Risk factors and management of white spot lesions in orthodontics

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ABSTRACT

The formation of white spot lesions or enamel demineralization around fixed orthodontic attachments is a common complication during and following fixed orthodontic treatment, which mars the result of a successfully completed case. This article is a contemporary review of the risk factors, preventive methods and fate of these orthodontics scars. The importance of excellent oral hygiene practice during fixed orthodontic treatment must be explained. Preventive programs must be emphasized to all orthodontic patients. Suggestions are offered in the literature for ways to prevent this condition from manifesting itself.

Key words: Fixed orthodontic treatment, oral hygiene, preventive measures, white spot lesions

INTRODUCTION

Demineralization is an inevitable side-effect associated with fixed orthodontic treatment, especially when associated with poor oral hygiene.[1] The acidic byproducts of the bacteria in plaque are responsible for the subsequent enamel demineralization and formation of white spot lesions (WSL). These can cause caries thereby leading to poor esthetics, patient dissatisfaction and legal complications.[1-3] The formation of WSL after completion of orthodontic therapy is discouraging to a specialty whose goal is to improve esthetics in the dento-facial region.

WSL develop in association with brackets, bands, arch wires, ligatures and other orthodontic devices that complicate conventional oral hygiene measures, leading to prolonged plaque accumulation. This concern raises the need for assessing the saliva, oral hygiene status and caries rate before beginning of treatment and initiating preventive measures. Orthodontists must take up the active responsibility to educate patients about the importance of maintaining good dietary compliance and excellent oral hygiene regime.

Clinically, formation of white spots around orthodontic attachments can occur as early as 4 weeks into treatment[4] and their prevalence among orthodontic patients ranges from 2% to 96%.[5-7] The labio-gingival area of the lateral incisors is the most common site for WSL and the maxillary posterior segments are the least common site with males affected more in comparison with females.[8] Tufekci *et al*. concluded in his clinical study that a sharp increase in the number of WSLs occurred during the first 6 months of treatment that continued to rise at a slower rate to 12 months, thus in initial months of the treatment critical evaluation of oral hygiene is recommended.[9]

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DEFINITION

The term WSL was defined as "the first sign of caries like lesion on enamel that can be detected with the naked eye."[3,10]

The WSL has also been defined as "subsurface enamel porosity from carious demineralization" that presents itself as "a milky white opacity when located on smooth surfaces."[3,10]

Etiology

The appearance of WSL on the enamel surface during fixed orthodontic treatment is due to a multiplicity of factors. Co-existence of the four factors namely, bacterial plaque, fermentable carbohydrates, a susceptible tooth surface and a sufficient period of time are necessary for WSL to develop.

Microbial factors

The presence of *Streptococcus mutans* and *Lactobacillus* and new sites of plaque appearance on the enamel surrounding

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the orthodontic attachments is common in patients undergoing fixed appliance therapy.[11-13] This may be further influenced by the duration of the orthodontic treatment and the number of orthodontic attachments.[13]

Salivary factors

The amount and rate of enamel demineralization and the likelihood of enamel remineralization is influenced by salivary factors such as pH, rate of flow and buffer capacity. Saliva also acts as a vehicle for the delivery of fluoride ions to the enamel and plaque.

Adequate flows of the saliva helps in physical cleansing of carbohydrates from tooth surfaces, maintains its buffering capacity and anti-microbial activities. Therefore, adequate flow of the saliva is considered as an important factor for prevention and management of enamel demineralization. Tooth surfaces that are more exposed to dietary carbohydrate with less exposure to saliva are common sites for demineralization to occur (maxillary anterior teeth).[7] The lingual surface of the lower incisors where salivary flow is adequate is often the site of calculus formation, indicating mineralization.[8]

Enamel demineralization is caused by the low pH of the plaque when not compensated by the buffering capacity of the saliva.

Oral hygiene

Fixed orthodontic appliances make tooth cleaning more difficult and also restrict the self-cleansing action of the tongue, lips and cheek to remove food debris from the tooth surface. Therefore, accumulated food debris, particularly of the cariogenic bacteria is seen in patients undergoing active orthodontic treatment.[14]

Diet

As the frequency of carbohydrate intake increases, the enamel surface may be exposed to overlapping episodes of acid without intervening repair, resulting in a net loss of minerals over time making it prone for enamel demineralization.

Alteration of the oral environment

Insertion of the fixed orthodontic appliance into the oral cavity creates new stagnation areas that in the presence of carbohydrate and the reduced access by saliva encourages the colonization of *S. mutans* and *Lactobacilli*.[11-19] It has been found that plaque deposition is greater on resin bonded material than on enamel.[20] Even plaque deposition is greater on gingival side of brackets.[21] Teeth ligated with elastomeric rings exhibited a greater number of cariogenic microorganisms than the teeth ligated with stainless steel ligature wires.[18,22] However, few studies failed to find an alteration in the number of *S. mutans* around the orthodontic brackets ligated with either ligature wire or elastomeric rings.[20,22]

Studies have shown that the resting salivary flow increases during fixed orthodontic treatment in few patients.[23] Since the salivary pH and buffering capacity increases with the increase rate of salivary flow, it counteracts the demineralization tendency that arises during fixed orthodontic treatment. This could be the reason why in some patients there are little white spots around orthodontic appliances despite moderate plaque accumulation.

Thus, at the beginning of fixed orthodontic treatment, an assessment of patient's susceptibility to enamel demineralization seems logical. Many authors recommended a range of factors to be examined in order to identify patients at risk of developing demineralization.[11] These factors include assessment of salivary flow rate, history of past enamel caries, caries incidence over the past year, plaque scores, caries activity tests, dietary pattern and resident as a part of fluoridated or non-fluoridated communities.

Prevention and Management

The risk of enamel demineralization during fixed orthodontic treatment can be prevented by:

1. By improving patient oral hygiene using mechanical plaque control methods
2. By enhancing the enamel resistance to the microbial acid by using topical fluoride
3. By additional methods using different mechanisms.

MECHANICAL PLAQUE CONTROL

Mechanical plaque control by proper tooth brushing is of paramount importance.[24] A modification of the standard toothbrush, use of disclosing solutions, use of floss can help our patients in attaining good oral hygiene.[24-26] Use of a power toothbrush or daily water irrigation in combination with manual tooth brushing may be a more effective method in reducing plaque accumulation than manual tooth brushing alone. Bracket attachment by direct bonding exposes the proximal surfaces to enamel demineralization because of the difficulty in maintaining oral hygiene with arch wires in place.[24] Dental flossing has proved helpful in interproximal cleaning. A floss threader can be used for threading the floss under the main archwire.[26] A soft rubber interdental stimulator can also be helpful in cleaning and massaging the interproximal areas.[25]

ENHANCING ENAMEL RESISTANCE USING TOPICAL FLUORIDES

Fluoride enhances enamel remineralization following orthodontic treatment.[4,24,27-31] The cariostatic effect of topical fluoride is primarily due to calcium fluoride (CaF_2) formation.[24] It has been documented that a high fluoride concentration in the enamel is less important than a moderate increase in fluoride concentration in oral fluid.[30] Proper oral hygiene maintenance, combined with daily use of topical fluoride, is found to significantly reduce enamel decalcification.[6,23] Home use of topical fluoride agents needs patient compliance.[32] As a result, different non-compliant topical fluoride delivery measures have

been implemented to prevent enamel demineralization around orthodontic brackets. When topical fluoride is applied on the tooth surface (enamel/dentin), a CaF_2 -like material builds up in plaque or in incipient lesions, which acts as a reservoir and releases fluoride ions when the pH is lowered during a caries attack.[32-34] Different modes in which fluorides has been documented to prevent WSL are as follows:

Fluoride Mouth Rinse

Daily mouth rinse with sodium fluoride (NaF) (0.05% or 0.2%) and/or weekly with acidulated phosphate fluoride (1.2%) rinse have been found to reduce the incidence of enamel demineralization during active fixed orthodontic treatment.[4,24,29,35-37]

After a systematic review, Benson recommended that the best method to prevent enamel demineralization during fixed orthodontic treatment is daily use of 0.05% NaF mouth rinse.[34] However, Hirschfield advocated the use of an APF mouth rinse to make enamel more resistant to orthodontic induced decalcification.[37] Geiger *et al*. reported 25% reduction in the number of WSL using fluoride rinse.[29] It was also found that following 2 weeks use of NaF mouth rinse, with one rinse per day, fluoride concentration in the saliva increased significantly.[38]

Fluoride Gel

Many investigators have tried Stannous fluoride gels (0.4%) during orthodontic treatment and reported decreased enamel decalcification.[39] Currently, Boyd compared the use of a 1100 ppm fluoride toothpaste alone or together with either a daily 0.05% NaF rinse or a 0.4% stannous fluoride gel applied twice daily by toothbrush.[38] He found that both the gel and rinse provided additional protection against decalcification when compared with toothpaste alone, but neither was superior.

Fluoride Toothpaste

The regular use of fluoride toothpaste is a very common recommendation by the orthodontist, but it is shown to be inefficient in inhibiting white spot development around the orthodontic brackets.[40,41]

Fluoride Varnish

Duraphat (5% NaF),[42] fluorprotector[43] (1% difluorosilane and 0.1% F), duraflor[42] (5% NaF) are the commonly used Fluoride varnishes. Azarpazhooh[42] concluded that over the 3-year follow-up period, application of fluoride varnish every 6 months was the most cost-effective method for high- and medium-risk group. He also concluded that the slow release of fluoride was seen for periods of up to 6 months, with Durafluor and Duraphat and the greatest release occurred in the first 3 weeks and more gradual release thereafter. On the basis of this observation, he supported the recommendation of twice-yearly application of single-dose preparations.[42] In contrast, some studies advocated that an application every 90 days (tri-monthly) would be sufficient to promote adequate protection.[43,44] Demito *et al*. found there was the increase of 32% in deminerization in areas where varnish was not applied in comparison with 30-50% reduction in WSL's in areas where duraphat was applied twice annually.[45] Use of Fluor Protector (polyurethane varnish) decreased WSL formation under molar bands.[43] Recently, chlorhexidine varnish was also suggested for reducing plaque accumulation and enamel decalcification.[46]

Pit and Fissure Sealant

Light cured pit and fissure sealants applied on the labial enamel surface adjacent to the bonded orthodontic brackets were found to be effective in preventing enamel demineralization without patient compliance.[47] The disadvantage being its technique sensitive and mechanical and chemical breaks in the sealant layer may lead to enamel decalcification under the sealant. According to Benham *et al*. highly filled flowable composites, which are resistant to micro abrasion, when applied gingival to the bonded brackets significantly reduced the WSL's.[48] On the other hand, in another study, it was found that dual-cured lightly filled bisphenol A glycidyl methacrylate, BIS-GMA fluoride releasing sealant did not provide added protection to enamel in comparison with control because material might not be resistant to mechanical and chemical wear.[49] According to Salar *et al*., fluoride releasing sealants demonstrated decreased WSL's when compared to conventional sealant, but potency was still lesser than high fluoride release glass ionomer cement (GIC).[50] As per Solliman,[51] the fluoride-containing sealant like Pro Seal had the ability to be recharged with fluoride ions when introduced into a foaming solution of acidulated phosphate fluoride acting like a fluoride pump. Discs of the said sealants released fluoride ions in a sustained but significantly decreasing amounts from a high concentration in the 1st week to a low concentration at 17th week, whereas composite sealant neither released fluoride nor were recharged with fluoride solutions.

Fluoride in Luting Cement

It has been advocated to use cements containing fluoride for banding like GIC. It had been suggested that fluoride releasing cements such as zinc polycarboxylate and resin modified GIC demonstrated less enamel demineralization than the zinc phosphate cement.[52]

Fluoride in Bonding Agents

Bonding agents containing fluoride have the potential for decreasing enamel decalcification.[53] It was concluded that the fluoride release is greater with resin modified GIC and also over a prolonged period, as compared with the fluoride containing composites.[54] Bonding with GIC showed less WSL in 12 year follow-up in comparison to conventional composite material.[55] However, traditional fluoride releasing cements, glass-ionomer cements and resin-modified GIC have bond strengths that are substantially lower than those of conventional resins.[56] Bioactive glass (BAG) materials have recently been incorporated into the field of dentistry and are surface active materials known to successfully release ions (calcium, phosphate and fluoride ions) in simulated body fluid.[57] Manfred

et al.[57] and Brown *et al*.[58] found that BAG-Bond adhesives outperformed conventional composites at maintaining superficial enamel hardness surrounding orthodontic brackets and released reservoir ions that decreased the chances of WSL around brackets. Thus, these adhesives hold the potential to be biomimetic bonding agents.[58]

Fluorides in Elastomers

Many investigations have also suggested that fluoride-releasing elastomeric modules were effective in reducing plaque accumulation and enamel decalcification around the brackets.[59,60] However, some authors concluded that fluoridated elastomers had no effect on the quantity of disclosed plaque around orthodontic brackets.[61] Even the fluoride release from a fluoride containing elastic chain was high for the 1st week and decreased significantly after that.[62,63] To address to this problem, it has been suggested to prescribe fluoridated toothpaste and mouth rinse so that fluoridated elastomers may imbibe fluoride from their environment.

Use of Fluoride Containing Antibacterial Adhesives

The antibacterial activity of 12-methacryloyloxydodecyl-pyridinium bromide incorporated in the antibacterial adhesive systems demonstrated inhibition of caries formation, especially along the enamel margins.[64]

ADDITIONAL METHODS TO PREVENT WSL

Intentional Use of Hawthorne Effect

Feil found that the home care of noncompliant adolescent orthodontic patients with "poor" oral hygiene could be improved through the use of a deception strategy designed to intentionally induce the Hawthorne effect.[65] As per this effect, the thought of participating in and fulfilling the requirements of a study alters subjects' behavior, thereby contributing to improvement in oral health. Compared with the control group; experimental group showed a reduction in plaque scores from 72 to 52% after 3 months, whereas in the control group plaque scores were increased. The Hawthorne effect can have an effect on patients' behavior that lasts as long as 6 months; hence, they suggested to further evaluate its role in controlling WSL in orthodontic patients where treatment will last more than a year.[65]

Essential Oil Mouth Rinse

Essential oil mouth rinse like Listerine has recognizable bactericidal activity. According to Tufekci, adding Listerine to the daily oral hygiene regimen reduces plaque and gingivitis development in orthodontic patients over a 6-month period in comparison with tooth brushing and flossing alone.[66] As fixed orthodontic appliances may cause enamel decalcification because of plaque accumulation around the bracket base, it is recommended that orthodontists instruct their patients to rinse twice daily with 20 mL of Listerine in addition to brushing and flossing.

Argon Laser

The mode of action of the argon laser for the prevention of enamel decalcification is by altering the crystalline structure of the enamel has been suggested.[67] Blankenau *et al*. for the first time found an average of 29.1% reduction in the depth of enamel decalcification with argon laser irradiation.[68] Many other studies have also reported a significant reduction in lesion depth after argon laser irradiation of enamel.[69,70] Thus, argon laser irradiation can be considered as an effective method in reducing enamel decalcification during the orthodontic treatment.

Use of Self-ligating Brackets

Buck *et al*., in a randomized clinical study found that most patients bonded with self-ligating brackets had fewer bacteria in plaque than did the teeth bonded with elastomeric ligated brackets both at 1 and 5 weeks after bonding.[71] On contrary, Polat, found no differences in terms of WSL formation between conventional straight wire and self-ligating brackets and WSL formation depend largely on patients' oral hygiene status, not the type of bracket or ligation used.[72] Further research is awaited on this topic before recommending self-ligating brackets over conventional brackets to reduce WSL.

Chewing Gums Containing Xylitol

Xylitol, a polyol (a type of carbohydrate) that does not act as a metabolizing substrate for *S. mutans*, can be used as a low-calorie sugar substitute to prevent caries.[73] It resulted in increased production of stimulated saliva containing more calcium and phosphate ionic concentrations when compared with non-stimulated saliva.[74] Moderate and high-risk adult patients are recommended to chew two pieces of xylitol gum for 10 min at least, 3-5 times a day.[3] Therapeutically, 6 g/day of xylitol is recommended for adults. However, xylitol can cause diarrhea if the recommended doses are exceeded.[3]

Use of Casein Phosphopeptides Amorphous Calcium Phosphate

Enamel demineralization might be prevented by the application of products containing Casein Phosphopeptides Amorphous Calcium Phosphate (CPP-ACP). For many years, it has been known that milk and its derivatives have a tooth protective effect. Reynolds reported that CPP-ACP, which is derived from milk casein, was capable of being absorbed through the enamel surface and could affect the demineralization-remineralization processes.[75,76] Recently, research has shown that this activity is due to a part of the casein protein called CPP, which carries calcium and phosphate ions 'stuck' to it, in the form of APP.[76] This complex of CPP-ACP is an ideal delivery system for bio-available calcium and phosphate ions. The proposed anticariogenic mechanism of CPP-ACP involves the incorporation of the nanocomplexes into dental plaque and onto the tooth surface, thereby acting as a calcium and phosphate reservoir. CPP-ACP has been shown to adhere to the bacterial wall of microorganisms and tooth surfaces.[75,77] When an intraoral acid attack occurs, the calcium and phosphate ions are released to produce a supersaturated concentration of ions in the saliva, which then precipitates

a calcium-phosphate compound onto the exposed tooth surface.[78,79] Few studies showed that daily applications of the remineralizing cream could reverse the severity and visual appearance of postorthodontic WSL more effective than or at least as good as, fluoride toothpaste.[80-82] The use of CPP-ACP can be more beneficial than fluoride rinse for postorthodontic remineralization.[83] Uysal *et al*. displayed reduced demineralization when ACP was incorporated in the orthodontic composite.[84]

Microabrasion

Microabrasion is an effective treatment for cosmetic improvement of longstanding WSL's.[83] Around 18 % hydrochloric acid was mixed with fine pumice powder to obtain a slurry form. The slurry was agitated into the tooth surface for 30 s and then washed off with an air-water spray. The cycle of microabrasion procedure and washing was repeated 3-4 times on each affected tooth.[85] It was the most beneficial method among the three methods tested-fluoride rinse, CPP-APP with fluoride rinse and microabrasion procedure.[83]

Chlorhexidine Varnish

Beyth *et al*. provided additional evidence that sustained release chlorhexidine varnish decreases *S. mutans* levels in orthodontic patients with fixed appliances and therefore might be useful in preventing caries lesions.[46] Kronenberg have shown *mutans streptococci* suppression and an enhanced prophylactic effect compared with non-protected teeth. When combining chlohexidine varnish with a fluoride varnish (Fluor Protector), the cariostatic effect was enhanced even further in comparison to ozone, which also have been shown to decrease *S. mutans* count.[86]

Recommendations

Based on this literature review, the following measures can be suggested to prevent WSL in orthodontic patients:

1. Educate and motivate the patients at every visit to maintain optimal oral hygiene around the appliances to obtain the full effect of fluoride.
2. Advise daily brushing with fluoride toothpaste twice daily. Use of interdental brushes to remove plaque around the brackets can be advised.
3. Daily use of a fluoride mouth rinse (0.05% NaF) or essential oil mouth rinse can be prescribed.
4. Performing oral prophylaxis (scaling) when needed and reinforcing instructions at each appointment in non-compliant patients.
5. Use of topical fluoride in the form of varnishes, around the brackets of non-compliant/high risk patients at 6 months interval.
6. Cementing the bands with good quality resin modified glass-ionomer cement and applying fluoride releasing sealants around brackets.
7. CPP-ACP remineralizing creams are recommended for prolonged periods post debonding.

Fate of Enamel Scars

Several studies have reported that demineralization ceases following removal of fixed orthodontic appliances.[87,88] This could be due to physical removal of the overlying acid-producing plaque, areas of plaque retention i.e., orthodontic attachments thereby improving accessibility to saliva.

The demineralized enamel that appear as white spot may disappear either because of surface abrasion or result from a reparative precipitation of mineral deposits once the treatment is over.[89,90] Fitzpatrick and Way demonstrated that after acid etching, the return to a normal enamel surface was because of a filling-in of material and not because of wearing away of the etch.[91] Some investigations also indicated that it was of an appatitic nature, with only minor amount of impurities.[90-92] It has been suggested that polishing or abrasion of the dull and irregular enamel surface results in the exposure of the more tightly packed enamel crystals, which give a harder and glossier clinical appearance.[87]

It is important that remineralization is significantly enhanced by fluoride. Therefore, routine fluoride mouth rinse might serve a valuable purpose also in the time period after debonding[31]The need to prescribe an additional topical fluoride will be dependent upon the needs of the individual patient and clinical judgment. However, the appearance of white lesions that persists after orthodontic treatment can be improved by a hydrochloric acid-pumice micro-abrasion technique.[93] Recently the studies of the effects of CPP-ACP have so far shown promising dose-related increases in enamel remineralization within already demineralized enamel lesions. The ability of CPP-ACP to prevent WSL formation has not as yet, been proven.

CONCLUSION

WSL are one of the common complications of fixed orthodontic treatment. It is the responsibility of an orthodontist to minimize the risk of the patient having decalcification as a consequence of orthodontic treatment by educating and motivating the patients for excellent oral hygiene practice. Different regimens suggested by different authors can be prescribed to the patients to control WSL along with topical fluoride application.

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