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Color Masking and Caries Inhibition Effects of Resin Infiltration: A Brief Review and Case Series

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ABSTRACT

Objectives: This case report aims to present few cases where resin infiltration was used to treat WSL in the anterior zone.

Materials and Methods: White spot lesions (WSLs) are enamel defects that can lead to aesthetic concerns when located on facial surfaces of anterior teeth. In recent years, resin infiltration has been suggested as a treatment to mask WSLs and arrest non-cavitated initial carious lesions. The concept of infiltrating carious lesions aims to occlude the porosity in the carious lesion, thus inhibiting the diffusion of cariogenic acids. This procedure utilizes capillary forces to carry methacrylate resins (infiltrants) with high penetration coefficients into the porous enamel. The resin refractive index is closer to the refractive index of enamel, which gives this material the ability to mask white spot lesions.

Results: The results were successful and stable in the short term.

Conclusions: In conclusion, resin infiltration is a promising WSL treatment. Protocols may vary depending on the etiology of the WSLs and the depth of the lesions. In the short term, color masking with resin infiltration seems successful and stable in the short term, but more clinical data is needed to report long-term masking effect.

Keywords: White spot lesion, Caries, Resin infiltration, ICON, Operative dentistry.

1. Introduction

Enamel discoloration, also known as white spot lesions (WSLs), can be found in multiple forms, including developmental enamel defects, such as fluorosis, hypomineralization from trauma or molar incisor hypomineralization (MIH), and non-cavitated initial caries in plaque retentive areas, such as along the cervical region of the teeth and around orthodontic brackets (1). This phenomenon can be explained by the difference in light refraction between sound enamel and that of porosities, where greater light scattering occurs. In anterior teeth, these WSLs can lead to aesthetic concerns and dissatisfaction (2).

1.1 WSL Causes

Developmental enamel defects are believed to be caused by environmental and/or genetic factors that affect tooth formation during its mineralization phase or maturation phase (3). The lesions can appear as opaque, creamy white or have yellow/brown discolorations. These can also be localized or generalized (4).

Fluorosis is a form of hypomineralization where excessive fluorapatite crystals exist along with hydroxyapatite crystals. These lesions usually involve several groups of teeth and are symmetrically distributed. Another example of localized hypomineralization is trauma involving the primary

dentition that can in turn affect the permanent teeth. This usually involves displacement, such as intrusion, concussion, subluxation, … etc. and periapical infections that can affect the development of permanent teeth. Finally, the most common hypomineralization defect in children is MIH, which affects the first permanent molar, and most often the permanent incisors (5).

WSLs caused by carious lesions represent a well-defined area in the enamel with distinguished white color. They form a relatively common dental condition that develops after bonding orthodontic appliances (6-7). Such appliances enhance plaque retention and the development of cariogenic biofilm. The bacteria in the biofilm are always metabolically active, causing fluctuations in pH. This eventually leads to gradual dissolution of minerals from the enamel surface (8-10). The resultant porosity leads to diffraction and scattering of light, making the lesion detectable by the eye of the observer and perceived as an esthetic burden by the patient (11). Such lesions are considered initial carious lesions and if left untreated can proceed and establish cavitated carious lesions. It has been reported that the teeth most affected with white spot lesions are maxillary lateral incisors, maxillary canines, mandibular canines and mandibular first molars, respectively (7).

1.2 WSL Treatment Options

Efforts have been made to arrest the demineralization process and mask the white color of the lesions. The structure of hydroxyapatite crystals is affected by a natural cycle between demineralization and remineralization. The remineralization cycle works when the environment provides enough minerals and a suitable pH. Utilizing fluoride varnish, casein phosphor peptide amorphous calcium phosphate containing pastes (CPP-ACP) and bioactive glasses have been proposed to enhance the remineralization process (12-15). When the size of a demineralization area may be such that it cannot be improved even if an effective remineralization agent is used, a more potent and effective treatment may be utilized in such cases. A systematic review conducted in 2020 concluded that topical fluorides yielded a 25%-30% prevention of WSLs; however, their effect on reversing WSLs was unclear. The CPP-ACP products are effective in preventing and reversing WSLs. Fluoride-releasing adhesives have shown no effect in the prevention of WSLs (16).

The first conservative treatment to consider to mask unaesthetic WSLs is a tooth whitening protocol, most often carried out with repeated home treatment with 10% carbamide peroxide. By increasing tooth brightness, the appearance of WSLs can potentially decrease. However, aesthetic results of this treatment modality aren't always successful and may require other treatments as described below (17).

Microabrasion is an effective treatment modality for superficial lesions that requires very little removal of enamel. In deeper lesions, concave tooth surfaces may develop, in which case this treatment is not recommended. Direct bonding leads to overall satisfactory results, but this mainly indicated in cavitated lesions (18-19). Another option called the etch-bleach-seal technique for young permanent teeth has also been described by Wright JT, where the affected surface is etched using 37% phosphoric acid to improve the penetration of the bleaching agent; in this case, 5% sodium hypochlorite is either applied in one appointment or in multiple appointments, followed finally by sealing with a highly penetrating clear resin or bonding agent (20).

Resin infiltration is a relatively new technique used to treat white spot lesions and arrest active non-cavitated lesions (21-23). The microporous enamel structure of non-cavitated carious lesions is infiltrated with low-viscosity light-cured resins, thus inhibiting further progression of caries lesions (18, 22, 24, 25). Additionally, the resin refractive index (1.52) is closer to the refractive index of enamel (1.62) compared to the indices of water (1.33) and air (1.00), which gives this material the ability to mask white spot lesions (26, 27). It was reported that the higher the level of infiltration is, the lower is the scattering of light (18). In pediatric dentistry, resin infiltration is recommended in treating MIH (28).

Resin infiltration is considered as a micro-invasive approach for the management of non-cavitated proximal carious lesions. Restorative treatment is recommended when the lesions are cavitated with a high ICDAS category. Lesions extending into the outer third of dentine were 100% cavitated according to Kielbassa et al, which puts those lesions in need for operative intervention instead of resin infiltration (29). The chance of cavitation and progression of lesions is increased with higher baseline ICDAS category (25, 30-32). The concept of resin infiltration for caries was first

developed in Berlin as a micro-invasive approach for the management of smooth surface and proximal non-cavitated carious lesions involving the dentino-enamel junction DEJ (33-35). It is marketed under the name Icon (DMG America Company, Englewood, NJ). The advantages of resin infiltration over other micro-invasive methods, such as low-viscosity composite resins, dental adhesives and sealants, is that those techniques do not penetrate the porous decalcified layer and work only on the surfaces of the lesions (36-40). Another advantage of using resin infiltration is that it does not rely on patient compliance as other preventive measures, such as oral hygiene practice, therefore providing increased efficacy (25, 41). The concept of infiltrating carious lesions aims to occlude the porosity in the carious lesions, thus inhibiting the diffusion of cariogenic acids (33, 42). This procedure utilizes capillary forces to carry the methacrylate resins (infiltrants) with high penetration coefficients into the porous enamel. According to Kielbassa et al., complete infiltration of the sub-surface lesions does not seem possible. This can be related to the thickness and the reduced porosity of the surface layer, in addition to the organic substances that exist in natural dental caries (43). Infiltration depth of 60 μm was found to be sufficient to prevent further caries progression (36, 43). The enamel is etched with 15% hydrochloric acid (HCL) instead of phosphoric acid to remove the pseudo-intact surface layer (24). Various modifications were proposed to improve the penetration depth of the resin, such as applying sodium hypochlorite to deproteinize the surface or extending the acid etching time (43, 44). A recent meta-analysis found that there is strong evidence that proximal carious lesion progression was less likely to occur in permanent teeth following treatment with resin infiltration and following oral hygiene measures as compared to non-invasive methods (only following oral hygiene instructions) for a follow-up period of 18 months to 2 years (3 studies: OR=0.14; 95%CI: 0.08, 0.25; P<0.001), as well as 3 years (4 studies: OR= 0.15; 95%CI: 0.06, 0.36; P<0.001). However, the quality of evidence was rated as moderate to low, respectively (25).

Several systematic reviews were carried out to investigate the effectiveness of resin infiltration in masking WSLs and stopping caries progression. According to Wisam Bakdach et al., the evidence to support resin infiltration and micro-abrasion is not reliable due to the limited number of available studies (16). A similar conclusion was reported by Sonesson et al. Another meta-analysis found that the monthly use of fluoride varnish was the best supplement to improve WSLs in terms of lesion area and enamel fluorescence, followed by the use of fluoride film (45, 46). On the other hand, the systematic review carried out by Borges AB et al. concluded that resin infiltration seems to be a feasible option for color masking of WSLs (47). Similar findings were reported in other reviews (36, 48-50). Several systematic reviews and meta-analysis found that resin infiltration has a significantly higher masking effect than natural remineralization or regular application of fluoride varnishes (18, 47, 50). A systematic review conducted by Tamara Di Giovanni in 2018 reported that there is a moderate quality evidence on the effectiveness of resin infiltration in treating dental fluorosis as compared to bleaching and concluded that resin infiltration seems to be the most promising treatment for dental fluorosis (51).

In vitro studies have reported that resin infiltration yielded an increase in surface roughness and hardness of artificially created carious lesions (52, 53). It was also found that the penetration depth of the infiltrants was deep enough to render a beneficial effect (54). In one study, cavitation and dentinal tubules up to a depth of 2 mm beyond cavitation were filled by the infiltrants (55). Three dimensional occlusion of porous enamel lesions was reported in the literature (43).

It was also found that resin infiltrated WSLs showed a significantly better color match with sound enamel (less ΔE) than untreated controls (56). A clinical trial carried out by Youssef et al. investigated the color masking effect of resin infiltration and compared it with remineralization using hydroxyapatite and fluorides and conventional oral care using fluoride-free toothpaste. They found that the L* and b*values were shifted in the resin infiltration group and yielded more improvement in the color of the WSLs. The difference was statistically significant compared to the other groups (21).

The susceptibility to color change and degradation of resin infiltrants was investigated by Chen et al., where they reported that resin infiltrants displayed reduced microhardness when compared to conventional resin-based restorations and also showed color changes after accelerated aging (57).

This clinical report shows different smooth surface WSL cases treated with resin infiltration.

1.2.1 Case 1

The patient is an 18-year-old female. She presented with generalized WSLs on maxillary and mandibular teeth after debonding of orthodontic braces due to poor oral hygiene during orthodontic treatment. Those WSLs were initial carious lesions. Resin infiltration was carried out canine to canine for both maxillary and mandibular arches, where aesthetics was a concern for the patient. It can be noted that although there is a slight improvement of WSL appearance, scarring persists on the remaining untreated posterior teeth The initial carious lesions were arrested with oral hygiene improvement, and no cavitation occurred. The treatment began with rubber dam isolation from premolar to premolar. The rubber was inverted to expose the cervical area of the teeth, and then the teeth were cleaned with water to remove any residues. Following the manufacturer's instructions, the teeth were etched with Icon® Etch (15% HCL) for 2 minutes using the specific brush with gentle stirring. The etch was rinsed with water for 30 seconds, and the surface was dried with an air syringe. Icon® Dry (99% ethanol) was then applied to the teeth and left for 30 seconds. The patient and the operator were satisfied with the appearance of the lesions after the ethanol application. Afterwards, an ample amount of Icon® infiltrant was applied to the teeth and left for 3 minutes to allow the resin to infiltrate. The resin was then light-cured for 40 seconds using a light-curing unit with a (385-520) nm wavelength and an intensity of 2200 mW/cm². Finishing and polishing were performed using fine and super fine diamond finishing burs, followed by Daicomp twist polishers (Eve, EVE Ernst Vetter GmbH, Germany). The patient was very satisfied with the results. The patient returned for follow-up visits after one year and two years, and the results remained stable and highly satisfactory.

Figure 1: A. Before resin infiltration; B. 1 year after resin; infiltration and C. 2 years after resin infiltration

1.2.2 Case 2

The patient is a 16-year old female. Finished orthodontic treatment showed up with generalized white spot lesions. Those WSLs were initial carious lesions. Resin infiltration was performed only on the maxillary arch. The teeth were isolated with a rubber dam, and floss was used to keep the rubber inverted in the sulcus. The teeth were cleaned with water, and then Icon® Etch (15% HCL) was applied for 2 minutes. The etch was rinsed with water for 30 seconds, and the surface was dried with an air syringe. Icon® Dry (99% ethanol) was then applied to the teeth and left for 30 seconds. The WSLs were still obvious, so the operator decided to repeat the etching for 2 minutes, followed by rinsing for 30 seconds, drying, and ethanol application. This time, the ethanol wetting improved the appearance of the WSLs, and both the patient and the operator were satisfied. Afterwards, an ample amount of Icon® infiltrant was applied to the teeth and left for 3 minutes to allow the resin to infiltrate. The resin was then light-cured as described earlier. Finishing and polishing were performed using fine and super fine diamond finishing burs, followed by Daicomp twist polishers (Eve, EVE Ernst Vetter GmbH, Germany). The patient was very satisfied with the results. The difference in appearance between the maxillary arch (treated with Icon®) and the mandibular arch (untreated) was very noticeable, as shown in the clinical photographs.

Figure 2: A. The maxillary teeth before resin infiltration; and
B. The maxillary teeth after resin infiltration

1.2.3 Case 3

The patient is a 23-year old male who was unsatisfied with the appearance of his anterior teeth due to developmental WSLs. The lesions were transilluminated before and after treatment to estimate the depth of the lesions and to show light refraction before and after resin infiltration. Notice how light refraction is similar to sound enamel once infiltrated. Developmental enamel defects tend to be deeper than carious lesions. Hence, the etching time is significantly prolonged to reach the base of the defect for efficient infiltration. In this case, Icon® Etch (15% HCL) was applied for 2 minutes, then rinsed and dried. Icon® Dry (99% ethanol) was then applied to the teeth and left for 30 seconds. The WSLs were still obvious, so all the steps were repeated six times until the ethanol-wetting step

showed an improved appearance. The total etching time was 12 minutes. Icon® infiltrant was then applied to the teeth and left for 4 minutes to ensure complete penetration of the resin into the deeper defects. The resin was then light-cured for 40 seconds using a light-curing unit with a wavelength of (385-520) nm and an intensity of 2200 mW/cm². A second application of Icon® infiltrant was performed for additional penetration and surface coverage. Finishing and polishing were carried out using fine and super fine diamond finishing burs, followed by Daicomp twist polishers (Eve, EVE Ernst Vetter GmbH, Germany). The patient was very satisfied with the results.

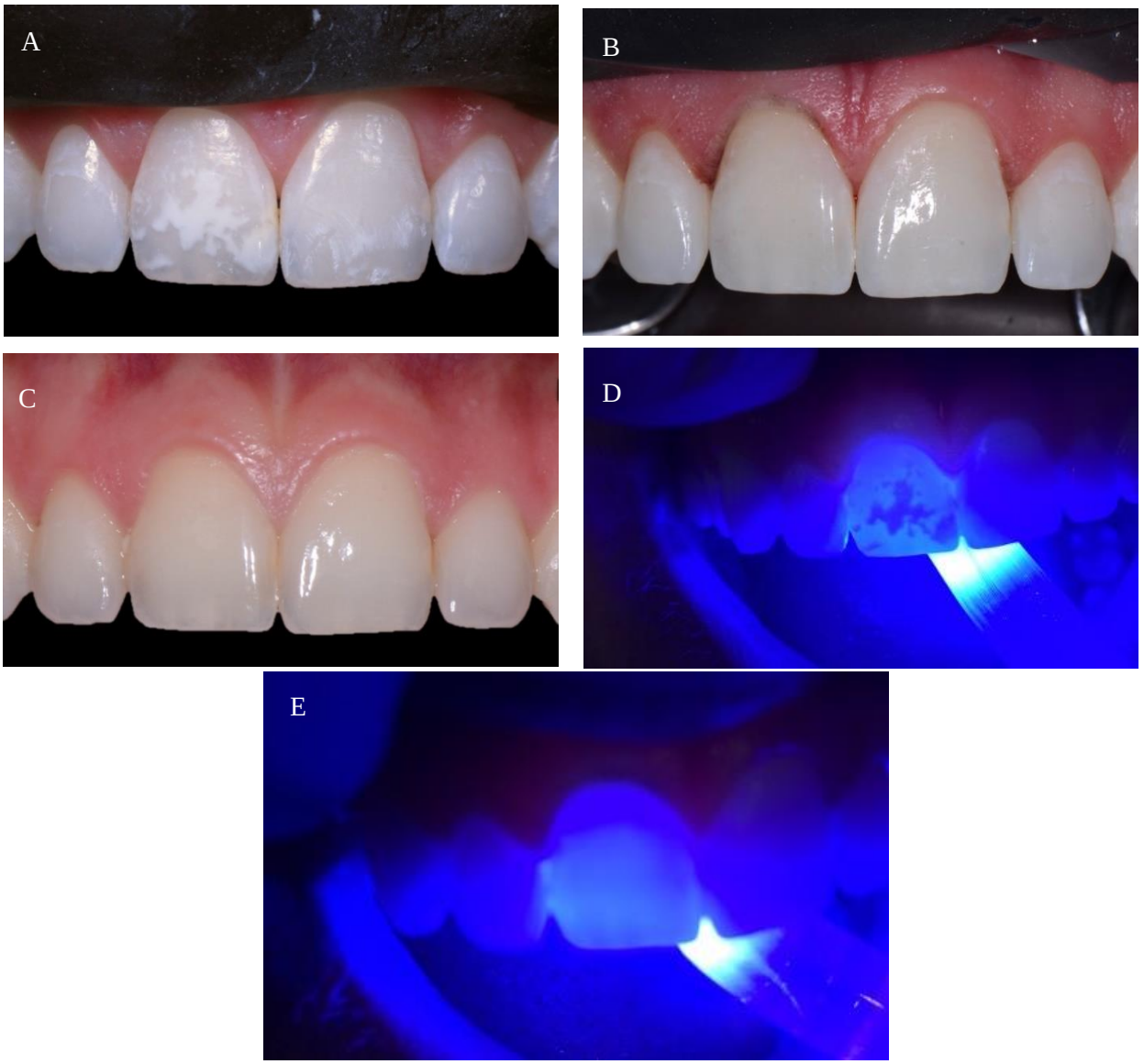

Figure 3: A. Maxillary central incisors before resin infiltration; B. Maxillary central incisors immediately after resin infiltration; C. Maxillary central incisors 1 year after resin infiltration; D. Transillumination of the lesions before resin infiltration; E. Transillumination of the lesions after resin infiltration

2. Discussion

Resin infiltration is used to stop initial carious lesions and mask the WSLs. The efficacy of this treatment approach was studied and reported by many systematic reviews (18, 36,47-50). The stability of this treatment approach is considered good as shown in the one-year and two-year follow-up in the second and third cases. All the cases above used resin infiltration as the safest and least invasive treatment approach. The protocol was adjusted depending on the case. When the

lesions appear to be very deep and resistant, prolonged etching time and frequency seem very beneficial. Alternative treatment options for these patients could be microabrasion and bleaching, followed by resin infiltration. However, resin infiltration alone was sufficient in these cases. Some WSLs that do not improve with resin infiltration, especially those caused by developmental defects, can be treated with partial composite veneers. However, tooth structure must be removed to create space for the composite material. Rubber dam isolation is imperative to ensure optimal isolation and to protect the soft tissue from the HCL acid. Chemical burns can occur if the acid contacts the tissues, leading to a white area that usually resolves on its own in a couple of days. It is very important to properly expose the cervical third of the tooth by inverting the rubber into the sulcus or using a specific clamp or dental floss to push the rubber into the sulcus. If that is not possible, the cuff technique can be used, but careful handling of the HCL is crucial.

It is important to understand that the results always depend on case selection. WSLs can result from developmental defects or initial carious lesions. From the authors' experience, when the WSLs are caused by a developmental defect in the enamel, the lesions are usually very resistant, and multiple etching attempts are needed to achieve improvement. Therefore, it is crucial to set patient expectations low and never promise more than 70% improvement. When the lesion is due to enamel demineralization around orthodontic brackets, the masking effect is, in most cases, very satisfying. Patients need to understand the limitations.

3. Conclusion

In conclusion, resin infiltration is a promising WSL treatment. Protocols may vary depending on the etiology of the WSLs and the depth of the lesions. In the short term, color masking with resin infiltration seems successful and stable in the short term, but more clinical data is needed to report long-term masking effect.

Conflict of Interests

All authors have no conflict of interests in this research.

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