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Demineralization, White Spot Lesions & Remineralization During and After Orthodontic Treatment - A Narrative Review

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ABSTRACT

Oral hygiene becomes cumbersome in patients with fixed orthodontic appliances and there is prevalent decalcification of the enamel surface adjacent to these bonded attachments. Decalcification is described as a white spot lesion (WSL) that orthodontic patients develop more than non-orthodontic patients. WSLs may produce carious cavitations if left untreated, and may also present esthetic problems. White spot lesions affect the esthetics of smile and the treatment of WSLs is important to decrease tooth decay and discoloration.

Key words*- Demineralization, Remineralization, Oral hygiene, fixed orthodontic appliances, white spot lesions.*

Introduction

Pearly white enamel of human dentition add all the glamour to smile. Any discolouration or spotting on teeth can have psychological impact on patient which prevents him or her from a social smile. Demineralization is a major challenge in orthodontics which appears as white spot lesions of enamel, around fixed orthodontic appliances. (1) Enamel decalcification or white spot formation can occur whenever bacterial plaque is retained on the enamel surface for a prolonged period.2 Oral hygiene and oral prophylaxis are more difficult with fixed appliances. These appliances create stagnant areas where accumulation of plaque increases, which causes enamel demineralization .The prevalence of these white spot lesions arising during fixed appliance therapy was widely from 2% to 96%.s. A recent study showed that up to 97 per cent of the patients treated with fixed appliances had WSL after therapy (Boersma et al., 2005) Orthodontic patients have an increased risk of developing gingivitis and enamel decalcifications that can lead to white spots and caries. (3,4,5,1,6)

Since fixed orthodontic appliances were introduced, WSLs have become a particular clinical problem. These can be attributed to the difficulties in performing oral hygiene procedures on bonded brackets and bands and the prolonged plaque accumulation on tooth surfaces.7,8 Recently a clinical study showed that 50% of the subjects with no preventive fluoride programs experienced an increase of WSLs during treatment with fixed appliance therapy. (9)

Pathogenesis

White spot lesions (WSLs) are defined as a “subsurface enamel porosity from carious demineralization” that presents as “a milky white opacity when located on smooth surfaces.”10 (Samir E bishara). The formation of WSLs is due to inadequate maintenance of oral hygiene and the extended accumulation of plaque that remains on the teeth. The enamel demineralization is a challenge in orthodontics, and the presence of these lesions significantly affects the esthetic appearance of the teeth and quality of life11

These white spot lesions are due to demineralization of the enamel by organic acids produced by cariogenic bacteria. These bacteria release acid by-products, lowering the pH of the plaque. As the pH drops below the verge for remineralization, carious decalcification takes place. (12,13)

The levels of acidogenic bacteria, such as S. mutans, become significantly elevated in orthodontic patients. The first clinical evidence of this demineralization is visualized within a time frame of 4 weeks, which is usually within the time period between two orthodontic visits. These WSLs are a significant finding and are important for both the patient and the clinician to realize. (13,14)

The white appearance of initial carious lesions is because of an optical phenomenon which is caused by loss of minerals in the subsurface enamel. There is substantial evidence that the initial mineral loss results in the development of a carious lesion at the surface of the enamel. Such lesions are called surface softened lesions and in the presence of fluoride in the oral environment they may develop into subsurface lesions. (15)

Dental tissues are continuously undergoing cycles of demineralization and remineralisation. A change in pH of the oral cavity results in demineralization, which can lead to loss of tooth surface. A reversal can occur if pH increases, resulting in deposition of calcium, phosphate, fluoride and other agents . For these reasons, tooth brushing with a multivalent toothpaste looks like the most convenient method for plaque control and salivary mineral resources acquisition. (16)

PREVENTION OF WSLs

How to treat WSLs after removal of fixed appliances to produce a sound and esthetic enamel surface is a question yet to be fully answered. Various treatment protocols and products have been suggested, such as remineralization through saliva, mouth rinses, and toothpastes with various components such as increased fluoride concentrations, casein phosphopeptide amorphous calcium phosphate, nanohydroxyapatite and calcium sodium phosphosilicate glass. To prevent decalcification and formation of white spot lesions, a good oral-hygiene regimen must be implemented, including proper toothbrushing with a fluoridated dentifrice (17,9)

WSLs should be managed using a multifactorial approach. The most important mechanism to arrest these lesions and biofilm formation, and use of strategies to prevent remineralization of these lesions,weakening of enamel, microabrasion, erosion-infiltration, adhesives, and the bonded facets. (18)

I. Oral hygiene control

Prevention should begin by tutoring and prompting the patient for maintaining good oral hygiene and compliance with a noncariogenic diet. Motivation includes professional instructions, adequate tools, and patient education. Fruitful oral hygiene is the substructure of prophylactic measures in orthodontic patients. Removal of plaque biofilm by proper brushing of the teeth twice daily with fluoride dentrifrices is highly adviced. (19,20)

Studies have proved that it takes minimum of 6 months for caries to develop, in a patient not undergoing orthodontic treatment, whlile it takes approximately 1 month to develop in an orthodontic patient because of the difficulty these patients have with performing oral hygiene (21)

II. Remineralizing Fluorinated Agents

• Fluoridated toothpaste

It has been well established that the application of fluoride to newly formed enamel white spot lesions will promote remineralization. The most commonly employed fluoride-containing formulations, such as dentifrices, contain sodium fluoride.22 Fluoride is important in the prevention of enamel demineralization. (23) The fluoride concentration of toothpastes above 1000ppm is recommended. The use of toothpaste with a high fluoride concentration (5000 ppm), twice daily, by patients at high risk for enamel decalcification is more effective than traditonal practices. (24)

• Mouthwashes containing fluoride

Daily use of mouthwashes containing NaF has showed marked decrease in the development of WSLs around bands and brackets. A regime containing daily mouthwash with concentration of NaF (0.05% or 0.2%) and/or weekly rinse containing alpha-1-fetoprotein (1.3%) have been demonstrated to minimize the incidence of enamel demineralization during fixed mechanotherapy.

III. Non-Fluoride Remineralizing Agents

The use of casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) has been described to induce remineralization because of its potential to balance calcium and phosphate in an unstructured state, hindering the accretion of calcium phosphate to a pedantic aggregate that leads to precipitation3

Decalcification of enamel by products incorporating (CPP-ACP), which was assimilated through the enamel surface and contrived the demineralization-remineralization cycle. Reynolds reported that CPP-ACP, is derived from milk casein. (25,26) Present day research has shown that this is accomplished by a part of the casein protein as which trasport calcium and phosphate ions "held" to it, in the form of APP. Reports have proved that the anticariogenic activity of CPP-ACP depends on the aggregate of nanocomplexes into the dental plaque and on the tooth surface, thereby behaving as a calcium and phosphate reservoir. CPP-ACP binds to the bacterial wall and tooth surfaces. (27,26)

IV. Probiotics

Probiotics are live microorganisms that might enhance the effect of fluoride in preventing dental caries. They provide health benefits when they are dispensed in sufficient numbers. It is postulated that probiotic strains impede with other microorganisms, particularly pathogens.

V. Polyols

Polyols are sweeteners that are not metabolized by caries producing bacteria or weakly metabolized (sorbitol). Substanital reports state that xylitol is noncariogenic,which manifest as a dose- and frequency-dependent effect on dental plaque and mutans streptococci. Chewing gum with xylitol (2 g of xylitol/socket) is prescribed after each meal (three times daily) for 10–20 min.

VI. Nano hydroxyapatite

To enhance lesion remineralization, increase of calcium or fluoride concentrations in the oral fluids would seem reasonable20Nano-hydroxyapatite (n-HAp) is considered one of the most biocompatible and bioactive materials, and has gained wide acceptance in medicine and dentistry in recent years. Synthesis of nano-scaled zinc carbonate hydroxyapatite (ZnCO3/n-HAp) yielded a significant progress, and showed considerable affinity to the enamel surface. Nano-sized particles have similarity to the apatite crystals of tooth enamel in morphology and crystal structure. (28)

VII. Enamel Remineralizing Systems

These agents can be categorized into one of three types—crystalline, unstabilize amorphous, or stabilized amorphous formulations. (29)

Unstabilized ACP Systems

The (ACP) technology is an unstabilized calcium and phosphate system that has been evolved and advertised. Its technique is based on unstabilized ACP, where a calcium salt (e.g., calcium sulphate) and a phosphate salt (e.g., potassium phosphate) are distributed separately intra-orally or delivered in a product with a low water activity. As this salt mixes with saliva, it releases calcium and phosphate ions. The combine effect of calcium ions with phosphate ions to produce an ion reactivity product for ACP that increases its solubility product results in the precipitation of ACP or, in the presence of fluoride ions, amorphous calcium fluoride phosphate (ACFP). (30)

VIII. Natural Remedies

Chewing sticks (miswaks) are used in many countries around the world for cleaning purposes, often up to 5 times a day. Fluoridated miswaks have a dual effect: producing a high fluoride concentration on the teeth and cleaning the buccal surfaces. (31)

Due to the innate proteolytic activity of enzymes, proteins are hydrolyzed, yielding peptides and amino acids. Enzymes have demonstrated reductions in plaque and gingivitis and they have the potential to lyse adhesive bonds between bacteria and the dental pellicle. Bromelain is a naturally occurring cysteine protease which is derived from pineapple stalks and is used in food and medical industries.32

Recent Advances

Fluoride-containing agents are used to increase remineralization, but the pleasing and esthetic appearance of enamel is usually not sufficiently enhanced. When treated with fixed appliances, sealants or bonding agents — are applied before or after the fixed appliances are bonded — as well as fluoride- or chlorhexidine containing mouthwashes as well as casein phosphor peptide amorphous calcium phosphate containing pastes (CPPACP) have been proposed. CPPACP-containing pastes or bioactive glasses can be used to enhance remineralization have been shown to enhance remineralization. The esthetic appearance most often remains impaired.

Microabrasion is another treatment option which is most suitable for very superficial lesions. In the case of deeper enamel lesions, concave tooth surfaces may result. Direct and indirect restorations also lead to predictable and satisfactory results, but these should be used in cavitated lesions. By resin infiltration, the microporous enamel areas of initial carious lesions are obturated by low-viscosity light-cured resins (infiltrants), thus, inhibiting further caries progression. Apart from caries inhibition, resin infiltration is also able to mask white spot lesions. As the refractive index of the infiltrant (1.52) is close

to the index of enamel/apatite (1.62), as opposed to the indices of water (1.33) and air (1.00), light scattering is reduced with increasing degree of infiltration. (33)

Topical application of remineralizing agents, micro abrasion , and bleaching represent attempts to reverse enamel demineralization and/or to improve tooth appearance. The resin infiltration technique was also found to be useful in these cases. (34)

Resin infiltration is based on the hydrochloric acid erosion of the lesion surface and posterior infiltration of a low-viscosity resin into the intercristaline spaces of hypocalcified or demineralized enamel. This alters the refractive index (RI) of the porous enamel, formerly filled with air (RI=1.00) or water (RI=1.33), since the infiltrated resinous material shows a RI (1.52) closer to hydroxyapatite (1.62). As a consequence, the optical characteristics of the affected enamel are altered and it seems like the surrounding sound enamel (Marinelli G et al). The penetration of the low-viscosity resin into porous enamel with caries or hypomineralization has been shown in in vitro studies. [8-10] Additionally, color masking efficacy with resin infiltration has been demonstrated using artificial caries models. Some clinical reports also showed favorable esthetic results. Nevertheless, there is a lack of evidence concerning the clinical efficacy of the technique for camouflaging enamel whitish discolorations. (34)

Clinpro™ XT varnish showed significantly better improvement than Icon® resin infiltration in restoring the colour and lightness of the WSLs at 3 and 6 months. The fluorescence loss significantly recovered with both intervention methods between immediate application and at 6 months. However, Clinpro™ XT varnish-treated WSLs showed a statistically significant difference compared to the adjacent sound enamel at 6 months. (35)

The bioactive glass is deemed more effective against WSL development due to its ability to immediately repair enamel surface, low cytotoxicity, and high biocompatibility. Moreover, clinical studies on bioactive glass are still needed to determine its acceptability among patients with fixed orthodontic appliance.36

Previous studies showed that fluoride-containing glass ionomer and composite adhesives decrease enamel decalcification around orthodontic brackets. However, the fluoride containing and releasing adhesives and primers show their greatest levels during the initial weeks after bracket bonding. Therefore, a fluoride-containing dentifrices and materials would not have a significant preventive effect on enamel demineralization if it was used just once. Fluoride releasing materials should be applied repeatedly to increase their mode of action. (37)

Conclusion

WSL are a major side effect of orthodontic fixed treatments. The prevention and treatment of this problem is the goal of any orthodontist because untreated WSL can lead to the formation of dental caries. This review showed the use of various strategies in preventing WSLs during and after fixed orthodontic therapy. To conclude these lesions should be managed in the initial stages of treatment and patients should be educated about the importance of oral prophylaxis and maintaining good oral hygiene habits. Prophylaxis with topical fluorides, including high-fluoride toothpastes, fluoride mouthwashes, gels, varnishes, fluoride-containing bonding materials, and elastic ligatures (Maryam Khoroushi et al) is recommended. Recently, other materials and techniques are also implemented, including the application of casein phosphopeptides-amorphous calcium phosphate, antiseptics, probiotics, polyols, sealants, laser, tooth bleaching agents, resin infiltration, and microabrasion. (38)

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