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Masking of white spot lesions by resin infiltration in vitro

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ABSTRACT

Objectives: The aim of this in vitro study was to evaluate the ability of one commercial and five experimental infiltrating resins (infiltrants) to camouflage enamel white spot lesions immediately after resin infiltration and after a staining period.

Methods: In each of 120 bovine enamel samples, two artificial caries lesions were created (windows A and C; pH = 4.95, 50 days), whereas two windows were protected serving as sound controls (B and D). After etching windows C and D (37% phosphoric acid), specimens were randomly allocated to 6 groups. Either one of 5 experimental infiltrants or a commercial infiltrant (Icon, DMG) (refractive indices 1.50–1.55) was applied and light cured. After half of each specimen was polished, samples were remineralized (pH = 7.0) and stained with tea and red wine for 50 days. Photographic images after various treatment steps were obtained. Color differences (ΔE) of untreated (A) and treated lesions (C) as well as infiltrated sound enamel (D) were compared with untreated enamel (B).

Results: All infiltrants showed significantly better color match with sound enamel (median ΔE [25th/75th percentile]: 2.2 [1.5/3.1]) than untreated controls (9.3 [8.0/10.9]) ($p < 0.001$, Wilcoxon, post hoc Bonferroni). Moderate correlation between refractive index and ΔE of infiltrated lesions was demonstrated ($R^2 = 0.43$, $p > 0.05$). Staining was significantly reduced for polished infiltrated lesions compared to untreated or infiltrated unpolished lesions ($p < 0.001$).

Conclusions: Resin infiltration is suitable to mask artificial white spot lesions. Polished infiltrated lesions are resistant to staining in vitro.

Clinical significance: Resin infiltration is a micro-invasive approach to camouflage post-orthodontic white spot lesions.

1. Introduction

Dentists are frequently faced with the treatment of color aberrations of teeth, for example extrinsic or intrinsic staining or white spot lesions. The latter are caused by demineralisation of enamel, and labial white spots are frequently associated with fixed orthodontic treatment. White spot prevalence of 50%,[1] 60%[2] or even 97%[3] after bonded or banded orthodontic treatment has been reported, affecting especially labial surfaces of maxillary incisors. Formation of these lesions occurs swiftly, as first clinical signs can be detected as early as two weeks after initial biofilm formation.[4,5] Lesions show an apparently intact surface layer, followed underneath by the more porous lesion body. An established active white spot lesion has a chalky, opaque appearance, as light is scattered mainly within the lesion body.[6] Scattering is caused at interfaces between substances with different refractive

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indices (RI), like enamel/apatite (RI 1.62–1.65), water (1.33) or air (1.00).[6–9] Thus, early lesion stages need drying to be visually detected, as the RI of water is closer to that of enamel compared with air.[10] Aside from drying, white-spot scattering was shown to be mainly dependant from mineral content of enamel.[11]

There is a range of treatment options for such enamel lesions. Enhancing remineralisation using fluoride or casein-phosphopeptide amorphous calcium phosphate has been shown to positively influence caries arrest. However, clinical studies could not show a cosmetic improvement or considerable reduction of the carious lesions according to the International Caries Detection and Assessment System.[12,13] Especially deeper lesions do not remineralise completely, as the formation of a hypermineralised surface layer hampers the remineralisation of the subsurface lesion body.[14,15] Hence, long-term aesthetics remain poor despite a bright and smooth surface.[16] Besides, results of remineralisation efforts are not predictable[17] and treatment needs to be commenced early and performed regularly. Therefore success is dependent on patient's compliance.[17,18] Additionally, extrinsic staining may cause a brownish discoloration of arrested lesions, which are aesthetically even more challenging, and persist for years.[19]

Microabrasion[20] is effective for shallow white spot lesions,[21] but is technically demanding and can involve considerable removal of per se remineralisable enamel.[22,23] Restorative techniques with composite or ceramic have been extensively used with excellent cosmetic results,[24,25] but are usually associated with substantial loss of dental hard tissue. Due to the reversible nature of white spots, and the cosmetic, thus elective treatment character, less invasive options should be preferred. This way, loss of dental hard tissues and eventual retreatment associated with restorative dentistry can be avoided.[26]

Resin infiltration was originally developed to arrest proximal caries lesions.[27,28] After erosion of the pseudo-intact surface layer, resins with low viscosity (infiltrants) penetrate the lesion driven by capillary forces.[28–30] Thus, porosities of carious lesions are occluded and diffusion of acids and minerals is reduced. Hence, lesion progression is hampered and caries progression slowed down or even arrested. Caries infiltration has been proven efficacious in situ[31] and in vivo.[32,33]

As a side effect, infiltration treatment was demonstrated to cosmetically camouflage enamel caries lesions.[34,35] A recent in vitro study showed superior aesthetic results of resin infiltration of artificial white spots when compared with remineralisation after application of fluorides.[36] A first clinical study demonstrated successful masking of post-orthodontic lesions (61% completely and 33% incompletely masked lesions) with infiltration treatment.[35]

The masking of enamel caries is caused by infiltrating the lesions by using resins with a similar refractive index (RI of infiltrant: 1.52) as apatite crystals. Thus, light scattering is reduced and visual color differences to enamel decreased. However, it is unknown if refractive indices of infiltrants influence either the immediate aesthetic outcome or the susceptibility for subsequent extrinsic staining. The aim of this in vitro study was to assess the influence of various refractive indices of experimental infiltrants on the appearance of artificial enamel caries lesions. Furthermore, possible colorimetric changes of both polished and unpolished infiltrated lesions were to be evaluated after a challenge by staining agents.

2. Materials and methods

2.1. Specimen preparation

Enamel–dentine specimens ($n = 120$, 5 mm × 4 mm, 3 + 1 mm enamel + dentine thickness) were prepared from bovine incisors of the second dentition (Band Saw Exakt 300cl; Exakt Apparatebau, Norderstedt, Germany), and ground flat (Phoenix Alpha; Buehler, Düsseldorf, Germany). After embedding in acrylic resin (Technovit 4071; Heraeus Kulzer, Hanau, Germany), the enamel surfaces were polished (abrasive paper 1200, 2400, 4000 Exakt Apparatebau). Subsequently, acid-resistant nail varnish (Rossmann, Burgwedel, Germany) was applied to cover two windows of the enamel surface of each specimen (windows B and D), leaving 2 windows unprotected (A and C). Artificial enamel subsurface lesions in the unprotected areas were created by specimen storage in 5 l of a demineralizing solution[37] containing 50 mM acetic acid, 3 mM $CaCl_2 \times 2H_2O$, 3 mM KH_2PO_4 and 6 μM methylhydroxy-diphosphonate (pH 4.95; 37 °C) for 50 d. PH was monitored daily and, if necessary, adjusted with either hydrochloric acid (10%) or potassium hydroxide solution (10 M).

2.2. Infiltration treatment

After demineralization, the nail varnish was removed. Thus, each specimen showed 2 sound enamel surfaces (B and D) and 2 lesions (A and C). Windows C and D were etched using 37% phosphoric acid gel (Total Etch; Vivadent, Schaan, Liechtenstein) for 2 s, thus leaving window A as negative and window B as positive untreated controls. Compared with clinically used hydrochloric acid,[38] phosphoric acid etching has been shown to be suitable to prepare artificial lesions for resin infiltration.[27] After rinsing the etching gel for 30 s, the specimens were dried by immersion in 100% ethanol, and subsequently desiccated with air blowing for 30 s.

Specimens were randomly allocated to six groups according to five experimental and one commercial infiltrant (Icon; DMG, Hamburg, Germany) differing in RI (Table 1). The resins were applied on windows C and D for 30 s before resin surplus was removed from the surface using a cotton roll, and the material was light-cured for 60 s (530 mW/cm^2; Astralis 5; Vivadent). Subsequently, the resin application was repeated, a glycerine gel applied (AirBlock, Dentsply Detrey, Konstanz, Germany), and again light-cured for 60 s. Each sample was cut perpendicular to the four enamel windows. Half of each specimen was polished (abrasive paper 4000, Exakt), whereas the other half was left unpolished.

2.3. Remineralisation and staining

To simulate remineralizing conditions, specimens were placed into a remineralisation solution containing 1.5 mM