Enamel caries lesions are characterized by a loss of mineral beneath an apparently intact surface layer. The increased porosity within the lesion body causes the characteristic whitish appearance of these lesions. Thus these lesions are often called white spots.¹

Buccal enamel caries lesions are a frequent adverse effect of orthodontic treatment with fixed appliances.² Fixed orthodontic appliances make it difficult to clean the area around the brackets and thus promote plaque accumulation and caries formation when oral hygiene is insufficient.³,⁴ After bracket removal, the lesions can be arrested by preventive measures but still may represent a severe esthetic impairment.⁴ Other risk factors often associated with smooth-surface enamel caries comprise extremely poor oral hygiene and salivary hypofunction.⁵ For patients with these risk factors, esthetic impairment is usually not the main problem, but the common preventive strategies may fail even for easily accessible lesions.

The common treatment strategy for enamel caries comprises topical application of fluorides and improvement of oral hygiene to achieve remineralization of the demineralized enamel.⁶,⁷ Because of the good accessibility of buccal white spots after debonding, this nonoperative approach is often successful to arrest lesion progression. However, especially deep lesions tend to remineralize only superficially. Consequently, arrested lesions show thick and highly mineralized surface layers.⁸,⁹ The underlying lesion body is still porous, however, and thus the whitish appearance often persists.¹⁰ Moreover, during remineralization stains can be incorporated into the lesion, leading to the formation of brown spots,¹¹ a situation that might be judged as even more unesthetic.

Several techniques have been proposed to improve the appearance of buccal enamel caries. Enamel microabrasion removes superficial parts of the lesion by abrasion with a slurry of hydrochloric acid and pumice.¹⁰–¹² Unfortunately, with this technique, substantial

Masking of labial enamel white spot lesions by resin infiltration—A clinical report

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This article describes a novel approach to treat smooth-surface white spot lesions micro-invasively. The technique is based on the infiltration of enamel caries lesions with low-viscosity light-curing resins called infiltrants. After the surface layer is eroded, the lesions are desiccated and a resin infiltrant is applied. The resin penetrates into the lesion micro-porosities driven by capillary forces and is subsequently hardened. Infiltrated lesions lose their whitish appearance and look similar to sound enamel. Additionally, the treatment prevents lesion progression. The proposed technique might be an alternative to microabrasion and restorative treatment, in particular for white spot lesions of esthetically relevant teeth. (Quintessence Int 2009;40:713–718)

Key words: caries, infiltrant, infiltration, penetration, resin, white spot

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amounts of enamel often have to be eroded to improve appearance.\textsuperscript{13} Restorative techniques such as ceramic veneers or composite restorations that may be indicated in severe cases often require the sacrifice of even more enamel.

Caries infiltration is an alternative therapeutic approach to prevent further progression of enamel lesions. This treatment aims to occlude the microporosities within the lesion body by infiltration with low-viscosity light-curing resins that have been optimized for rapid penetration into the porous enamel (infiltrants).\textsuperscript{14} After conditioning of the lesion surface using hydrochloric acid gel,\textsuperscript{14,15} a resin infiltrant is applied on the lesion. The resin penetrates into the lesion body, driven by capillary forces. Because this technique aims to create a diffusion barrier inside the lesion and not on the lesion surface, excessive material is removed from the surface before the resin is light cured.\textsuperscript{16}

A positive side effect of resin infiltration is that enamel lesions lose their whitish appearance when their microporosities are filled with the resin and look similar to sound enamel. Therefore, this treatment may be used not only to arrest enamel lesions but also to improve the esthetic appearance of buccal white spots.

This article describes a novel approach to treat smooth-surface white spot lesions microinvasively. The proposed technique might be an alternative to microabrasion and restorative treatment of esthetically relevant teeth.

**CLINICAL PROCEDURE**

Rubber dam is applied to protect soft tissues and achieve clean and dry working conditions. Either conventional rubber dam (Fig 1b) or a light-curing liquid dam (Fig 2b) should be used. After the teeth have been cleaned using prophylaxis paste, the surface layer is eroded by application of a 15% hydrochloric acid gel (preproduct material, composed of 15% hydrochloric acid, water, silica, and additives; DMG) for 120 seconds\textsuperscript{14} (Figs 1c and 2c). Neighboring teeth should be protected (eg, with plastic matrices). To avoid inhomogeneous etching patterns due to emerging bubbles, it is recommended to stir the gel from time to time during application with a microbrush. Subsequently, the etching gel is thoroughly washed away (30 seconds) using water spray. The etching procedure removes superficial discolorations and the higher mineralized surface layer, which otherwise might hamper resin penetration.\textsuperscript{14,15} To remove the water that is kept inside the microporosities of the lesion body, lesions are desiccated by application of ethanol for 30 seconds and subsequent air drying. To maximize removal of water, this step should be repeated at least once. After air drying, the whitish appearance of enamel lesions is more pronounced (Figs 1d and 2d).

A resin infiltrant (preproduct material, composed of tetraethylene glycol dimethacrylate, additives, and initiators; DMG) is applied on the lesion surface using a microbrush and allowed to penetrate for 5 minutes (Figs 1e and 2e). Because caries infiltration aims to create a diffusion barrier inside the lesion and not on top of the lesion surface, resin surplus on the tooth surface is wiped away using a cotton roll before light curing (Fig 2f). The proximal spaces should be cleaned from excessive resin using dental floss. After light curing (Figs 1f and 2g), the application of infiltrant should be repeated once to minimize enamel porosity.\textsuperscript{17} Finally, the roughened enamel surface is polished using disks and silicone polishers to avoid rediscoloration by food stains. An immediate improvement of the esthetic appearance is achieved (Figs 1g and 2h) and remained stable until the 10-month follow-up (Fig 1h).

**DISCUSSION**

The principle of masking enamel lesions by resin infiltration is based on changes in light scattering within the lesions. Sound enamel has a refractive index (RI) of 1.62. The microporosities of enamel caries lesions are filled with either a watery medium (RI 1.33) or air (RI 1.0). The difference in refractive indices between the enamel crystals and medium inside the porosities causes light scattering...
Fig 1a  Facial view of white and brown spot lesions 1 month after bracket removal.

Fig 1b  Application of conventional rubber dam.

Fig 1c  Erosion of the surface layer (preproduct material, 15% HCl; DMG).

Fig 1d  Etched and desiccated lesions. The whitish appearance is more pronounced.

Fig 1e  Application of the resin infiltrant (preproduct material; DMG).

Fig 1f  After removal of surplus material, the area is light cured.

Fig 1g  Facial view after removal of rubber dam and polishing.

Fig 1h  Satisfying esthetic result after 10 months. Some staining on the left lateral incisor can be observed, probably due to incomplete infiltration.
Fig 2a  Facial view of buccal whitish discol- orations 3 months after bracket removal.

Fig 2b  Application of liquid rubber dam (opal dam, Ultradent).

Fig 2c  Erosion of the surface layer (preproduct material, 15% HCl; DMG).

Fig 2d  Etched and desiccated lesions.

Fig 2e  Application of the resin infiltrant (preproduct material; DMG).

Fig 2f  Removal of resin surplus.

Fig 2g  Light curing.

Fig 2h  Facial view after removal of rubber dam and polishing.
that results in a whitish opaque appearance of these lesions, especially when they are desiccated.\textsuperscript{1} The microporosities of infiltrated lesions are filled with resin (RI 1.46) that, in contrast to the watery medium, cannot evaporate. Therefore, the difference in refractive indices between porosities and enamel is negligible and lesions appear similar to the surrounding sound enamel.

Infiltrants are light-curable resins that are optimized for rapid penetration into the capillary structures of the lesion body. These materials show a very low viscosity, low contact angles to enamel, and high surface tensions.\textsuperscript{18} These material properties are important for a complete penetration of the resin infiltrant into the lesion body of enamel caries lesions. However, the mineralized surface layer hampers resin from penetrating into the lesion. Thus, this layer should be removed. Hydrochloric acid gel (15\%) has been demonstrated to be superior to 37\% phosphoric acid gel in removing the surface layer of natural enamel lesions when applied for 120 seconds.\textsuperscript{14,15} In contrast to enamel microabrasion,\textsuperscript{13} only 30 to 40 µm are eroded with this technique.\textsuperscript{15} Moreover, erosion of sound and demineralized enamel is similar because no pressure is applied. Thus, the enamel loss is marginal with this etching technique.

The original aim of caries infiltration is to arrest lesion progression by occlusion of the microporosities that provide diffusion pathways for acids and dissolved minerals.\textsuperscript{19} It has been argued that irrespective of the seal, entrapped bacteria at the lesion bottom could trigger the caries process. Today, there is good evidence that entrapped bacteria are not detrimental, if they are properly sealed.\textsuperscript{20} Moreover, it has been reported that uncavitated lesions show only small bacteria counts.\textsuperscript{9}

Active lesions show only thin and porous surface layers that are easier to infiltrate than inactive lesions.\textsuperscript{1} Best results can be achieved if infiltration treatment is started shortly after debonding of orthodontic appliances on relatively active lesions. If more inactive lesions are supposed to be infiltrated, the application of ethanol can be used to confirm the complete erosion of the surface layer. The color of desiccated lesions should change during penetration of ethanol. If color does not change, ethanol will not reach the lesion body, because of surface layer remnants. Thus, the etching step should be repeated.

Caries infiltration offers some advantages compared with the remineralizing (fluoridation) approach. First, the appearance even of deep lesions can be improved because the resin infiltrant is capable of penetrating deep into the lesion as described.\textsuperscript{16} Second, the esthetic improvement is achieved instantly. Compared with enamel microabrasion or conventional restorative techniques, caries infiltration is much less invasive, and only negligible tooth substance must be sacrificed by etching and polishing. Similar to remineralizing approaches and enamel microabrasion, the esthetic outcome of caries infiltration cannot be precisely predicted. But even if not all whitish parts of a lesion disappear completely, resin infiltration usually leads to a considerable improvement of the appearance. Thus, caries infiltration is a relatively fast treatment option for masking buccal caries lesions.

**CONCLUSION**

The proposed technique might be a promising application of caries infiltration for a frequent clinical problem. Besides an arrest of lesion progression, an improvement of the esthetic appearance of the lesions is achieved. Therefore, this technique may be considered as an alternative microinvasive treatment of smooth–surface white spot lesions that might fail to disappear during preventive treatment. However, more clinical data are needed.

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