [14].

At each follow-up visit, oral hygiene status and the patient's motivation should be re-evaluated.

If necessary, professional cleaning should be performed and oral hygiene and diet instructions should be repeated. Professional tooth cleaning should be carried out at least once every 6 months, and if needed, even once every 3–4 months [15].

In our study, extensive oral hygiene instruction was given to patients prior to the insertion of FOA. Patients from both groups were instructed to thoroughly clean their teeth with a toothpaste containing sodium fluoride (NaF) after every meal and snack, floss before brushing, and rinse once a day with a NaF mouth rinse.

Brushing was recommended without specifying a particular toothbrush type – manual, electric, sonic, or magnetic – because there is no difference in plaque removal effectiveness between different types of toothbrushes. Orthodontists should rather focus on increasing patients' awareness of proper oral hygiene principles and emphasize professional prophylaxis rather than specifying toothbrush type [16].

Some authors recommend motivational interviewing, which stimulates patients' internal motivation and improves compliance; therefore, during the follow-up visits, we reassessed patients' oral hygiene and motivated them to properly care for their oral hygiene [17].

As not all patients perfectly followed the hygiene recommendations, and as research points out, using fluoride toothpaste alone is not effective in preventing demineralization in the majority of orthodontic patients even if their oral hygiene is good, the use of additional preventive methods is recommended.

Among the additional methods of caries prevention, fluoride and non-fluoride preparations are mentioned.

Among fluoride agents, NaF mouthwashes, varnishes, and gels used in-office are recommended. Mouthwashes containing 0.05% or 0.2% NaF prevent WSL development during fixed orthodontic treatment when used daily [18, 19]. However, benefits from the application of topical fluorides, like fluoride mouth rinses in addition to fluoride toothpaste, are questionable, as various clinical trials show inconsistent results [20, 21].

Recent studies suggest that orthodontically treated patients should brush twice daily with a dentifrice containing 5000 ppm fluoride, which provides a greater prophylactic effect than daily use of 1000 ppm fluoride toothpaste combined with a daily use of a 500 ppm NaF rinse. However, the number of WSLs significantly increases in pre-adolescents [22], and in this group, the use of toothpaste containing 5000 ppm fluoride cannot be prescribed.

An in-office application of a high concentration of fluoride can be beneficial for less compliant patients. Fluoride varnish should be used regularly. A 1-time application just before FOA insertion is inefficient [23]. Fluoride varnish should be applied 2–4 times yearly or even more often, mainly in orthodontic patients [24]. Benson et al. recommend fluoride varnish application every 1.5 months [25]. Varnish protects the enamel in the absence of patient compliance by constantly releasing fluoride over a long period. Zabokova-Bilbilova et al. revealed a 44.3% decrease in the number of WSLs in orthodontic patients after application of fluoride varnish [18].

As the results of this study revealed the development of new demineralizations despite the implementation of additional fluoride prophylaxis, in orthodontic patients it is worth considering the use of additional prophylactic methods with non-fluoride preparations to support primary prophylaxis of WSLs.

Multiple additional approaches are being developed to prevent new enamel demineralization. These include chlorhexidine, triclosan, zinc, casein phosphopeptides-amorphous calcium phosphate (CPP-ACP), antiseptics, probiotics, or polyols.

Mouthwashes containing chlorhexidine, triclosan, nano-silver, or zinc have cariostatic effects.

The use of chlorhexidine is considered a good preventive method, although the results of studies evaluating the efficacy of multiple applications of chlorhexidine varnish on levels of *Streptococcus mutans* (MS) and the frequency of new WSLs are not conclusive [26, 27].

Nano-silver mouthwashes proved to be more effective than chlorhexidine and fluoride mouthwashes [28].

Investigations indicate the potential role of probiotic bacteria in interfering with the oral biofilm and improving the effect of fluoride in preventing dental caries. Studies on the effects of probiotics on MS reduction showed satisfactory results. Caries prevention with daily use of oral probiotics or toothpastes with probiotics might be effective [29, 30].

Studies show the effect of polyols on plaque and MS. To neutralize the acidity of dental plaque, xylitol lozenges or chewing gum with xylitol or polyols is recommended after each meal (3 times daily) for 10–20 min [31, 32].

Laser enamel surface attenuation (Argon, Nd:YAG, CO2, and Er:YAG lasers) can be an addition to acid etching at areas of increased biofilm retention in patients receiving FOA treatment. Laser beams strengthen enamel microhardness and resistance to acid attacks by altering the enamel's crystalline structure [33, 34, 35]. Elaut and Wehrbein reported that argon laser irradiation alters the enamel surface by creating microspaces where minerals from saliva can precipitate, thus strengthening resistance to demineralization [35].

Preparations with CPP-ACP, derived from milk casein, have been shown to prevent WSL development by influencing the demineralization–remineralization process [36]. The use of CPP-ACP incorporates nanocomplexes into dental plaque and the tooth surface, providing a reservoir of calcium and phosphate. The efficacy of CPP-ACP in preventing demineralization during FOA therapy has been demonstrated [37, 38]. Enamel lesions remineralized with CPP-ACP are more resistant to further acid attacks compared to normally remineralized enamel because CPP-ACP remineralizes enamel subsurface lesions with hydroxyapatite. Furthermore, the low carbonate environment of the subsurface lesions treated with CPP-ACP improves crystallinity and reduces microstrain compared to normal enamel [39]. Casein phosphopeptides-amorphous calcium phosphate can be incorporated into chewing gums, lozenges, gels, or sports drinks. Creams containing CPP-ACP, such as Tooth Mousse (GC), should be applied to the tooth after brushing, twice a day. After application, a 30-minute break from eating or drinking is recommended.

New alternative methods for preventing WSLs are being developed. The antimicrobial and anti-inflammatory effects of curcumin photodynamic antimicrobial chemotherapy (c-PACT) and methylene blue photosensitizer (antimicrobial photodynamic therapy) have been examined [40, 41]. Ryu et al. showed that silver-platinum (Ag-Pt) coatings applied to stainless steel orthodontic brackets can provide suitable antimicrobial activity during active orthodontic treatment [42]. Pilot studies have assessed the influence of titanium dioxide nanoparticles (TiO_2) coating on orthodontic brackets and wires in reducing bacterial colonization [43, 44]. Studies have shown that nanoparticles such as zinc oxide (ZnO_2) decrease bacterial counts on the surface of bonding composites [45].

Orthodontists should also pay attention to the method of preparing the tooth for FOA fixation and the materials used.

The method of etching the enamel or the type of material used during FOA insertion may also affect demineralization. The development of WSLs is influenced by the time of enamel etching and the etching technique. Studies indicate that partial etching is more successful compared to total etching [46]. Prolonged etching and the use of excess etching material should be avoided.

White spot lesion development can be prevented by a continuous fluoride release from the bonding system around the bracket base. Some cements used during FOA insertion contain microcapsules that release fluoride, calcium, and phosphate ions [47].

Studies on the influence of the type of cement used on the development of WSLs have revealed that polycarboxylate-cemented teeth developed the most WSLs, followed

by glass-ionomer-cemented teeth. Compomers showed the best results [48]. A significant increase in the level of MS was observed in the biofilm adjacent to composite resin. It was concluded that composites do not prevent WSLs during FOA therapy [49]. Fluoride-releasing adhesives protect an area of 1 mm around the bracket [50].

For patients with disturbed oral hygiene, mobile phone apps, such as WhiteTeeth or Dental Monitoring, can be useful in promoting oral health behavior. These apps, working as reminders and motivators, improve the interaction between the orthodontist and the patient, taking advantage of artificial intelligence (AI) and teledentistry. The mobile application can supplement traditional orthodontic appointments, providing additional control of oral health behavior and additional motivation [51, 52].

The results of this analysis indicate that demineralization during FOA treatment is still a significant problem. Despite an oral hygiene regimen and regular patient motivation, new WSLs were observed. Although the patients' oral hygiene was acceptable throughout the study period, new WSLs were detected after 6 months of therapy in the examined group.

The basic principle of prevention of WSLs during multibracket therapy is patients' oral hygiene. Oral hygiene status should be consistently evaluated before and throughout the entire course of treatment. In patients where frequent motivation does not bring the expected results, it is advisable to use additional methods to support the prevention of WSLs.

CONCLUSIONS

It can be concluded that:

- despite intense oral hygiene instructions, motivation, and fluoride prevention, there is still a group of patients with disturbed oral hygiene, which statistically significantly influences the development of new WSLs after 6 months of fixed appliance therapy;
- there is a need for intense oral hygiene education and motivation in early childhood in order to develop proper oral hygiene habits for a lifetime, as a 6-month period proved to be insufficient for some patients.

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