



REVIEW ARTICLE

Effects of fluoride agents used in orthodontic treatment on demineralization

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ABSTRACT

White spot lesions seen during orthodontic treatment could lead to unsuccessful esthetic results. For conducting a successful orthodontic treatment, orthodontists should be aware of decalcifications and take preventive measures. The aim of this review is to evaluate the effects of fluoride agents on prevention of white spot lesions that may occur during the treatment.

INTRODUCTION

The enamel demineralization is an undesired complication in the individuals who are subject to fixed orthodontic treatment, especially with weak oral hygiene, but is seen frequently.¹ The frequency of decalcification occurrence during the orthodontic treatment was reported between 2% and 96%.²⁻⁴

Placement of fixed orthodontic appliances differentiates the oral flora, and this causes the dental plaque change both regarding the quantity and quality. Just after insertion, the dental plaque begins to increase gradually around the bands and brackets and the oral flora composition

changes. As a result of this, it is difficult to provide the oral hygiene for the patients.⁴⁻⁶

The first sign of enamel decalcification in the patients subjected to orthodontic treatment is the white lesions of the enamel around the brackets, namely in the zones where the tooth decay risk is normally low.² Even though these decalcifications may be remineralized after debonding, the white spot lesions are usually at the frequently seen zones and continue to disturb the patients.⁷

The responsibility of orthodontists is to be aware of decalcification risk and to take the necessary steps in order to avoid decalcifications. The fluoride products

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are the most important agents to prevent the decalcification and to preclude their development and progression. The clinicians should know the use, mechanism of action and procedures of fluoride preparates and should become familiar to the actual protective principles.

The purpose of this review is to discuss the effects of fluoride agents in prevention of white spot lesions that may occur during the orthodontic treatment.

Formation mechanism of white spot lesions during the orthodontic treatment

The white spot lesions develop depending on the unbalancing of demineralization-remineralization process due to the long-term plaque retention in the affected zone.⁸ It is suggested that the fixed orthodontic appliances rapidly increase the dental plaque volume and the formed plaque pH is lower than in the individuals not subjected to the orthodontic treatment.^{9,10} Scheie et al.¹¹ observed that *Streptococcus mutans* levels increase prominently in the plaque and saliva after inserting the orthodontic appliances. All these changes cause the demineralization in the enamel and white spot lesions develop depending on it.

Light transmittance of decalcified porous enamel surface changes and creates a white appearance. These white spot lesions progress rarely so as creating the apparent cavities and require the restorative treatment. The enamel damages may occur around the orthodontic appliances in the low proportions, even if the fluoride toothpaste is used regularly. The white spot lesions may develop very fast.¹² In many cases, the lesions are small and observed at a thin band around the bracket bases or as the zones between the bracket and gingival margin. In some patients, the lesion development may be more extensive, and if the oral hygiene and fluoride regimes

are not applied correctly, earlier debonding may be required. The tooth decay lesions may also develop due to the retainers cemented after debonding. If the patients are not warned about breaking off of some zones of the retainers and the necessary steps are not taken, then the decays may rapidly turn to the serious lesions.

40 patients who participated a randomized clinical research¹³ in which the effects of anti-decay program were studied, were re-examined and it was observed that approximately 75% of small white spot lesions regressed 6 years after debonding, it was reported that 25% turned into the bigger lesions and maintained their existence.⁵ Shungin et al.¹⁴ evaluated the changes in white spot lesions with treatment and 1, 2 and 12 years after debonding. They pointed out that white spot lesions significantly increased during orthodontic treatment, decreased markedly after debonding but did not reach to pretreatment levels even after 12 years.

Fluoride and cariostatic effect

Fluoride is an important anti-decay agent. Fluorine ions prevent the demineralization and provide the remineralization effect. When a topical fluoride agent is applied, calcium fluoride-like material is formed within the plaque, on the tooth surface or within the initial lesion. This calcium fluoride acts as a reservoir releasing the fluoride ions when pH drops during the decay attacks.¹⁵ When pH drops under a certain level, the fluoride's protective effect decreases fast. After bonding, oral pH decreases fast, but pH may be maintained beyond 4.5 which is the critical level through a good oral hygiene and in this case the fluoride remineralization increases and avoids the lesion development. In the existence of weak oral hygiene, the plaque around the appliances develops and the oral pH drops to 4.5, limiting the fluoride effect

and in this case, the decays and erosions may occur with the acid attacks.¹⁶

Important clinical preferences in plaque accumulation

The patient compliance providing the optimal oral hygiene and fluoride protection have the critical importance,¹⁷ but despite of endeavor by patient to provide a good oral hygiene, many different appliance designs facilitate the plaque accumulation risk. The complicated appliance designs such as loops, auxiliary arch wires, springs and some fixed functional appliances create some areas that are almost impossible to clean. In addition, not removal of remnant bonding materials around the bracket base creates the gingival pockets where the bacteria settle easily.¹⁸ The steel ligatures or self-ligating brackets¹⁹ may be preferred instead of elastic ligatures in order to minimize the retentive areas. In a recently published research,²⁰ it was shown that in subjects treated with lingual orthodontics, the occurrence of white spot lesions was less than that in labial orthodontic treatment.

Fluoride applications during the orthodontic treatment

Calcium fluoride is the active substance in the topical fluoride treatment applied to the enamel and it is known that the fluoride has a prominent role in the cariostatic effect. The fluoride may be applied in the several ways during the orthodontic treatment. Those are the systemic (fluoridation of waters), topical (fluoride toothpastes, mouthwashes, gel and varnishes) and adhesive (fluoride releasing cements, elastomeric modules and chains) methods.

Fluoridation of the waters and community fluoride intake programs

It was shown that the dental decay prevalence decreases in many developed

countries.^{21,22} Community-based fluoride applications and accessibility of fluoride toothpaste are directly effective in the decreasing of decay incidence.²¹ In addition to the fluoridation of waters, the decay frequency decreases about 30% to 50% as a result of fluoride mouthwash.²³ Long-term fluoride intake in the optimal doses does not cause any systemic damage to the body.²⁴

Fluoride toothpastes mouthwashes and gels

The studies, evaluating the effect of fluoride in prevention of white spot lesions show that use of daily sodium fluoride mouthwash may minimize the enamel demineralization around the orthodontic appliances.^{25,26} Other recommended fluoride intake methods include the daily use of toothpaste and gels having the higher fluoride concentration (1500-5000ppm) or fluoride toothpaste combined with the chlorhexidine mouthwashes.²⁷ It is recommended to the patients who start the orthodontic treatment to brush their teeth with the toothpaste involving 5000 ppm fluoride twice a day. This regime is found to be more effective than use of mouthwash involving 0.05% sodium fluoride combined with toothpaste having 1000 ppm fluoride.²⁸⁻³⁰ Despite all prophylactic measurements including daily use of fluoride toothpaste, fluoride mouth rinse and weekly use of products with high fluoride content, Enaia *et al.*³¹ observed that during orthodontic treatment new white spot lesions develop nearly on 60.9% of upper front teeth.

Fluoride varnishes

Application of fluoride varnishes is a protective method requiring less patient compliance and has no adverse effect on shear bond strength of orthodontic brackets.³² A protective coating is provided on the tooth surface with the application of fluoride varnish and the enamel solubility.^{33,34} The fluoride varnishes absorb longer on the enamel surface than

other topical fluoride products³⁵ but still the highest fluoride release occurs during the first 8 hours.³⁶ The fluoride varnish is applied to the patients with the fixed orthodontic appliance as a recommended fluoride regime twice or more in a year according to the patients' oral hygiene.³⁷ It is suggested that the fluoride varnishes, regularly applied to the maxillary incisor tooth with bracket, are effective to minimize the lesion occurrence.³³ In a study by Todd *et al.*³⁸ 50% less demineralization is observed in the teeth which the fluoride varnish is applied around the brackets than of those not applied. Since the varnish is eroded through the tooth brushing and oral functions within several days, the varnish should be reapplied quarterly.³³

Fluoride-containing orthodontic bonding agents

In order to minimize the patient compliance and for continuous topical fluoride releasing, the fluoride-containing bonding agents were developed. The glass ionomer cements were developed as an alternate bonding agent to composite by the end of 1980s. However, the studies,^{39,40} showed that bonding power of glass ionomer cements to the tooth surface is weaker than composite resins and this limits the use of glass ionomer cements. The bonding power of resin modified glass ionomer cements to the tooth is higher than the traditional glass ionomer cements and the studies showed that it minimizes the decay occurrence risk around the bracket.⁴¹ It is reported that inhibiting efficiency of fluoride-containing cements is localized around the bracket only.⁴² It is suggested that the cariostatic effect, obtained by glass ionomer and resin modified glass ionomer cements releasing the fluoride, is higher than fluoride-containing composites or compomers.^{43,44} Many fluoride-releasing bonding agents release the higher fluoride on the first days just after bonding, and in the lower quantities thereafter.⁴⁵⁻⁴⁷

According to the study of Marcusson *et al.*⁴⁷ the use of glass ionomer cement for bonding purpose minimizes the occurrence of white spot lesions about 16.5% rather than the use of composite resin. In another work,⁴⁸ it is reported that only the use of resin modified glass ionomer cement against enamel demineralization provides the equal protection to the combined use of composite resin with daily topical fluoride application. Shungin *et al.*¹⁴ compared the effects of usage of acrylic bonding material and glass ionomer cement during orthodontic treatment on white spot lesions and pointed out that white spot lesion areas were significantly reduced with the use of fluoride releasing glass ionomer cement and its effects were evident even 12 years after debonding. For orthodontic banding, conventional⁴⁹ or resin modified⁵⁰ glass ionomer cement should be preferred as it shows greater resistance for enamel demineralization.

Fluoride-containing elastomeric modules and ligatures:

Use of elastomeric modules and chains for space closure and providing controlled tooth movement is a frequent approach in the today's orthodontic applications. Due to less effective power transfer and insufficient fluoride releasing, the fluoride-releasing elastomeric modules is not prevalent.^{51,52} According to an in-vitro study⁵², the fluoride-containing elastomeric chains or modules lose 88% of the fluoride ingredient after insertion. The benefits of usage of such elastomeric modules have been questioned today when the self-ligating brackets has been used frequently.

Determining the white spot lesion occurrence risk in the patients to be subjected to the orthodontic treatment

If a patient shows two or more factors from the below listed symptoms, that individual will be classified as high risk:⁵³

- Existing white spot lesion,
- Insufficient oral hygiene,
- Improper diet (carbohydrate-rich foods, acid beverages),
- Long treatment time,
- Excessive etching,⁵⁴
- Labial appliances,
- Higher decayed, missing or filled teeth,
- Intratreatment lesions.

Geiger *et al.*⁵⁵ reported a meaningful correlation between the white spot lesion occurrence and not observing the protective procedures depending on the patient in the orthodontic patients. No meaningful difference was reported between the genders or various age groups regarding such compliance insufficiency. The patient's decay history and activity in the past are the decay indicators that may be observed clinically. Such clinical indicators may provide the clear information about the past dental history. There are four powerful decay indicators: cavitation, proximal lesions, white spot lesions and a restoration within the last 3 years or tooth that is extracted due to decay. The existence of one of them shows that the patient is in the higher risk group.⁵⁶ Many works were carried out on the correlation between the refined sugar consumption, frequency of snacks and foods and the decay.⁵⁷⁻⁵⁹ The daily sugar food intake is an important issue that the attention must be paid in the evaluation of patient's diet.⁵⁹ Even though the orthodontists do not generally evaluate the patient's nutritional habit due to time limit, such evaluations are important to prevent the white spot lesions and should not be disregarded. Regular patient motivation and mechanical tooth cleaning by dentist help maintaining good oral hygiene for the patient.⁶⁰

Fluoride application after debonding

It is known that the fluoride increases the initial rate of remineralization and

slows down the decay formation. This effect depends on the reaction of fluoride with the minerals on the lesion surface and results with interruption of lesion progress.¹⁵ These interrupted lesions may continue in the white color, namely in white spot lesion or may be subjected to the color change and may turn to the yellowish or dark brown color. It depends on the lesion type whether this lesion will be mineralized completely. The initial surface lesions may be remineralized fast even with the saliva without fluoride.⁶¹ Willmot⁶² compared the changes in the size of post-orthodontic white spot lesions treated with a low fluoride (50 ppm) and non-fluoride mouth rinse and toothpaste. White spot lesions were reduced in the following 6 months regardless of the use of fluoride containing mouth rinse and toothpaste. Al-Khateeb *et al.*⁶³ followed longitudinally 7 patients subjected to orthodontic treatment and have enamel lesions at debonding up to 1 year. The fluoride toothpaste was used daily in those patients and additional topical fluoride product was not applied. The changes in the mineral content of lesions were monitored using the quantitative laser fluorescence. During one year work, the fluorescence shining increased in the lesions and the lesion zones decreased so as showing the remineralization. Since the minerals are not stored in the manner same as the intact enamel surface, the partly remineralized lesions may be discriminated from the intact enamel surface. It has been shown that the white spot lesions could not be remineralized completely in clinical studies that the enamel surfaces have been evaluated for 2 years⁶⁴ and 12 years¹⁴ after treatment.

Even though for cavitated lesions restoration is essential, noncavitated lesions should receive preventive treatment instead of restoration. The first approach to eliminate white spot lesions is remineralization. Fluoride containing solutions, varnishes,

cream pastes and chewing gums can be used for topical remineralization treatment.⁶⁵ Du *et al.*⁶⁶ evaluated the efficacy of fluoride varnish after fixed orthodontic treatment and concluded that topical fluoride varnish application is effective in reversing white spot lesions after debonding. Also it is known that the frequent use of fluoridated miswaks had a remineralizing effect on white spot lesions.⁶⁷ Recently lesion infiltration with low-viscosity light-curing resins (Icon infiltrant; DMG, Hamburg, Germany) has been proposed to inhibit further demineralization⁶⁸ and to improve esthetic appearance of demineralized teeth.⁶⁹

Results and clinical recommendations

The enamel decalcification is a major clinical problem in the fixed orthodontic treatment. The most important thing is to prevent the development of lesions during the treatment. After the lesions occur, it is very difficult to provide the remineralization completely.

The fluoride may control these lesions, but the lesions may change the color in the course of time. These lesions damage the aesthetic correction provided with the orthodontic treatment. The fluoride is an effective cariostatic agent. All orthodontic patients should use the fluoride-containing toothpaste and should support it with the fluoride-containing mouthwashes. In order that the fluoride provides the full effect, it is necessary to provide the optimal oral hygiene around the orthodontic appliances.

The topical fluorides in solution, varnish or gel should be applied regularly around the brackets. It is not possible to say which topical agent or procedure is the most effective based on the current knowledge. The risk factors of individuals must be evaluated and the protective measures must be combined according to the needs of individuals.

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