A review on preventive measures and treatment of white spot lesions in patients with fixed orthodontic appliances

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Abstract

Objective: One complication of fixed orthodontic treatment in patients with poor oral hygiene is development of demineralized enamel lesions compromising esthetics. This study aimed to review preventive measures and treatment of white spot lesions (WSLs) in patients with fixed orthodontic appliances.

Review of Literature: In this review study, PubMed and Google Scholar databases were searched for articles published during 1964-2013 using the keywords "white spot lesions", "demineralization", "mastic gum", "casein phosphopeptide amorphous calcium phosphate or CPP-ACP", "chitosan" and "orthodontics"; 96 articles were evaluated.

Conclusion: White spot lesions can be prevented by conventional plaque control and adjunct measures such as the use of fluoride-containing compounds, chlorhexidine (CHX), xylitol gums, chitosan compounds and laser. Low-concentration fluoride, CPP-ACP compounds and laser help remineralize these lesions. If not treated, bleaching, microabrasion and tooth restoration are the final solutions.

Key words: Demineralization, Fixed orthodontic appliances, Fluoride, Prevention, White spot lesions.

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Introduction:

Enamel white spot lesions (WSLs) are among the important complications of fixed orthodontic treatment with a prevalence of 2-96% depending on the diagnostic method used (1-4). The white appearance of these lesions is due to the loss of mineral crystals of the enamel surface or subsurface. Increased surface roughness, loss of shine and changed pattern of light refraction results in an opaque appearance (4). Presence of brackets, ligatures, wires and other orthodontic appliances in the mouth makes tooth self cleansing more difficult and enhancing the accumulation of microbial plaque. Increased number of mutans streptococci and lactobacilli at the site increases the prevalence of WSLs (5-7).

Enamel WSLs are divided into two groups of carious and non-carious lesions that can be differentiated by examining the dried tooth surface under adequate lighting. The carious lesions are opaque with a rough, porous surface; while the non-carious lesions have a smooth, shiny surface. Carious WSLs are often seen in the buccal surface of teeth adjacent to brackets; in plaque accumulation areas. They may extend to proximal surfaces as well. Thus, patients with WSLs on the buccal surface of their teeth must be examined for presence of these lesions on proximal tooth surfaces (8). The most common sites of involvement include cervical areas and the middle third of the buccal surfaces of the maxillary lateral incisors, mandibular canines

and first premolars (3, 9).

These lesions are often resolved and remineralized in the first year or two following the removal of appliances by tooth brushing abrasion and elimination of the etiologic factor (i.e. bacterial plaque attached to the appliances); although they may remain for up to five years following completion of orthodontic treatment. Remineralization of these lesions by the saliva does not usually resolve patients' esthetic problems (5-7, 10-13).

Poor oral hygiene, limited cleaning effect of the saliva and tongue in presence of fixed orthodontic appliances and consumption of high-carbohydrate, highly fermentable food can cause WSLs. Inappropriate cementation of orthodontic appliances, early initiation of fixed orthodontic treatment and unfavorable salivary characteristics including its flow and pH and salivary level of calcium, phosphate and bicarbonate may also play a role in development of these lesions. Inadequate fluoride intake and genetic background also affect susceptibility to WSLs (3, 8, 14).

This study aimed to review preventive measures and treatment of white spot lesions (WSL) in patients with fixed orthodontic appliances.

Review of Literature:

Prevention

Oral hygiene instruction:

The main responsibility of preventing WSLs is on patients; however, cooperation between the patient, parents, orthodontist and general dentist is necessary for the prevention and treatment of these lesions (15).

Oral hygiene instruction along with periodic professional prophylaxis particularly in uncooperative patients decreases the risk of WSLs.

Tooth brushing according to Charters brushing technique twice daily with fluoride-containing toothpaste is the main method of plaque control. Electric toothbrushes, interdental brush, end tuft brush, floss threaders and home irrigation are among other plaque control adjuncts than can be used by these patients (4, 16, 17).

Evidence shows that toothpastes containing 5000 ppm fluoride are more effective for decreasing demineralization and increasing remineralization than the conventional types (containing 1000 ppm fluoride) and twice daily application of these toothpastes is recommended for orthodontic patients. Duraphat (Colgate, Palmolive AB) and Prevident 5000 Plus (Colgate, Oral Pharmaceuticals Inc., Danderyd, Sweden) are two such toothpastes. Some studies have demonstrated that twice daily use of these toothpastes is more efficient than using sodium fluoride (NaF) mouth rinse containing 500 ppm fluoride alone or in combination with 1000 ppm fluoride toothpaste (8, 18-20).

Fluoride compounds:

Fluoride mouth rinses can also be useful by providing a rich source of fluoride in the oral cavity. However, strong evidence showing inhibition or decrease of WSLs following application of such mouth rinses has not been documented (8).

It has been discussed that application of mouth rinses along with the use of fluoride-containing toothpaste is not significantly different from the use of fluoridated toothpaste alone in terms of efficacy for prevention of caries (4). On the other hand, a systematic review reported that daily application of 5.50% NaF mouth rinse was the most efficient method to decrease WSLs (13).

Several studies have confirmed the positive effects of fluoride therapy with fluoride varnish containing 5% NaF (22000 ppm) at least twice a year for prevention of WSLs (8, 21-23). Application of these varnishes is very beneficial especially when the brackets are bonded with composite resin. However, application of fluoride varnish does not seem to provide greater protection when brackets are bonded with glass

ionomer (4, 21). On the other hand, fluoride gel with a pH of 5.3-7 may damage the oxide layer on the surface of nickel-titanium (NiTi) and stainless steel (SS) wires and compromise their mechanical properties (24, 25).

Antimicrobial agents:

Antimicrobial agents such as chlorhexidine can change the ecology of the biofilm and can effect dental caries (26) and therefore, are beneficial for patients with poor oral hygiene. Application of 0.2% chlorhexidine (CHX) twice daily each time for 60 seconds is recommended in patients who are not cooperative for using other preventive measures. Its application has a synergistic effect with the use of xylitol chewing gums (16,17. 27). Use of 1% CHX varnish intensively i.e. 3-4 times a day for 2 days or once a day for 10-14 days decreases Streptococcus mutans count (28-29).

Chitosan is another antimicrobial agent. It is a bio poly-amino-saccharide with bacteriostatic, bactericidal, antifungal, antiviral, antiprotozoal, anticancer, anti-plaque and anti-calculus properties. Its pH is adequate for buffering the acidic oral environment. It increases the salivary secretion and flow and decreases demineralization by preventing phosphate release from the tooth structure (30-32). Chitosan is available for use in the form of solution, mouth rinse, toothpastes such as AloeDent (Optima-Health Nutrition Ltd., Cardiff, Wales, UK) and Chitodent (B&F Elektro GmbH, Filsum, Germany) and also in the form of chewing gums (33-35).

Evidence shows that four weeks application of chitosan toothpaste decreases the plaque index by approximately 70% and the microbial index by approximately 85% (30). One study showed that its application for 60 days decreased demineralization around brackets (34).

Chewing gums:

Chewing gums help prevent caries by mechanical plaque removal and increasing the stimulated saliva secretion with higher calcium and phosphate contents and greater buffering capacity (8, 17).

Chewing xylitol gums decreases the S. mutans count in the plaque, saliva and adjacent to brackets and makes a shift towards less-virulent strains (36-38). It has been demonstrated that in patients with fixed orthodontic appliances, chewing xylitol gums for two weeks prevents pH drop following the consumption of carbohydrates. The recommended protocol for patients with moderate to high risk of caries is chewing xylitol gums at least for 10 minutes three to five times a day (8, 39).

Chewing mastic gum can also prevent WSLs. Mastic gum is a resinous material with antibacterial, anti-inflammatory and anti-ulcer properties. Its application as an effective agent against Helicobacter pillory for treatment of stomach ulcer confirms its possible antibacterial properties against oral pathogens. The antibacterial effects of chewing mastic gum on Gram positive and Gram negative bacteria have been confirmed by many studies (40-43). One study reported the antimicrobial efficacy of mastic gum to be similar to that of vancomycin (41). Another study reported that chewing mastic gum by patients with fixed orthodontic appliances significantly decreased salivary S. mutans count after 15 minutes and lactobacillus count after 135 minutes (42).

CPP-ACP:

Casein phosphopeptide amorphous calcium phosphate is a phosphorylated peptide derived from milk casein. It bonds to enamel calcium and phosphate at one end and dental plaque at the other end, decreasing the occurrence of WSLs (4, 44, 45). It acts as a reservoir for calcium, phosphate and fluoride ions and maintains a state of super-saturation of the ions in the enamel surface (4, 11, 44-47). A commercially available, FDA approved product containing CPP-ACP is the Tooth Mousse (GC Corp., Japan) gel available in the Iranian dental market as well.

MI Paste Plus is another commercial product containing CPP-ACP also enriched with 900 ppm fluoride (47, 48).

CPP-ACP has also been incorporated into some chewing gums like Trident White and Recaldent (Recaldent Pty Ltd., Australia), Recaldent Mint, sport drinks and also in glass ionomer cement (4). It is safe if swallowed and is recommended for all age groups. Its use inhibits plaque accumulation around orthodontic wires and brackets in orthodontic patients (45).

Other compounds:

In recent years, researchers have attempted to prevent WSLs by incorporating fluoride releasing compounds into elastics, bonding agents and cements (49).

Fluoride-containing chains, ligatures and elastic modules have the advantage of releasing fluoride adjacent to brackets; however, they are not routinely used because the fluoride release is limited to the first couple of days and also, they compromise force delivery (4, 13).

Fluoride releasing adhesives such as GIs, light-cure GIs and fluoride releasing composites also decrease tooth decalcification. GI is more effective than composites due to its rechargability. However, because of the low tensile and shear bond strengths of GIs, they cannot be used as adhesives (2, 4, 13, 49).

Recently, bioactive glass (BAG) (Novamin®/Calcium-sodium-phosphosilicate) has been introduced into the dental market. It releases sodium, calcium and phosphorous when in contact with the saliva or body fluids and enhances enamel remineralization. After primary application of this material, release of ions continues for up to two weeks (44, 49).

By adding BAG to composite resins, sol-gel BAG is achieved, which is a three-dimensional matrix. This composite resin is commercially available in the market under the brand name “Bioglass”.

BAG bonding agent (BAG Bond) acts as a source of calcium and phosphate. By increasing the pH, it prevents critical pH drop and decreases demineralization around brackets. Studies have demonstrated that BAG-containing GI cement can inhibit the growth and proliferation of S. mutans (6, 44, 49).

Hydroxyapatite-containing toothpastes (zinc carbonate hydroxyapatite) have been recently introduced as well. Studies have mentioned that this compound can repair enamel lesions due to its affinity to the enamel surface (50-52).

Laser:

In recent years, laser has been suggested to increase enamel resistance to caries. It increases enamel resistance via different mechanisms including enamel surface melting, re-crystallization and changing the enamel organic matrix (53). CO2, Nd:YAG, Er;YAG, Er,Cr:YSGG and argon laser are more commonly used for this purpose (54, 55). Argon laser changes the enamel crystalline structure and decreases decalcification around brackets. Some studies have demonstrated that argon laser irradiation before bonding decreases the depth of WSLs (4, 56, 57). Also, application of laser in conjunction with fluoride has been recommended to increase enamel resistance (58-62). An in-vitro study reported less demineralization around brackets in teeth treated with fluoride and laser compared to the application of laser alone (58).

Treatment:

First phase of treatment of WSLs is their six months follow up in order for the natural remineralization to occur. Active lesions with opaque, porous appearance have better prognosis for achieving normal translucency compared to smooth shiny lesions (63).

Some researchers believe that applying concentrated fluoride to white enamel lesions on the labial surface prevents calcium and phosphate uptake by the underlying layers via hyper-mineralization of the outermost enamel layer. As the result, the white color of these lesions remains, compromising esthetics (11, 14,

48). Thus, WSLs must be treated within 2-3 months following the removal of orthodontic appliances by maintaining adequate oral hygiene and application of low-concentration fluoride followed by high-concentration fluoride therapy (varnish) every six months (14). Application of CPP-ACP compounds like MI Paste Plus and MI Paste are believed to be effective for treatment of WSLs as well (48, 63). These pastes must be applied to the teeth surfaces by toothbrush, swab, tray or finger twice daily, each time for 10 minutes (46). However, long-term studies are required to confirm the superior efficacy of these compounds over natural remineralization (63).

One study reported that application of 1% CPP-ACP solution before bracket removal, and adhesive removal by tungsten-carbide bur decrease the depth and extension of enamel lesions (48). CPP-ACP, in contrast to high-concentration fluoride, causes slow release of calcium, phosphate and fluoride and results in better remineralization of deeper layers of WSLs and regaining enamel translucency (8).

Chewing mint and gums enhances the remineralization of these lesions by increasing the stimulated salivary flow (8). Chewing xylitol gums facilitates access and penetration of calcium ions and causes remineralization of deeper enamel layers (44). External bleaching also improves the appearance of these lesions. Bleaching lightens the shade of WSLs and the adjacent enamel; however, this whitening is greater in the intact enamel, which helps achieving a better color match (8).

Microabrasion using a combination of 18% hydrochloric acid and pumice paste is another technique for treatment of resistant WSLs. Last but not least, esthetic restorations are considered as the last resort for treatment of these lesions (56, 63).

Discussion:

Dental plaque accumulation accompanied by poor oral hygiene during orthodontic treatment can result in development of WSLs around orthodontic brackets (3, 4, 64).

Saliva remineralizes these lesions to some extent; however, this is a slow process and does not always yield favorable results. Also, it is influenced by salivary characteristics (48, 56). Several techniques have been suggested for prevention and treatment of these lesions; among which, favorable oral hygiene ranks first in terms of importance. Older studies found no difference between manual and powered toothbrushes (65, 66); however, more recent studies have confirmed the superior efficacy of electric toothbrushes over manual types (67-69). Moreover, one study showed that electric toothbrushes with a customized head for orthodontic patients like Oral B Triumph (Oral B, Procter and Gamble, Cincinnati, Ohio) were superior to electric toothbrushes with regular head in terms of tooth cleaning efficacy (69). In an 80-day study, a reduction in dental plaque was noted in the first 40 days following the use of powered toothbrush and no significant difference was seen thereafter. This finding may be due to the novelty effect of electric toothbrush in the first days of using it (65).

The efficacy of toothpastes with different concentrations of fluoride has been evaluated in several studies and it was demonstrated that application of a toothpaste containing 5000 ppm fluoride without rinsing increased the fluoride content of saliva at the interproximal surfaces by more than two folds and had the highest efficacy for prevention of enamel demineralization (70, 71).

Different studies have confirmed the optimal efficacy of fluoride varnishes for prevention of WSLs (12, 21, 72-74). However, the results regarding the efficacy of fluoride mouth rinses are controversial. Some evidence are available regarding the decreased severity and prevalence of WSLs in fixed orthodontic patients using fluoride mouth rinses; however, further

investigations are required in this regard (7, 13, 75).

Results of a study demonstrated that daily application of NaF mouth rinse completely ceased and reversed the process of demineralization in these lesions compared to the control group (76); these findings are consistent with the results of other investigations (77, 78). However, use of mouth rinses requires patient cooperation and therefore, cannot be considered as an effective solution for decreasing WSLs in uncooperative patients (8).

Studies on the effects of fluoridated elastomers on WSLs have demonstrated that weekly replacement of these elastomers decreases these lesions (79-81). On the other hand, another study indicated that the quantity of plaque around brackets did not change a couple of weeks following the use of these elastomers (82).

Moreover, another previous study showed that application of these elastomers did not decrease S. mutans count in the saliva after two weeks (83). Considering the approximately four weeks time interval between orthodontic visits, fluoridated elastomers do not seem to play a significant role in prevention of WSLs.

Studies on different compositions of chitosan all indicate the efficacy of these compounds for decreasing dental plaque and oral bacterial count (30, 34, 84-86). The concentration of this material required to increase enamel resistance and penetrate deep to the dentinoenamel junction has reported to be 5-5.2 mg/ml (32). However, 400-500 µg/ml concentration is adequate for its antimicrobial activity (86). According to the literature, chewing chitosan gums decreases the S. mutans count by 80% (87).

Different studies have confirmed the role of CPP-ACP in prevention and treatment of WSLs (4, 44, 45, 88, 89) and showed that application of this compound has no negative effect on the shear bond strength of brackets (90). Based on the obtained results and safety of this compound if swallowed compared to fluoride-containing products, application of this compound by orthodontic patients can effectively decrease WSLs.

Novamin is a Bioavtive glass (BAG) containing calcium sodium phosphosilicate that decreases plaque index and gingival index. This compound is available in different forms including gel, toothpastes i.e. Oravive tooth revitalizing paste, Renew (containing fluoride and Novamin), NUPRO Prophylaxis Paste (containing 5000 ppm fluoride) and DuraShield varnish (containing 5% NaF and 10% Novamin). Several studies have evaluated the effect of this compound on WSLs (91, 92). An in-vitro study showed that the efficacy of Novamin toothpaste for increasing enamel microhardness was greater than that of 1.1% NaF gel (93). The efficacy of Novamin toothpaste was compared with that of two toothpastes containing fluoride or potassium nitrate for treatment of dentin hypersensitivity in another study and it was reported that Novamin was more effective than the other two compounds in this regard (94). The efficacy of this material for dentinal tubule obstruction may not be necessarily attributed to decreasing demineralization and increasing remineralization of WSLs; however, use of this toothpaste may be helpful in orthodontic patients suffering from dentin hypersensitivity. Novamin compound has also been reported to be useful for prevention of demineralization and induction of remineralization in another study (95).

Lower gingival bleeding index and plaque index were also reported following the use of a toothpaste containing Novamin compared to placebo toothpaste (96). Considering all the above and the fact that dental plaque is the main cause of WSLs, we may conclude that Novamin can effectively prevent WSLs, at least indirectly.

Conclusion:

Development of enamel WSLs during fixed orthodontic treatment can be prevented by

proper oral hygiene and use of devices and compounds such as the electric toothbrush, toothpastes containing 5000 ppm fluoride, fluoride varnishes, CHX, xylitol chewing gums, mastic gum, chitosan compounds, CPP-ACP, laser and Novamin. If not treated with natural remineralization by the effect of saliva, bleaching, micro abrasion and tooth restoration are the ultimate solutions for treatment of WSLs.

Conflict of Interest: "None Declared"

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