EFFECT OF FLUORIDE ON PREVENTION OF DEMINERALIZATION ON ENAMEL DURING THE ORTHODONTIC TREATMENT

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ABSTRACT

The formation of white spot lesions, or enamel demineralization, around fixed orthodontic attachments is a common complication after the end of fixed orthodontic treatment. This article is a contemporary review of measures for the prevention of white spot lesions during orthodontic treatment with fixed appliances. Preventive programs must be included for all orthodontic patients by educating and oral hygiene motivation for using topical fluoride agents, casein phosphopeptide-amorphous calcium phosphate agents, high-fluoride toothpaste, fluoride mouthwashes, gels and varnishes during and after the orthodontic treatment so as antimicrobial agents and resin infiltration. Reducing the risk of WSL formation by using these methods and early treatment with the appropriate technique is recommended to obtain healthier and more aesthetic results.

Keywords: white spot lesions, fixed orthodontic appliance, topical fluorides

Introduction

After the orthodontic appliances are removed, it is common to see a regression appearance of WSLs due to natural remineralization by saliva and abrasion due to brushing in the presence of oral and food hygiene. This improvement depends on the severity of lesions and occurs in the period of 6 months after debonding process; however, it is not sufficient and these WSLs should be applied. As a result, Guzmán-Armstrong et al. recommends a delay of 6 months before treating these lesions.(1)

The prevalence of WSL on the enamel surface is caused by multiple factors in the period of fixed orthodontic treatment. The presence of bacterial plaque, fermentable carbohydrates, a susceptible tooth surface and a sufficient period of time are necessary for the formation of WSL. Many irregularities are present in the fixed appliance of orthodontic treatment which causes easy accumulation of food debris along with the cariogenic bacteria thus causing manual teeth cleansing more difficult as well as averts the self-cleansing action of tongue, lips and cheeks to remove accumulated food debris from the tooth surfaces. The gingival side of brackets are the area of great plaque deposition. (30)

Elastomeric rings ligated teeth have a greater number of cariogenic microorganism colonies which can't be seen clearly in stainless steel ligature wires ligated teeth. (31)

Prevention and management of WSLs

The prevention and management of white spot lesions can be achieved by applying multifunctional approaches during orthodontic treatment. Fixed orthodontic appliances create stagnation areas for plaque and make tooth cleaning difficult. Brackets, arch wires, ligatures and other orthodontic appliances complicate the use of conventional oral hygiene measures. This often results in significant plaque accumulation around the bracket bases. Demineralization of enamel around brackets can be an extremely rapid process and appears most frequently on the cervical and middle thirds of the buccal surfaces of the maxillary lateral incisors, the mandibular canines and the first premolars. (2) Demineralized enamel can remineralize after debonding under favorable conditions.(3, 4)

The first choice for the elimination of WSLs is remineralization which, apart from strict oral hygiene measures, involves repeated applications and the compliance of a motivated patient and may take some time. Several professional and home applied products are available in different forms for such a purpose: solutions, varnishes, creams, pastes and chewing gums. These products contain fluorides and/or casein phosphor-peptide-amorphous calcium phosphate. There is evidence with varying degrees of success in the dental literature. (5 - 8)

Fluoride is the most reactive element in the periodic table and its presence in the biofilm is important in limiting demineralization and stimulating remineralization of the hydroxyapatite crystal. There is convincing evidence that fluoride has a major effect on demineralization and remineralization of dental hard tissue. The source of this fluoride could either be fluorapatite (formed due to the incorporation of fluoride into enamel) or calcium fluoride-like precipitates, which are formed on the enamel and in the plaque after the application of topical fluoride. (9, 10)

The risk of enamel demineralization during fixed orthodontic treatment can be prevented by: improving patient's oral hygiene with mechanical plaque control methods, using bonding agents with fluoride, enhancing the enamel resistance to microbial acid by using topical fluoride and additional methods using different mechanisms.

Oral hygiene control

The most important prophylactic measure to prevent the occurrence of WSLs in orthodontic patients is implementing a good oral hygiene regimen. Good oral hygiene is thus more important in orthodontic patients treated with fixed appliances than in non-treated individuals. Mechanical plaque control by proper tooth brushing is of paramount importance. The 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. (11) Zabokova (12) in her study concluded that improvement of oral hygiene was detected in the group where preventive treatment with Fluorogal was implemented and showed statistically significant difference between medium values of the simplified oral hygiene index (OHI-S) before and after orthodontic treatment, which was not the case with control group. This finding might be explained by the way the oral hygiene is maintained (adequate and not adequate oral hygiene). The subjects treated with dental cream (GC Tooth Mousse) had significantly decreased oral hygiene index at the end of orthodontic treatment (1.49) in comparison with the beginning of the treatment, where the average monthly value of the index of oral hygiene was 1.55. Besides oral hygiene at home, professional prophylactic cleaning is designed to reduce the bacterial load, enhance the efficacy of brushing and facilitate cleaning by the patient. Professional tooth cleaning two or three times a year maintains a healthy mouth and reduces the risk and number of teeth with caries. It allows proper cleaning of the areas that are hard for the patient to brush. The coronal surfaces can be polished using fluoridated pastes of progressively finer particle size, and elastomer polishing cups or brushes to impede the mechanical retention of bacteria. (13)

Usage of agents with fluoride

Fluoride application is commonly used method to reduce enamel tendency to demineralization. The concentration of fluoride in saliva and plaque is effective in prevention of demineralization and the formation of remineralization. The organic acids formed by cariogenic bacteria cause a decrease in pH level of plaque resulting in fluoride diffusion into enamel from plaque and saliva as response. Displacement of hydroxyl ions of enamel structure with fluoride causes existence of fluorapatite crystals. This new crystal form is more resistant to acids. Fluoride also affects the activities of cariogenic bacteria and prevents formation of caries. Laboratory studies have shown that low concentrations of fluoride make *Streptococcus mutans* to produce less amount of acid.

Different modes in which fluorides have been documented to prevent WSL are as follows: Fluoride Mouth Rinse, Fluoride Gel, Fluoride Toothpaste, Fluoride Varnish, Fluoride in Bonding Agents and Fluorides in Elastomers. The fluoride ion has a preventive effect against caries. It modifies bacterial metabolism in dental plaque by inhibiting some enzyme processes, inhibits the production of acids by acting on the composition of the bacterial flora and (or) on the metabolic activity of micro-organisms thus reduces demineralization and stimulates the remineralization of early carious lesions by exerting a remineralization effect, especially at low concentrations. (14) Fluoride enhances enamel remineralization following orthodontic treatment. The cariostatic effect of topical fluoride is primarily due to calcium fluoride (CaF_2) formation. 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. Proper oral hygiene maintenance, combined with daily use of topical fluoride, is found to significantly reduce enamel decalcification. 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. (15, 16)

Fluorinated toothpaste

The fluoride concentration of toothpaste (in the form of sodium fluoride, monofluorophosphate, and stannous fluoride) should be over 1000 ppm; toothpaste with higher fluoride concentrations is more effective. (17, 18) The use of a dentifrice with a high fluoride concentration (5000 ppm), twice daily, by patients at high risk for WSL is more effective than conventional formulations. (19, 20) However, such toothpaste (Duraphat) cannot be prescribed for patients under 16 years of age. Heymann and Grauer recommend this toothpaste for brushing in the evenings only. (21) Nonetheless, the use of fluoride toothpaste alone is not effective in preventing WSL in the majority of patients, even with good oral hygiene.(22) 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. As orthodontic patients are at an increased caries risk, an appropriate level of fluoride ions is needed to provide an anticaries benefit by promoting enamel remineralization. Thus,

for orthodontic patients, fluoride concentration below 0.1% in dentifrices is not recommended. This is because when fluoride ions are incorporated into the enamel surface, a fluorapatite crystal structure is formed having lower solubility in the oral environment compared with hydroxyapatite.

Fluoridated mouthwashes

Daily use of fluoridated mouthwashes containing sodium fluoride has been shown to result in a significant decrease in the development of carious lesion around and beneath bands. Antibacterial agents have been incorporated into these mouthwashes, including chlorhexidine, triclosan or zinc to promote their cariostatic effects. Benson carried out a systematic review and recommended the daily use of 0.05% NaF mouthwash to prevent enamel demineralization during fixed orthodontic treatment. (23) A daily mouthwash containing NaF (0.05% or 0.2%) and/or weekly rinse containing alpha-1-fetoprotein (1.2%) have been demonstrated to decrease the incidence of enamel demineralization during fixed orthodontic treatment.

Fluoride varnishes

For the prevention of white spot lesion, sodium fluoride is the agent that is mostly used, toothpaste is commonly used so as the fluoride varnish. For less motivated patients, fluoride varnish should be used. The use of a fluoride varnish gives a protective coating over the tooth surface reduces enamel solubility. These varnishes were produced to adhere to the enamel surface for longer period slowly releasing fluoride on the enamel surface. Usage of fluoride varnishes has proven to be a possible and protected technique of fluoride application. It has been reported that 44.3% reduction in enamel demineralization in orthodontic patients after application of fluoride varnish (24) Fluoride varnishes should be used in less-motivated patients in an intensive treatment schedule (three days running), repeated every three or four months, or at least twice or three times a year. The varnishes are thus used as a preventive measure to reduce demineralization of the enamel around the brackets, promote the remineralization of the carious lesions and avert further lesions. Fluoride varnishes (Fluor Protector* with 1% difluorosilane and 0.1% F, Duraphat* with 2.2% F, Bifluoride* with 5% F) are usually applied twice a year on specific areas with incipient lesions on smooth surfaces. These varnishes were developed to adhere to the enamel surface for longer periods (up to 12 hours or more) and release their fluoride slowly on the enamel surfaces. (25) The use of fluoride varnishes has proven to be a feasible and safe method of fluoride application. Advantages of the fluoride varnish over other topical fluoride regimens include providing fluoride protection of enamel despite patient noncompliance and delivering the fluoride in a sustained manner over a longer period of time. It has been reported that the application of a fluoride varnish resulted in a 44.3% reduction in enamel demineralization in orthodontic patients. Azarpazhooh et al. after a 3-year follow-up period, reported that application of fluoride varnishes every 6 months proved the most cost-effective technique for high- and medium-risk groups. (26) They also concluded that Durafluor and Duraphat released fluoride at a slow rate for up to 6 months, with the greatest release observed during the first 3 weeks, followed by a more gradual delivery. Therefore, they supported the recommendation of a biannual application of single-dose preparations. However, some studies have recommended an application every 90 days (every 3 months) to promote adequate protection. The application of a fluoride varnish every 6 weeks during orthodontic treatment has been shown effective in some other studies. (27) Recently, an in vivo study by Perrini et al. showed that periodic application of fluoride varnishes in patients undergoing fixed orthodontic treatment can provide some protection against WSLs, which might not be statistically significant if the patients exhibit excellent oral hygiene. (28) A one-time application of a fluoride varnish, just before the initiation of orthodontic treatment, did not provide any additional preventive advantage over good dental hygiene with the use of fluoride toothpastes in terms of the development of WSLs and gingivitis in patients at a low to moderate caries risk. Patients often undergo an application of fluoride varnish just before orthodontic treatment with fixed appliances. However, the efficacy of this technique is yet to be elucidated. (29) Demito et al. found there was an increase of 32% in demineralization in areas where varnish was not applied in comparison to a 30–50% reduction in WSLs in areas where Duraphat was

applied twice annually.(30) Zabokova (31) in her study concluded that the level of fluoride in enamel before and after bonding the brackets with composite resin (Dentaurum, Germany), and application of a fluoride varnish was significantly increased. Thus, the amount of fluoride in enamel before fixing the brackets was 614 ppm. After 30 days of fluoride varnish application the amount of fluoride in enamel was 844 ppm, which was statistically significantly higher than the initial coverage of fluoride in enamel. These results confirmed that fluoride varnish application is a simple and fast technique that could be useful in preventing enamel demineralization associated with orthodontic treatment.

Fluoride in bonding agents

Considering the low efficacy of patient-applied measures, there have been attempts to use the benefits of materials releasing fluoride over time, including continuous release of fluoride from the bonding system around the bracket base, which can be very advantageous. Fluoride-containing adhesives have not proved effective in decreasing demineralization, but compomers and glass-ionomer cements have been promising in this context. (33 - 35) Glass-ionomer cements are less strong than composite resins; therefore, there are more bracket failures when they are used for orthodontic bonding procedures. (36)

Generally, there is high risk of caries formation due to the longer duration of orthodontic treatment. Thus, continuous fluoride release would be highly beneficial around the bracket base. Glass ionomer cements (GICs) were at first initiated as orthodontic bonding adhesives exploiting some of their attractive attributes, to be specific, their capacity to chemically bond to the tooth structure, in addition to their continuous fluoride release following bonding. In addition to increasing the strength of the GICs bond, resin particles were added and these resin-modified GIC (RMGIC) bonding systems release fluoride like conventional GIC and have higher bond strength [26,27]. In the future, it has been suggested that RMGICs should play a greater role in orthodontic bracket bonding.

The release of fluoride from elastomeric ligatures might help decrease demineralization prevalence; however, incorporating fluoride into elastics might affect their physical properties, resulting in their faster deterioration in the oral cavity. (37) A recent study suggested that orthodontic cements with microcapsules release bioavailable fluoride, calcium and phosphate ions near the tooth surface, with the capacity to be recharged with fluoride and with no effect on the adhesion of the material to enamel. The incorporation of microcapsules into dental materials might promote remineralization. Various intraoral fluoride slow-release devices, including copolymer membrane device, glass device containing fluoride, hydroxyapatite-Eudragit RS 100 diffusion-controlled fluoride system and slow-release tablets for intrabuccal use have been introduced in recent years, with the capacity to release small amounts of fluoride over a long period of time, possibly for up to 6 months, before being replaced. (38)

It was reported that light-cured pit and fissure sealants placed on the buccal surfaces near bonded orthodontic brackets were very effective (80%) in preventing demineralization in vitro, requiring no patient compliance. (39) However, these sealants cannot be removed easily and require meticulous polishing after removal. Application of a fluoride-containing sealant to the buccal aspects of bovine incisors to prevent the development of carious lesions around orthodontic brackets showed that ProSeal sealant alone or in association with brushing and/or brushing and the use of a fluoride-containing mouthwash was more efficient in protecting enamel compared to brushing alone. (40)

Conclusion

White spot lesions are an iatrogenic effect of Orthodontic treatment. Their prevalence in Orthodontic populations is particularly high, and since they affect teeth in the aesthetic zone, they prove to be a concern to both patients and clinicians. While prevention is ideal, there are high-risk patients with these lesions and their management becomes increasingly important. While there are many different treatment modalities to manage these lesions, prevention is optimal and should constitute the first line of defense.

Oral hygiene motivation, topical fluoride agents, casein phosphopeptide-amorphous calcium phosphate agents, high-fluoride toothpaste, fluoride

mouthwashes, gels and varnishes during and after the orthodontic treatment, antimicrobial agents and resin infiltration are the current options for prevention and treatment of white enamel lesions. Reducing the risk of lesion formation by using these methods and early treatment with the appropriate technique is recommended to obtain healthier and more aesthetic results.

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