ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at:www.ijdsir.com

Volume – 4, Issue – 5, September - 2021, Page No. : 130 - 137

Resin infiltration: a micro-invasive approach to white spot lesions

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Citation of this Article: Dr. Aabha Rawal, Dr. Dipti Choksi, Dr. Barkha Idnani, Dr. Darshil Sodha,"Resin infiltration: a micro-invasive approach to white spot lesions", IJDSIR- September - 2021, Vol. – 4, Issue - 5, P. No.130 – 137.

Type of Publication: Review Article

Conflicts of Interest: Nil

Introduction

With the advancement in preventive and adhesive techniques in dentistry, newer methods are applied for inhibiting the carious process aiming to preserve the tooth structure. Thus introducing the concept 'Minimally Invasive Dentistry' for preservation of healthy dental structures. It is a systematic respect for the original tissue by replacing and removing with little tissue loss.[1]

Enamel demineralization and remineralization are considered as a continuous process. Cavitated lesions occur as a result of demineralization of the hard tissues and destruction of the organic matter of the tooth by production of acid by hydrolysis of carbohydrates in the plaque.[2] Non cavitated caries lesions show increased porosity within the lesion due to loss of inorganic substance beneath an intact surface layer. When compared with the refractive index of sound enamel (RI 1.65), incipient enamel caries lesions are porous and are filled with air (RI 1.0) and water (RI 1.33). Consequently, due to scattering of reflected light, the lesion looks opaque.[3]

Recent minimally invasive concepts in Operative Dentistry are focused on the control of the etiological factors using noninvasive and microinvasive strategies. The current modalities for the treatment of early lesions are either invasive or non-invasive in nature. Noninvasive strategies target at arresting or reverting noncavitated enamel caries lesions, microinvasive strategies include barriers that prevent further dissolution of enamel by the acidic challenge from cariogenic bacteria. Two microinvasive procedures are used: (a) pit-and-fissure

sealants applied onto phosphoric acid-etched enamel and (b) low-viscosity resins that permeate or infiltrate into hydrochloric acid (HCl)-etched noncavitated enamel lesions (or white spot lesions [WSLs]) by capillary action.[4]

White Spot Lesions

White spot lesions (WSLs) are early signs of demineralization under the intact enamel, which may or may not lead to the development of caries. In 1908, G.V.Black described enamel white spot lesions as "occasional white or ashy gray spots that were small and covered with the standard glazed surface of the enamel, so that an exploring tine will glide over them an equivalent as over the right enamel."[5]

WSLs occur when the pathogenic bacteria releasing organic acids have breached the enamel layer and have leached out a specific amount of calcium and phosphate ions that may or may not be replaced naturally by the remineralization process.[6] They can occur on any tooth surface in the oral cavity where the microbial biofilm is allowed to develop and remain for a period of time. These areas of demineralized enamel that sometimes develop due to prolonged plaque accumulation would lose their translucency due to an in depth subsurface porosity caused by demineralization. If the method isn't interrupted and demineralization reversed, they could progress from demineralization, to non-cavitated lesions, and eventually to cavitated lesions.[7] White spot lesions aren't only the result of demineralization, however, as fluorosis, hypomineralization/hypomaturation and hypoplasia also can cause lesions.[8]

Classification of white spot lesions[9]

White-spot lesions were first classified in orthodontics consistent with their visual size. This classification made consistent with the width of opacity formed on enamel surface was as follows:

Class 0: None or but 1 mm opacity

Class 1: Opacity covers 1/3 of tooth surface

Class 2: Opacity covers 1/3 to 2/3 of tooth surface

Class 3: Opacity covers wider than 2/3 of tooth surface

Another classification made by Gorelick, et al., which considers both size and intensity of lesions is as follows:

Class 1: No white spot lesion formation

Class 2: Mild white spot lesion present

Class 3: Severe white spot lesion present

Class 4: Cavitation is present in addition to white spot lesion

Treatment Options[10]

Various treatment options for treating white spot lesions on the labial surfaces of teeth:

1. Tooth whitening
2. Application of amorphous calcium phosphate directly on to the lesion or using a bleaching tray (Abreu et al 2011).
3. Microabrasion using 6.6% HCl acid (Greenwall 2006, product used Opalustre, Optident UK) and 10% HCl acid (Premier Products, USA).
4. Resin infiltration using 15% acid (Icon, DMG, Germany)
5. Combination therapy of whitening and increasing concentrations of acid
6. Composite bonding directly over the lesion
7. Removing the white mark with a handpiece followed by restoring with composite resin, dentine, enamel and opaque shades
8. Direct resin veneer
9. Indirect resin veneer (Edelweiss, Optident UK) Porcelain laminate over the entire labial surface.

Table1: Etiology and Management of white spot lesions [11]

	Type of white lesion	Aetiology	Possible treatment
1.	Isolated single white spots with diameter less than 0.5mm adult maxillary incisors	Natural occurrence	Whitening only
2.	White speckled lesions: mottled enamel	Fever during development	Whitening then micro abrasion at 6.6%
3.	Multiple lesions: brown and white discolourations	Fluorosis	Whitening then micro abrasion
4.	White line/ stripes	More severe developmental disturbance	Whitening then micro abrasion
5.	White patches	Trauma to the primary dentition	Whitening, followed by resin infiltration
6.	White spots covered with yellow layer	Bleeding had occurred during the traumatic injury and seeped into the areas of mineralisation	Whitening, micro abrasion then resin infiltration
7.	Faint white lesions, some black edges	Demineralisation lesions after removal of orthodontic brackets	Resin infiltration or whitening or Micro abrasion depending on the size of the mark
8.	Enamel defects and white lesions in deciduous incisors and molars	Ceoliac disease, Molar Incisor hypoplasia	Whitening, glass ionomers placed onto the defective molar teeth, resin infiltration of the anterior lesions
9.	White spot or enamel hypoplasia	Preterm birth (prevalence 45% normal birth weight to 92% preterm babies - lai et al)	Whitening. Micro abrasion then resin infiltration

Resin Infiltration

Caries infiltration may be a novel treatment option for white spot lesions. The concept was first developed in Germany, at the Charite University Hospital in Berlin. It is marketed under the name of Icon® (DMG America Company, Englewood, NJ).[12] It is a micro invasive technology that fills, reinforces and stabilizes demineralized enamel, without drilling or sacrificing healthy tooth structure. The micro-invasive infiltration can be used to treat smooth surface and proximal carious lesions up to the first third of dentin (D1).It prevents lesion progression and increases life expectancy of a tooth. It provides an alternative to microabrasion and other restorative treatments for cariogenic white spot lesions. After infiltration, white spot lesions take on the appearance of the surrounding healthy enamel.[13]

Principle of Resin Infiltration

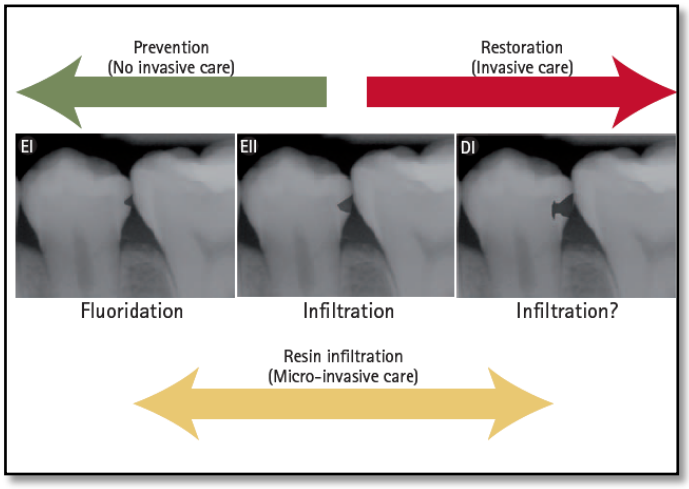
The principle of resin infiltration is to fill porous enamel with resin by capillary action, thereby halting the process of demineralisation and stabilising the carious lesion. The

caries-infiltration technique comprises erosion of the pseudo-intact and relatively impermeable surface layer with hydrochloric acid gel, dessication of the lesion with ethanol and subsequent application of an infiltrant. Thus the caries inhibiting effect is primarily achieved by occlusion of the pores within the body of the lesion, which results in slowing down of diffusion processes.[14]

The infiltration takes place within the enamel, forming a superficial mechanical barrier on the outer surface of the initial lesion and depriving the bacteria that colonise the surface of the lesion of nutrients from the biofilm. Once the resin has been cured, bacteria which have penetrated the demineralised enamel are trapped inside it. The presence of these trapped bacteria does not inhibit the resin infiltrating and does not warrant operative treatment by surgical tissue removal and restoration.[15]

Indications[16]

1. Small white lesions inherent on the tooth
2. Smooth surface white decalcification on the tooth such as after stasis of plaque after orthodontic treatment
3. Larger white marks and bands on the tooth
4. Lesions due to molar incisor hypoplasia (MIH)
5. Hypoplasia stains due to traumatic injuries
6. Mild to moderate fluorosis
7. Large single bands due to fluorosis.



E1: demineralisation in the outer half of enamel; E 2 demineralisation of the entire width of the enamel; D 1: demineralisation of the outer third of dentine without cavitation (corresponding with the SiSta classification: E1 and E2 = Stage 1; D1 = stage 2).

Figure 1: Schematic representation of comparative indications for remineralisation by fluoride, by resin infiltration and minimal intervention dentistry. These treatment options are offered for guidance, given the difficulty of creating a categorical decision based on the radiographs alone.

Composition

Figure 2: Icon® treatment kit

Table 2: Composition [17]

Commercial name (manufacturer)	Composition	Instructions for use
Icon-Etch (DMG)	15% hydrochloric acid, water, pyrogenic silica, surfactant, pigments	Apply the gel and leave it for 2 min • Remove excess material with a cotton roll • Rinse with water for 30 s • Dry with oil-free and water-free air
Icon-Dry (DMG)	Ethanol	• Apply an ample amount of material and let it set for 30s • Dry with oil-free and water-free air • When wetted with Icon-Dry, the whitish-opaque coloration on the etched enamel should diminish. If this is not the case repeat the etching step once or twice for 2 min each, and rinse and dry the teeth again as above
Icon-Infiltrant (DMG)	TEGDMA-based resin, initiators and stabilizers	• Apply an ample amount of Icon-Infiltrant onto the etched surface • Let Icon-Infiltrant set for 3 min • Remove excess material with a cotton roll and dental floss • Light-cure Icon-Infiltrant for 40 s • Screw a new Smooth Surface-Tip onto the Icon-Infiltrant syringe, repeat the application and let set for 1 min • Remove excess material with a cotton roll and dental floss, and light-cure for a minimum of 40 s

Material Characteristics[18]

The well-defined requirements for potentially useful materials were characterized. These should be:

- Highly surface active and with low viscosity.
- Bacteriostatic.
- Hydrophilic.
- Resistance against mechanical and chemical challenges of the oral cavity.
- Non-toxic to oral tissues.
- Polymerizable to a solid state.
- Cosmetically acceptable.
- Some commercially available adhesives have been shown to be suitable for artificial infiltration subsurface lesion as well, but when infiltrants with differing penetration co-efficient were used significant differences are revealed

Technique[19]

The technique consists of these components:

1. The preparation phase – the surface of the teeth is cleaned and 15% hydrochloric acid is applied on the teeth for 2-5 minutes (Figure 3)

2. Alcohol is placed onto the surface as a drying agents and left for 2 minutes (Figure 4)

3. The TEGMA resin is applied onto the tooth for 2-5 minutes (Figure-5)

4. The tooth is light cured.

Figure 3: The direct application of the 15% hydrochloric acid gel onto the surface of the white spots for two minutes.

Figure 4: Application of ICON Dry (alcohol) DMG

Figure 5: Direct application of the resin onto the tooth using a special applicator. This is applied slowly to let the resin infiltrate gently.

Advantages[20,21]

- This technique is highly accepted by patients
- Improved aesthetic outcome as a masking resin on demineralized labial surfaces.
- No postoperative sensitivity and pulpal inflammation.
- Reduced risk of gingivitis and periodontitis.
- The progression of lesion is retarded.
- Minimum risk of secondary caries.
- Obturation of porous deeply demineralized areas.
- Delay of restorative intervention for longer periods.
- Resin infiltrant fills the spaces between the crystallites and forms an enamel hybrid layer which is more resistant to acid attack
- Mechanical stabilization of demineralized enamel.
- Prevention of sound hard substance.
- Permanent occlusion of superficial micro pores and cavities

Masking Effect

Sound enamel has a refractive index (RI) of 1.62 while demineralized WSLs have many pores filled with water with a refractive index (RI) of 1.33 or air (RI = 1.00). The whitish appearance of the lesions is due the difference in the refractive indices between the enamel crystals and medium inside the porosities which affects the light scattering, especially when desiccated. The difference in RIs between porosities and enamel was decreased to a negligible level when the micropores of WSLs were infiltrated by resin (RI = 1.46), which has a similar RI as enamel and cannot evaporate. Thus the masking effect is manifested as the WSLs regained translucency, appearing similar to that of the surrounding sound enamel. [22,23]

Disadvantages

- It may not always fade the white spot lesion entirely

- Higher degree of water sorption as they lack fillers to lower the viscosity for penetration into the lesion body.
- Hydrophilic TEGDMA also contributed to high moisture absorption which leads to separation of matrix-filler interface and discoloration.[24]

Conclusion

White spot lesions have become an esthetic challenge. The successful treatment of the esthetic imbalance depends on the intrinsic characteristics of white spot lesions and the complete infiltration of the low viscosity resin. Resin infiltration is an applicable method for the treatment of white spot lesions. It can immediately restore the color of white spot lesions and inhibit the progression of emerging caries by blocking diffusion pathways. Further research is necessary to confirm the efficiency of this treatment modality.

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