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The Impact Of Different Oral Hygiene Practices On The Prevention Of White Spot Lesions During Orthodontic Treatment

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ABSTRACT

White spot lesions (WSLs) are a common complication of orthodontic treatment, resulting from enamel demineralization beneath an intact surface due to plaque accumulation around fixed appliances. Their prevalence ranges from 30% to 70%, with higher rates in patients exhibiting poor oral hygiene, high carbohydrate intake, prolonged treatment, or pre-existing enamel defects. Prevention relies on a multifaceted approach, including meticulous mechanical plaque control, fluoride-based chemical adjuncts, resin sealants, and advanced remineralization agents such as CPP-ACP, bioactive glass, and hydroxyapatite pastes. Emerging strategies, including probiotics, polyols, laser irradiation, antimicrobial peptides, nano-silver agents, appliance design innovations, and AI-guided compliance monitoring, offer adjunctive benefits. Post-treatment management of WSLs involves remineralization, microabrasion, bleaching, and resin infiltration depending on lesion severity. Despite technological advances, patient compliance and regular professional reinforcement remain pivotal. Future research should focus on long-term, standardized clinical trials to establish evidence-based protocols for the prevention and management of orthodontic WSLs.

KEYWORDS: White spot lesions, Orthodontics, Remineralization, CPP-ACP, Fluoride.

INTRODUCTION

Enamel decalcification, one of the most common sequelae of orthodontic treatment, is largely aggravated by inadequate oral hygiene and manifests clinically as white spot lesions (WSLs). These represent the earliest visible evidence of enamel demineralization, occurring beneath an intact surface layer and appearing chalky white due to altered light reflection compared with sound enamel.[1] WSLs often develop rapidly, sometimes within four weeks of appliance placement, and are frequently observed around brackets as small lines or extensive decalcified areas, with or without cavitation, making them a significant esthetic concern at debonding and a source of disappointment for both patients and

clinicians.[2] Their prevalence among orthodontic patients varies widely, with epidemiological studies reporting rates from 2% to 97%, depending on detection methods such as visual inspection, photography, quantitative light-induced fluorescence, and digital image fiber-optic transillumination.[3] Pathogenesis involves plaque accumulation around brackets, bands, and wires, which hampers natural self-cleansing and fosters acid production from bacterial metabolism, thereby tipping the demineralization remineralization balance toward mineral loss.[4] Multiple risk factors contribute to WSL formation, including poor oral hygiene, high intake of fermentable carbohydrates, prolonged treatment duration, long etching times, excessive bonding material, and pre-existing decalcified or restored molars.[5] This article gives an overview on the impact of different oral hygiene practices on the prevention of white spot lesions during orthodontic treatment.

PATHOGENESIS AND IDENTIFICATION OF WHITE SPOT LESIONS DURING ORTHODONTIC TREATMENT

The pathogenesis begins with biofilm formation, as brackets, bands, and wires create retentive niches that favor the proliferation of acid-producing bacteria such as Streptococcus mutans and lactobacilli.[7] These microorganisms ferment dietary carbohydrates to produce lactic acid, lowering the plaque pH below the critical threshold for enamel demineralization (pH < 5.5). Continuous acid exposure removes calcium and phosphate ions from hydroxyapatite crystals, increasing subsurface enamel porosity. This mineral loss manifests optically as milky white, chalky opacities, while the enamel surface often remains intact.[8] Multiple risk factors influence WSL development, including the type of orthodontic appliance with fixed appliances posing higher risk than removable ones treatment duration, dietary habits, oral hygiene practices, and salivary flow and composition.[9]. Clinically, WSLs appear as opaque white lesions on buccal or gingival enamel, most visible after air-drying. Radiographically, whereas advanced techniques like quantitative light-induced fluorescence (QLF), digital imaging fiber-optic transillumination, and laser fluorescence devices allow earlier detection of subsurface demineralization.[10]

REGULAR MAINTENANCE AND ORAL HYGIENE STRATEGIES FOR PREVENTING WHITE SPOT LESIONS IN ORTHODONTIC PATIENTS

Mechanical plaque control through brushing at least twice daily with fluoride-containing toothpaste, particularly around biofilm retention areas, is strongly recommended, and professional reinforcement during recall visits including prophylactic cleaning and repeated dietary and oral hygiene instructions enhances compliance and effectiveness.[11] The use of powered toothbrushes or daily water irrigation alongside manual brushing may further reduce plaque accumulation compared to manual brushing alone, while professional prophylaxis two to three times per year reduces bacterial load, improves patient cleaning efficacy, and maintains oral health. [12] Regarding brushing techniques, flat-trim manual toothbrushes can outperform orthodontic-specific or criss-cross designs in single-event plaque removal, though orthodontic brushes offer region-specific advantages around brackets, particularly on anterior teeth.[13] Orthodontic-specific brushes with V-shaped bristles or single-tufted designs facilitate targeted cleaning around wires and brackets, while interdental aids such as floss threaders, specialized orthodontic flossers, and interdental brushes are critical for plaque removal in hard-to-reach areas.[14]

RESIN SEALANTS AND ADVANCED REMINERALIZATION AGENTS FOR PREVENTION AND TREATMENT OF WHITE SPOT LESIONS

Resin-based sealants, such as Pro Seal, Opal Seal, and Clinpro™ XT, form a protective barrier around brackets, shielding enamel from acid attack and reducing demineralization, with light-cured, fluoride-releasing formulations additionally promoting remineralization.[14] Advanced remineralization agents, including casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), bioactive glass, and hydroxyapatite pastes, enhance enamel repair and protect against early carious lesions. CPP-ACP, as in GC Tooth Mousse or CPP-ACFP formulations, delivers bioavailable calcium and phosphate ions to enamel surfaces, facilitating remineralization of subsurface lesions, buffering plaque pH, and inhibiting bacterial adhesion and biofilm formation.[15] Bioactive glass-based pastes release calcium, phosphate, and

sodium ions to form hydroxycarbonate apatite, occluding enamel porosities, while hydroxyapatite pastes fill microporosities and improve enamel surface luster.[16]

FLUORIDE AND EMERGING ADJUNCTS IN THE PREVENTION OF WHITE SPOT LESIONS DURING ORTHODONTIC TREATMENT

Topical fluoride varnishes, especially 5% formulations applied periodically every six weeks to six months, significantly reduce lesion incidence, while daily use of fluoride toothpaste (1,000–1,500 ppm) and prescription-strength pastes or gels (up to 5,000 ppm) provide additional protection for high-risk individuals.[17] Professional fluoride gels (~12,300 ppm), daily 0.05% sodium fluoride rinses, and sealants applied around brackets further strengthen enamel against acid attack. Adjunctive use of chlorhexidine rinses lowers bacterial load, though long-term use is limited by side effects, while fluoride-releasing bonding agents, glass ionomers, and compomers enhance sustained protection. Beyond fluoride, novel strategies are being explored, including probiotics and xylitol-based polyols to modulate plaque microbiota, laser irradiation (argon, CO_2, Nd:YAG, erbium:YAG) to increase enamel resistance, and advanced agents like antimicrobial peptides, nano-silver formulations, and bioactive materials to inhibit biofilm formation and promote remineralization.[18] Appliance innovations such as self-ligating brackets and clear aligners reduce plaque retention, while artificial intelligence enabled apps and wearable sensors offer digital support for improving compliance and detecting early WSLs. [19]

CONCLUSION

Fluoride remains the most evidence-based and widely validated cornerstone for WSL prevention, delivered effectively through toothpaste, varnishes, gels, rinses, and fluoride-releasing bonding materials. The greatest success is achieved when fluoride is integrated with rigorous oral hygiene, professional maintenance, and adjunctive approaches such as probiotics, lasers, or bioactive agents.

REVIEW OF LITERATURE

Øgaard and co-workers, in a randomized controlled trial involving 115 patients, compared AmF/SnF_2 toothpaste with rinses against NaF toothpaste and rinses, reporting a prevented fraction of 43%, though not statistically significant.[1] Vivaldi-Rodrigues and Gontijo, in split-mouth studies, found fluoride varnish applications reduced decalcification indices, with Vivaldi-Rodrigues reporting a 33% reduction.[20,21] The most compelling evidence came from Stecksén-Blicks and colleagues, who conducted a large, double-blind randomized controlled trial with 273 participants, showing that fluoride varnish applied every six weeks around brackets reduced WSL incidence from 26% in the placebo group to 7% in the test group, corresponding to a 70% prevention rate.[22] Farhadian also noted a 40% reduction in lesion depth with varnish application.[23] Benham demonstrated that buccal sealants prevented 73% of lesions compared to untreated controls, while Kronenberg reported ozone therapy was less effective than chlorhexidine fluoride varnish, with negative prevention rates.[24,25]

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