Micro-invasive treatment of carious white spots on smooth surfaces

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Carious enamel lesions are characterized by a considerable loss of minerals below a seemingly intact surface. The porosities inside the lesion body result in the typically whitish appearance of these lesions, so-called white spots [1]. Carious enamel lesions on smooth surfaces are a frequent adverse effect of orthodontic treatment with fixed appliances [2]. Although adhesively bonded brackets simplify orthodontic treatment, they inhibit thorough cleaning of the surrounding tooth surfaces, thus promoting plaque accumulation and the formation of carious lesions in these areas [3, 4]. Even though the progression of these lesions, after removal of the brackets, may be inhibited with preventive measures such as topical fluoridation, the persistence of the white spot lesions in the visible areas frequently lead to severe esthetic impairment [4]. Other risk factors for the formation of smooth surface lesions include insufficient oral hygiene, hypo salivation, or xerostomia [5]. The standard treatment for white spot lesions includes topical fluoridation and improvement of the patient’s oral hygiene in order to promote the remineralization of the demineralized enamel [6, 7].

Due to the improved access of the smooth surface white spots after debonding, these non-operative measures show good results with respect to limiting the lesion progression. However, especially for deeper lesions, only a mere superficial remineralization is achieved. These lesions often have a very pronounced and mineralized surface layer [8, 9]. But the lesion body under this surface layer remains porous, thus the white appearance of the lesion persists [4, 10]. During the remineralization phase, pigments from food, beverages, or tobacco products can also penetrate this lesion causing dark or brownish discolorations of the lesion [9]. Many patients perceive these brown spots as even more unesthetic.

Different methods to treat these lesions have been established with varying success. The micro abrasion technique removes superficial enamel portions using a slurry of 18% hydrochloric acid and pumice [10–12]. Unfortunately, considerable amounts of enamel up to a depth of several hundred micrometers have to be sacrificed with this procedure in order to achieve satisfactory esthetic results [13]. Other invasive restorative techniques, such as ceramic veneers or direct composite restorations, require the removal of extensive amounts of non-carious enamel and are very costly for the patient.

The caries infiltration method is a novel, alternative therapy approach for the treatment of white spot lesions, based on the concept of sealing the micro-porosities of the lesion body and thereby inhibiting the substrate supply to inhibit the progression of the caries. For this purpose, the hyper mineralized surface layer is removed with a 15% hydrochloric acid gel [14]. In a next step, a specially developed, very liquid composite is applied onto the lesion to infiltrate it, driven by capillary forces [15]. Since the capillaries in a carious lesion are extremely thin, a penetration time of three minutes is required to ensure a complete infiltration of the lesion. The caries infiltration creates a diffusion barrier for cariogenic substrates inside the lesion, different from the traditional sealing method, which only forms a barrier on the surface. This procedure prevents the creation of artificial plaque retention areas and the formation of marginal gaps. Before the infiltration composite is light-cured, any excess material should be removed [16]. A positive result of the caries infiltration is that the enamel lesions will lose their whitish or brownish appearance and the unfavorable esthetic effect is neutralized. Once the micro-porosities are filled, the light refraction behavior adjusts to that of the surrounding healthy enamel. The light refraction behavior is described by the refraction index (RI).

The refraction index of healthy enamel (RI = 1.62) differs significantly from that of the air entrapments inside a lesion (RI = 1.00). This difference results in diffuse light scattering which is visually displayed in the afore-mentioned white spots. Filling the air entrapments with the infiltrant (RI=1.52), which has a refraction index similar to that of healthy enamel, eliminates the diffuse light scattering and removes the white spots. Brown spots can be cleared through etching, which removes the embedded organic pigments. In-vitro and in-vivo studies have confirmed the effectiveness of the caries infiltration [17–18] as a quick and effective treatment method, which preserves the hard tissue, but still providing excellent esthetic results for such lesions.
Treatment of post orthodontic white spot lesions with Icon Caries Infiltrant – Smooth Surface

Case report
A 17-year old patient, who received orthodontic treatment with fixed appliances for 24 months, was diagnosed with post orthodontic white spot lesions after the successful conclusion of his orthodontic treatment and removal of the brackets. These lesions persisted even four weeks after debonding, and in addition exhibited yellow-brownish discolorations (fig. 1). These pronounced discolored lesions seriously compromised the patient’s smile. It was decided to treat these post-orthodontic lesions with a new treatment method called resin infiltration.

In a first step, all teeth were polished with a fluoride-free polishing paste using a rubber cup. Then, the soft tissue of the affected teeth was isolated. Especially for white spot lesions in the cervical areas the application of rubber dam might lead to overlapping, thus making their accessibility during the treatment more difficult. In such cases a light-curing resin barrier material can be used (Opaldam, Ultradent, South Jordan, USA) (fig. 2). This procedure is frequently used for in-office bleaching treatment because it is very user-friendly and it effectively isolates the soft tissue in the working area. In order to prevent overlapping of the white spots in the cervical regions, the barrier material was applied carefully in the following way. First, by leaving the marginal gingiva free, the attached gingiva and alveolar mucosa were covered with the light curing barrier material using a 20 gauge micro tip. Then the barrier material was applied directly onto the marginal gingiva with a finer micro tip, e.g. 25 gauge, and light cured. Thus, the barrier material can be precisely applied along the gingival margin without overlapping of the white spots. In some cases the additional use of a retraction cord before applying the barrier material might be also useful.

After successful isolation of all surrounding soft tissue areas the application of the resin infiltration (Icon Caries Infiltrant – Smooth Surface, DMG, Hamburg, Germany) followed. During the first step of the infiltration treatment, the pseudo-intact surface layer was eroded using a 15% HCl gel (Icon-Etch) (fig. 3). It was applied with an applicator, which was specially developed for smooth surface application and which can be attached to the syringe containing the etching gel. In the center of the applicator is an opening through which the material is dispensed. The flocking surrounding this opening ensures an even application of the etching gel or resin to the desired areas. In this case, teeth 35 to 42 were treated with Icon. For comparison purposes, teeth 43 to 45 were treated with a fluoride varnish. The etching step required two minutes of contact time to remove the surface layer sufficiently. For older, more inactive or heavily discolored lesions it may be necessary to repeat the etching procedure for another two minutes. Adjacent teeth, which are not going to be treated with Icon, can be protected with a Mylar strip or Teflon tape. In order to obtain a homogenous etching pattern, the etching gel was stirred in circular movements with a microbrush during the contact time. Then the etching gel was thoroughly rinsed off with water spray and the teeth were air-dried. Now, the surface should have a chalky white appearance comparable to the etching pattern occurring with the conventional enamel etching technique using a 37% H₃PO₄ gel. After the etching step, all discolorations should be removed completely.

In order to remove water from the inside of the micro-porosities, which would inhibit the penetration of the infiltrant, the lesion surface was wetted with 99% ethanol (Icon-Dry) for a minimum of 30 seconds and then air-dried. Just 5–10 seconds after application of Icon-Dry, white spots became invisible or reduced in intensity. This step provides an excellent...
intermediate control of the possible esthetic result of the infiltration treatment. However, should discolorations or the white spots persist at this point, the etching and drying step should be repeated. With the evaporation of the ethanol and following the air-drying, the lesions should turn to a chalky white appearance again (fig. 4). In total, the etching step can be performed three times.

Then, with a new applicator attached to the Icon-Infiltrant syringe the resin infiltrant was applied. This happened in two steps. The first infiltration step required a contact time of three minutes, after which excess on the surface was carefully removed with cotton rolls and dental floss, then the infiltrant was light-cured for 40 seconds (fig. 5, 6). The infiltrant was applied for a second time, but now for only one minute (fig. 5, 6), followed by light-curing for another 40 seconds. The purpose of the second infiltration step is to optimize the surface by filling any irregularities. Any remaining excess material was removed with a scaler or sickle-shaped scalpel blade. Then the infiltrated surface was polished (fig. 7). Figure 8 shows a perfect esthetic result following the infiltration treatment after one month (fig. 8).

**Summary**

Esthetic improvement of carious white spot lesions is based on the masking effect of these enamel lesions by resin infiltration, which optically adapts the appearance of the lesions to that of the surrounding healthy enamel. Active lesions or post-orthodontic white spots immediately after removal of fixed orthodontic appliances often have a very thin surface layer. These types of lesions are therefore especially indicated for the infiltration treatment and their esthetic appearance can easily and effectively be improved.

**References**


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