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Prevention and Management of Post-Orthodontic Occuring White Spot Lesions

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Abstract

Treatments using fixed appliances have become a major part of modern orthodontics, but the usage of these complex fixed appliances results in the formation of White spot lesions (WSLs), which tend to be one of the most common adverse effects of the orthodontic treatment. These WSLs are opaque white patches appearing on the tooth surface as a result of demineralization of enamel. The incidence of WSLs is highest in banded or bonded teeth due to the retention of plaque, which eventually leads to the demineralisation of enamel resulting in WSL. The severity of WSLs depends upon the technique used for the orthodontic treatment, the bracket position, and the treatment duration. The appearance of WSLs is highest in conventional and self-ligating brackets and lowest in clear aligners and lingual orthodontic appliances. Regardless of the type of appliance, a periodic assessment by an orthodontist and oral hygiene maintenance is the first step in preventing and managing WSLs. In addition to oral prophylaxis, these lesions are managed by fluoridated toothpaste, fluoride mouth rinses, gels, varnishes, bonding materials and elastic ligatures. Other novel approaches include the application of casein phosphopeptides-amorphous calcium phosphate (CPP-ACP), resin infiltration, antiseptics, antimicrobial sealants, LASER, bleaching agents and microabrasion. Nowadays, with the emergence of newer technologies such as nanotechnology, the eradication of WSLs appears to be possible in the coming days. This review aims to synthesize evidence from existing studies to explore preventing and treating WSLs in orthodontic patients.

Keywords: Modern orthodontics, Varnishes, Mouth rinses, Microabrasion, Oral prophylaxis

Introduction

Orthodontic treatments have significantly advanced over the years and have been able to transform smiles across the globe by offering a range of options to correct malocclusions with improvement of dental aesthetics and treatments using fixed appliances have become an integral part of modern orthodontics. However, a common side effect in the form of White Spot Lesions (WSLs) tends to appear commonly on the tooth surfaces, thereby impacting dental aesthetics. The White Spot Lesions (WSLs) are enamel surface and subsurface porosities arising as a result of demineralization that appear as white opaque patches when present on smooth surfaces.[2,3,4,5,7,8] These lesions are characterized by a white, chalky, opaque appearance and are commonly located in pits, fissures, and smooth surfaces of teeth, Clinically WSLs appear within 1 month after starting the treatment[1,4,5,17,19], usually with a prevalence of 2% - 97%.[1,6,8,9,14,17,19,20] There are several causes of enamel demineralization, including poor nutrition and hygiene, and the use of incorrect adhesive techniques, of which longer duration and difficulty in maintenance of proper oral hygiene because of the bracket's position are the important factors which favour plaque accumulation which increases the risk of enamel demineralisation ultimately leading to the formation of the white spot lesions.[2,3,4,8,18] These lesions may either appear as small lines around the brackets or they might be visible as large decalcified areas with or without cavitation.[1]

Enamel demineralization involves the removal of mineral ions from hydroxyapatite (HA) crystals found in enamel. The primary etiological factor in decalcifying the enamel during orthodontic treatment is an increase in the quantity of dental plaque harbouring cariogenic bacteria. The prolonged plaque accumulation leads to a decrease in pH that tips the demineralization–remineralization balance toward mineral loss (demineralization), which in turn can lead to WSL development and eventually to cavitation and caries extending into the dentin. [2,4,6,10]

WSLs are known for their opacity, mineral loss, and decrease of fluorescence radiance, in contrast to healthy enamel. The whitish appearance is due to an optical phenomenon caused by mineral loss in the surface and sub-surface which alters the refractive index and increases the scattering of light in the affected area, resulting in greater visual enamel opacity. [4]

Since fixed orthodontic therapy is of long duration there is a need for proper oral hygiene maintenance to prevent the plaque accumulation in and around the orthodontic components attached to the teeth. The basic philosophy behind the management of these early lesions is focused on promoting natural remineralization and preventing further demineralisation. However, natural remineralization occurs through saliva which results in mineral gain only on the surface layer of WSLs which has little improvement on the aesthetics and structural properties of the deeper lesions the complete elimination of WSLs is unlikely and some WSLs last for up to 5–12 years.[11] Therefore, it becomes necessary to apply remineralizing agents to repair the deeper parts of WSLs which comprise of using high-concentration fluoride components such as varnish, mouth rinse, and casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), and methods like bleaching, micro-abrasion, and resin infiltration that focus on improvement of aesthetics.[5]

The purpose of this literature review is to summarise and evaluate the current knowledge from published studies regarding the prevalence of WSLs and to identify recent prevention and treatments used in achieving white spot lesion remineralization.

Material and Methodology

To review the literature, Studies were selected from PubMed, Scopus, Web of Science, and Google Scholar without restrictions on publication year, to provide a comprehensive overview of current knowledge on occurrence of White Spot Lesions following orthodontic treatment. The review focused on occurrence and management of WSLs. The search terms included: "White spot lesions," "Demineralization," "Decalcification," "Remineralization," "Orthodontics," and "Fixed Orthodontic treatment". The research encompassed, Case reports, laboratory studies, clinical studies, and systematic reviews

Malocclusion

Edward Angle defined normal dental occlusion as "the upper and lower molars should be related so that the mesio-buccal cusp of the upper molars occludes in the buccal groove of the lower molars and with the teeth arranged in a smoothly curving line of occlusion" and classified malocclusion in four classes (normal occlusion, Class I, Class II and Class III malocclusion) based on the relationship between the upper and lower first molars. According to White TC, Gardiner JH and Leighton B, "Malocclusion is a condition in which there is a departure from the normal relation of teeth to the other teeth in the same arch and/or to the teeth in the opposing arch". Malocclusion is a multifactorial condition influenced by genetic and environmental factors, these are treated using Orthodontic treatments (Fixed and removable) to achieve esthetic and functional improvement via mechanical therapy which align teeth into a more ideal position depending upon several factors, such as the facial profile, facial balance, and aesthetic concerns. Orthodontists use several methods to treat malocclusion such as palatal expanders, spacers, braces, clear aligners. [16]

Occurrence of White Spot Lesions

Fixed Orthodontic treatment employs usage of Fixed Appliances, which are devices or equipment that are fixed to the teeth [19] either by cementation or bonding to the etched teeth surface, cannot be removed by the patient and are capable of causing various tooth movement. White Spot Lesions (WSLs) are enamel surface and subsurface porosities arising as a result of demineralization that appear as white opaque patches when present on smooth surfaces. WSLs are common adverse effect following the fixed orthodontic treatment, almost 97% of people who underwent fixed orthodontic treatment had developed WSLs and 23% of patients developed WSLs while undergoing fixed orthodontic treatment [18]. These are non-fluoridated areas representing the early sign of demineralization having the potential to become a carious lesion extending into dentin [4,10].

Fixed orthodontic treatment results in difficulty to maintain oral hygiene due to presence of brackets, bands, wires and other appliances limits the self-cleansing action of oral cavity resulting in prolonged accumulation of plaque [2,3,4,8,13,17,19]. The plaque comprises of higher concentration of acidogenic bacteria mainly Streptococcus mutans and Lactobacilli [1,2,4,9,10,13,16,17,19,23].

Other causes of demineralization in patients undergoing fixed orthodontic treatment might include an increased etching time, genetic susceptibility, systemic diseases like diabetes mellitus, hypothyroidism, high sticky food consumption rich in fermentable sugars, any medication which causes xerostomia and so on[17].

Formation of WSL

Accumulation of plaque with altered and high level of aciduric bacteria results in fermentation of sugars and elaboration of acidic substances creating an acidic

environment thereby decreasing the Critical pH to 3.9-4.1 from 5.5 that causes the shift of demineralization-remineralization balance towards demineralization resulting in faster demineralization of tooth [2,4,6,10,17]. During this process, the fluoride content from the surface hydroxyapatite crystals is lost which ultimately leads to WSL.

Enamel demineralization occurs in two stages. Surface softening, the first stage characterized by loss of inter-prismatic substance in the enamel. The second stage includes sub-surface dissolution with the body of the lesion covered by a richly mineralized layer that is porous [4,17]. WSL tends to be precursor of frank enamel caries [4]

Distribution of WSL

Clinically WSLs appear within 1 month after starting the treatment [1,4,5,17,19] prevalence of 2% - 97% [1,6,8,9,14,17,19,20,22] and the occurrence of WSLs tend to rapidly increase during the first 6 months of the treatment and continue to raise at a slower rate to 12 months [1,10]. The frequency of WSLs is 11.86% in patients who has just started orthodontic treatment whereas at six months of orthodontic treatment it is 37.34% and at 12 months it is 46.57%.[16]

WSLs commonly occur on the buccal aspects of the teeth especially around the brackets and in gingival areas [1,4,10,19]. WSLs in orthodontic patients are most commonly found upon maxillary lateral incisors and canines [10,13,20], And more frequently in the maxillary arch (96.3%) compared to mandible (3.70%) [2,4,9,13,20]. WSL development has been shown to be significantly increased in pre-adolescents (≤16 years) compared to adolescents (>16 years) [6], and has a greater incidence in males compared to females [1,2,4,6,10,14,19].

The age and duration also play a key role in the appearance of WSL, Adolescents and longer duration of treatments results in difficulty in oral hygiene maintenance resulting in a greater incidence of WSLs [2,4], the likelihood of formation of WSLs increase by a factor of 0.008 lesions per month and by 3.65 times as the length of treatment increases from <24 months to >36 months [4].

Prevention and Management of WSLs

WSLs are to be managed using a multifactorial approach focusing on preventing demineralization and promoting remineralization of existing lesions. All patients wearing orthodontic appliances tend to be at risk for developing WSL, hence for them a preventive, prophylactic approach to be implemented before, during and after orthodontic treatment.

Preventive measures

1. **Oral hygiene maintenance**

   Prevention strategies should start with educating and motivating patients to adhere to a noncariogenic diet and maintain meticulous oral hygiene. Effective oral hygiene practices are fundamental for preventing issues in patients undergoing fixed orthodontic treatment. This involves thorough mechanical plaque removal through brushing teeth at least twice daily with fluoride toothpaste, paying particular attention to areas where biofilm tends to accumulate. During follow-up visits, it is crucial to reassess patient motivation and consider professional cleaning if necessary, along with reinforcing oral hygiene and dietary guidance, plaque control can be achieved by incorporating power toothbrushes or daily water irrigation alongside manual brushing.[2,10,17,19] Regular professional cleanings, performed two to three times annually, are vital for reducing bacterial

load, improving brushing effectiveness, and supporting patient hygiene efforts.[1,2,10,19]

2. **Fluoride**

The fluoride ion prevents demineralization by altering bacterial metabolism in dental plaque through inhibition of few enzymatic processes, acid production by altering the composition of bacterial flora and/or the metabolic activity of microorganisms, and by decreasing demineralization and promoting remineralization of carious lesions at early stages through a remineralization effect, especially at low concentrations [1,10,11]. Fluoride exposure can cause hydroxyapatite crystals lose "OH− ions" and replace them with "F− ions", resulting in "fluorapatite", which is more resistant to disintegration. [22] Fluoride can be incorporated via fluoride mouthwashes, fluoride gels, fluoride toothpastes, fluoride varnishes, fluoride in bonding agents, and fluoride in elastomers.

2.1. Fluoride Toothpaste

The use of toothpaste with a fluoride concentration (in either the form of sodium mono-fluorophosphate, sodium fluoride (NaF), Amine fluoride, Stannous fluoride) of over 1000 ppm reduces the frequency of enamel lesions by 20%.[1,2,6,10,11,22] However high fluoride concentration (5000 ppm), twice daily used by patients at high risk for WSL is more effective than conventional formulations.[1,2,8,11,20] The dosage and concentration is a bit controversial but in general high dose of fluoride is recommended in inhibiting lesion formation and low dose of fluoride for the remineralization and controlling lesion progression.[11] However regular brushing with two different fluoride dentifrices (Clinpro 5000 and Clinpro Tooth Creme) twice daily for two minutes is effective in hindering WSLs.[5] Nonetheless, using fluoride toothpaste alone is ineffective in avoiding WSL in most patients, even with good dental hygiene and has to be supplemented with other fluoride sources.[22]

2.2. Fluoride Mouthwash

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.[1,2,10]The Incorporation of Antibacterial agents into these mouthwashes, including chlorhexidine, triclosan, or zinc promote cariostatic effects.[1,10,20] Daily mouth rinse with NaF (0.05% or 0.2%) and/or weekly rinse with acidulated phosphate fluoride (APF) (1.2%) have been found to reduce the incidence of enamel demineralization during active fixed orthodontic treatment [10] and to prevent caries, a daily mouth rinse with 0.05% sodium fluoride is presently recommended. [22]

2.3. Fluoride Varnish

The fluoride concentration of fluoride varnishes is at a very high level (5% sodium fluoride, 22,600 ppm F). Since the amount of fluoride exposure can be kept under control, fluoride varnish application is thought to be safe, they gradually release fluoride [1,2,11]. Varnishes are used as a preventive measure to reduce demineralization of the enamel around the brackets, promote the remineralization of the carious lesions [10]. However recent studies shows that fluoride varnishes in patients undergoing fixed orthodontic treatment can provide some protection against WSLs, The application of a fluoride varnish resulted in a 44.3% decrease in enamel demineralization in

patients undergoing orthodontic treatment[1,10,20], this might not be statistically significant if the patients exhibit excellent oral hygiene.[1,5,7] However application of 1.5% ammonium fluoride every six weeks to patients with poor oral hygiene reduced the number of severe lesions.[5] Even though there were differences upon the suggested frequency of application, applying fluoride varnish twice per year was a consensus.[2] The frequent application can be significantly decreased with the introduction of light-curable fluoride varnish (LCFV), It has proven to be more sustainable and long-lasting than traditional fluoride varnish due to the gradual release of fluoride by these compounds.[20]

2.4. Fluoride Bonding agents

Prolonged duration of orthodontic treatment increases risk of demineralization of teeth so continuous release of fluoride is beneficial which may be achieved by continuous fluoride release from the bonding system around the bracket [12], compomers and glass-ionomer cements has been proven to be effective in decreasing demineralization [1,6] of which Compomers being the best with developing the fewest WSLs[6], Nonetheless, a sharp decrease in fluoride ion released from the resin over the first few weeks after application have largely affected the capacity of inhibiting WSL [12] and durability of sealants may vary due to mechanical abrasion from mastication and brushing. These factors cause sealant abrasion so sealant preservation should be evaluated with 3-, 5-month periods and renewed if necessary, hence repeated applications are recommended for preventing WSLs formation effectively [2], In order to tackle this various developments and modifications were made such as the sealants placed on the labial surface adjacent to bonded orthodontic brackets were 80% effective in preventing demineralization in vitro and required no patient compliance [1,10]. Addition of resin particles to create resin modified GIC bonding systems to increase their bond strength [10] in addition to better control of the levels of Streptococcus Mutans (SM) in the adjacent biofilm [6]. Adding agents such as bioactive glass (BAG) provides adequate mechanical strength and physical properties [18], The use of primer with BAG showed highest microhardness [1,3,17,18] and BAG-Silver achieved the best remineralization potential.[1,3,17] BAG-Bonds might provide a useful aid in maintaining enamel surface hardness, and showed the capacity for buffering acidic oral environments, hence, it can help to prevent white spot lesions adjacent to orthodontic brackets.[18,20] Incorporation of organo-selenium into resin sealant tends to possess immense potential in the prevention of WSLs, Organo-selenium containing pit and fissure sealant and primer has been reported to effectively prevent plaque accumulation and prevent demineralization due to its antimicrobial action when applied alone or in combination, the experimental results showed a 100% protection against demineralization.[12] The combination of selenium-based primer and Enamel Surface Sealant may offer a thicker protective layer that is comparable to other sealants, so there was no special advantage with this method of application. However, this combination may offer advantage in the length of protection by increased resistance to wear by toothbrush abrasion.[12] ZnO has recently emerged as an alternative to other metal oxide nanoparticles as it is theoretically known to be biocompatible,

nontoxic, and doesn't cause discoloration, Experimental orthodontic adhesives developed by addition of 0.1% ZnO and 0.5% ZnO as nanofillers enhance their antibacterial properties as ZnO has antibacterial effects against various bacteria and fungi, Hence it might prevent WSLs. [21]

2.5. Elastomeric Ligatures

The release of fluoride from elastomeric ligatures might help decrease demineralization however, incorporating fluoride into elastics might affect their physical properties.[1] However recent studies has refuted the theory that elastomeric ligatures retain a richer bacterial colony than metal ones. The amount of plaque and colonized bacteria were not significantly different between the two groups. WSLs were found to be equally prevalent in the two groups evaluated.[6] Recent research has shown that silver nanocoated elastic modules outperform traditional ligatures in terms of physical characteristics and the biosynthetically developed silver nanocoated elastomeric ligatures displayed to have a high potential in minimizing white spot lesions caused by orthodontic procedures as the silver granules visible on the surface may prevent biofilm buildup and, in turn, lead to lower plaque and calculus deposition. [23]

3. **Casein Phosphopeptides Amorphous Calcium Phosphate (CPP-ACP)**

Enamel demineralization can prevented by the use of CPP-ACP [1,7,10,17] also known as Recaldent [9], which is derived from casein[1,3,9,10,17] and get absorbed into enamel to affect the demineralization-remineralization processes the part of the casein protein called CPP carries calcium and phosphate ions 'stuck' to it, in the form of APP.[1,10] The 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 [1,2,10] thereby reducing demineralization and promote remineralization by reforming into calcium phosphate crystals[2] however The efficiency of casein is considered unreliable and showed various results in different studies[1,2,3,20] Nonetheless, several in vitro and in situ studies have shown that CPP-ACP-containing products decrease demineralization and support remineralization.[12] CPP stabilized calcium phosphate solutions tends to remineralize enamel lesions at a rate of 1.5-3.9×10-8 mol hydroxyapatite/m2/s.[9]

4. **Probiotics**

Probiotic bacteria when administered in adequate number might enhance to the effect of fluoride in preventing dental caries by inhibiting pathogens.[1,2] They can be delivered via milk, yogurt, cheese, ice cream, tablets, lozenges, powder, and drops, declines SM count.[2]

5. **Polyols**

Polyols such as Xylitol, Sorbitol mannitol, maltitol, and lactitol are sweeteners which are not completely metabolized by cariogenic bacteria [1,2], Xylitol can support the remineralization process of subsurface lesions of enamel [2,17] and has frequency and dose dependent effect on dental plaque and SM, Chewing gum with xylitol (2 g of xylitol/socket) or polyols is recommended after each meal (three times daily) for 10-20 min additionally xylitol lozenges significantly decreased the acidity of dental plaque in fixed orthodontic appliance patients.[1,2]

6. **Chlorhexidine**

Chlorhexidine is the most commonly used antiseptic in dentistry and has proved very effective in the

control and management of biofilms in gingivitis, It affects cariogenic flora and decreases SM. [1,2] It is known to reduce plaque accumulation on teeth surface and CHX comes in various formulations such as mouthwash, gels, chips, toothpaste, coated brushes, and floss, For short-term intense plaque management, 0.2% is indicated, while 0.06% can be used daily. [20,22] For mouthwashes, it is recommended to rinse with 10 ml twice a day for 30 seconds [20] The combined use of fluoride and chlorhexidine varnish tend to be more effective in active WSLs than the use of one alone.[2] However, using CHX might cause undesirable effects such as dry mouth (xerostomia), changed taste perceptions (hypogeusia), discolored tongue and other less common adverse effects include burning sensations (glossodynia), oral mucosal desquamation, and parotid gland enlargement and teeth discoloration [22].

7. Lasers

Laser irradiation increases enamel microhardness and resistance to acid attack making it as a beneficial adjunct to conventional acid etching at susceptible sites in patients at high caries risk, including those with rampant caries, those unable to follow oral hygiene instructions and those receiving orthodontic treatment with attachments on their teeth that retain plaque. Commonly used are argon lasers, CO2, Nd-YAG, and erbium YAG.[1,2,5,17,20] Argon lasers (488nm) decreases enamel demineralization up to 30-50%.[1] Nd:YAG laser is effective in preventing occlusal caries in pits and fissures of primary teeth by low energy level and CO2 laser was also effective in the control of demineralization, with being quick, comfortable, and simple application, especially in children.[2] CO2 laser (0.4 mw, 10.6 μm, 5 Hz) for 20 s following bracket attachment and uncovered that CO2 laser irradiation not only caused a reduction in WSL incidence, but it also diminished their extent and severity after 6 months.[5] Apart from decreasing demineralization lasers also decrease the dissolution threshold pH by maintaining intact enamel surfaces, however exact mechanism of role of lasers in prevention of WSLs is yet to be elucidated.[1,2,17] using laser with topical fluoride leads a synergistic effect [2,3] like increased uptake and less consumption of fluoride and decreased dissolution rate of the enamel due to transformation of hydroxyapatite to fluoroapatite [2].

8. Type Of Orthodontic Appliance

Demineralization is seen in both treated with a clear aligner (CA) or fixed device, with the main difference being that in the CA group, larger but less developed lesions with a mineral loss of 0.4% were found, while the fixed group developed several new WSLs with a greater depth of more mineral loss of 1.2% but of a reduced surface size and higher plaque index [6,13]. The majority of the studies shows a potential decrease in WSLs with the use of CA when compared with Fixed mechanotherapy due to shorter treatment durations and better oral hygiene and lower plaque as aligners can be removed Hence, Clear aligner therapy could be preferred in orthodontic patients at high risk of developing WSLs.[13] Additionally both types of lingual devices (Incognito and WIN) reduced the frequency of WSLs compared to conventional devices.[6] WSLs frequently appear on maxillary teeth due to the usage of broad bracket base with an added disadvantage of less salivary cleansing leading to higher chance of plaque accumulation.[9]

Management of WSLs

Despite many attempts aiming at prevention of WSLs, the prevalence of WSLs remain as high as 61% on debonding [11] and it is common to see a regression appearance of WSLs due to natural remineralization by saliva and abrasion due to brushing. However, this depends upon the severity of lesions and occurs in a span of 6 months of the debonding process, if it is not sufficient then these WSLs should be treated. [1,5,19]

1. **Remineralization**

   The first choice for the elimination of WSLs is remineralization [1,5] which, involves repeated applications and the compliance of a motivated patient and might take a long time. Several products are available in different forms for such as: solutions, varnishes, creams, pastes, and chewing gums. These products contain fluorides and/or CPP-ACP, and there is evidence with varying degrees of success [1,5,10,11,19]. The application of 10% CPP-ACP with a good oral hygiene for 3 months and use of fluoridated dentifrice (1000 ppm) for next 3 months has significantly ameliorated post orthodontic white spot lesions, Regression of WSLs was observed after 3 months and were stable over 1-year period[9,11].Care to be taken while treating incisors and canines with high fluoride concentration products as it may lead to tooth discoloration.[1,5] Clinical trials strongly support using 5% sodium fluoride varnish as an effective treatment for WSLs applied professionally once per month for 6 months. Although application of fluoride varnish on a monthly basis can effectively lead to reversal of WSLs after debonding, the use of high concentration fluoride immediately after debonding is under question.[5] Another study suggests use of a fluoride toothpaste twice a day leads to remineralization after 2 months, and on combining fluoride toothpaste and fluoride gels remineralization takes place in 1 month.[10] Self-assembling peptide P11-4 (SAPP11-4) is also a product that can be used in combination with fluorine, not limiting its action and promotes enamel remineralization. SAPP11-4 can diffuse into carious lesions and promote hydroxyapatite formation, significantly reducing the size of buccal WSLs. [3,7] Calcium carbonate carrier (SensiStat) is a mixture of arginine bicarbonate and calcium carbonate, Arginine attaches calcium carbonate to the tooth surface and allows remineralization of the enamel whereas Anticay, a calcium sucrose phosphate–calcium orthophosphate blend reduces demineralization and advances remineralization.[17]

2. **Resin Infiltration**

   A minimally invasive procedure often considered Gold Standard [14] in which the WSL is infiltrated with a low-viscosity resin, Etching with 15% hydrochloric acid for 20 s, followed by rinsing, drying, and dehydration of the enamel surface with ethanol makes the outer surface (40 micrometre) erode[9] and more permeable, the underlying porous structure is then infiltrated by triethylene glycol dimethacrylate-based resin (ICON).[1,2,3,5,9,17,19] This resin stops the progression of caries and the other, with a refractive index (1.46) close to that of sound enamel (1.65).[9] Resin infiltration along with pit and fissure sealants masks the WSL by the camouflage effect in addition to reinforcing the compromised enamel prism structure.[2,3] The effectiveness of sealers with proper oral hygiene in the prevention of WSLs showed 100% positive results[6].It is more effective esthetically in the early stages when it is in the active rather than in the

inactive stage.[1,2,19] Resin infiltration shows greater improvement immediately after intervention [5,14] and it has been reported that resin infiltrate was wholly masked in 61% of the teeth [2,3], partially masked in 33% of the teeth and no change was observed in 6% of teeth in post orthodontic defects[2] and also gained 92.5% clinical stability with this type of treatment.[3] Very recent studies suggest that resin infiltration and micro-abrasion techniques are comparably effective in reducing the sizes of WSLs, but resin infiltration has an aesthetic advantage over micro-abrasion.[6,19]

3. **Bleaching**

Bleaching incipient enamel caries with 10% carbamide peroxide[1,2] or 35% Hydrogen Peroxide[17] could mask WSLs without compromising mechanical and chemical properties of the enamel and application of CPP-ACP along with it promotes mineral gain. Bleaching can conceal the discolorations by enhancing the overall lightness of enamel and reducing its yellowness however, it has the potential to compromise the hardness of WSLs enamel due to additional mineral loss [14] resulting to tooth sensitivity and a decreased enamel microhardness.[1,2,17,19].Hence, a gentle non-invasive bleaching procedure by incorporating three different biomaterials, including nano-BAG, nano-hydroxyapatite, and nano-amorphous calcium phosphate, into bleaching agents might mitigate the negative effects of tooth bleaching and prevent the irreversible changes in the enamel surface.[1,20] Also Post-bleaching resin infiltration proved to be advantageous in the aesthetic treatment of WSLs, leading to greater brightness and lower yellowness both in short-term and long-term.[14]

4. **Microabrasion**

The microabrasion technique can reduce the size of white spot lesions by 83% [2], It's done via Chemical and mechanical conditioning of the enamel surface by applying an abrasive slurry of 6.6% (Opalustre) or 6% (Whiteness RM) and 18% hydrochloric acid with a brush which removes approximately 100 μ from the surface layer [1,2,9], The delayed application is beneficial given the improvement of lesions via saliva-based remineralization and spontaneous surface abrasion subsequent to debonding.[1,12,17] Microabrasion is capable of masking more severe and long-standing lesions however, care must be taken as this is a sensitive method and should be repeated several times.[5] Hence, when the depth of the lesion is under 0.2mm this is a useful method for the treatment of postorthodontic WSLs and it might be associated with the bleaching technique.[1,2,17,19,20]

5. **Plasma Treatment**

Cold-plasma treatment is proven to increase remineralization capability and alter the micro-hardness of the enamel in WSLs, Plasma penetrates easily into irregular surfaces and is shown to effectively improve the substrate surface hydrophilicity.[17]

6. **Natural Extracts**

Few Naturally occurring substances exhibited the ability to enhance remeineralization such as chitosan, Galla chinensis, Ginger, Honey, Cinammon, Theobromine (Bitter Chocolate). These substances exhibit anti-cariogenic properties thereby promotes remineralization.[17] Syzygium aromaticum (clove), a spice that offers antibacterial, antifungal and antioxidant benefits and Elettaria

cardamomum (Cardamom) posess anti-cancer, anti-inflammatory, and antibacterial effects, Cardamom oil has been shown to have antibacterial actions against Streptococcus mutans. [23]

Sequence of WSL Therapeutic Management

The treatment of post-orthodontic demineralization should use a top-down strategy beginning with the least invasive and most preventative procedures aiming remineralization of demineralized enamel, If this fails it implies that the deterioration has progressed to deeper level of the enamel, remaining solely on the mineral-rich enamel surface and under such conditions, resin infiltration or other therapeutic alternatives will be necessary to seal the microporosities.[22] A possible ideal sequence would be as follows

Oral Hygiene Control → Fluoride Treatment {Dentifrices and Fluoride application} → Remineralizing agents {CPP-ACP} → Bleaching → Microabrasion → Resin Infiltration

Conclusion

With this narrative review it can be concluded that the occurrence of WSL around fixed orthodontic appliances is a common complication during and after orthodontic treatment. Although preventative therapies exist, they cannot replace patient compliance and constant home care as poor oral hygiene reduces the effectiveness of preventative actions. Hence, the preliminary step is to educate and motivate the patient to maintain a good oral hygiene. In addition, prophylaxis should be carried out with use of fluoride as varnish, toothpaste or in various combinations with different agents as they have an impact in reducing these lesions. Both the Resin infiltration and CPP-ACP have desired and durable esthetic improvement in the management of post orthodontic white spot lesions (WSLs). Other materials and methods including antiseptics, probiotics, polyols, sealants, lasers, tooth bleaching, BAG, and microabrasion have also been recommended. Enriching adhesives with different ions seems to have a good influence while use of nanoparticles presented promising results regarding enamel regeneration. Some naturally occurring substances tend to show remineralizing ability. A general strategy to tackle WSL is application of 5% fluoride varnish or using a CO_2 laser after bonding in patients with compromised oral hygiene and for those formed during fixed orthodontic treatment, fluoride varnish 5% and resin infiltration are effective methods for treatment. If deeper, more advanced lesions existed, then more invasive techniques should be employed. Although some traditional methods for treating white spot lesions seem to have undesirable results, nowadays with new technologies emerging and with further insight in nanotechnology, eradicating these lesions appears to be achievable in the near future and a long-term research is needed to evaluate the effectiveness of various treatment approaches for post-orthodontic WSLs.

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