Chapter

White Spot Lesions and Remineralization

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Abstract

As all practitioners are aware, the prevalence and incidence of dental caries keep increasing constantly and therefore early diagnosis and cessation of further progression would greatly help in maintaining the sound tooth structure. One of the earliest signs of dental caries is a white spot lesion, which is mostly missed, and only treated when the condition worsens. WSL are areas of demineralized enamel that occur due to a prolonged period of retained microbial biofilms most commonly associated in patients with poor oral hygiene and fixed orthodontic appliances. If caught early and intervened, WSLs can be reversed. Therefore, the diagnosis and treatment of WSL are of outmost importance, and this chapter will explain in detail various methods of diagnosing WSLs, its treatment protocol with the significance of remineralization of the same.

Keywords: dental caries, demineralization, fluorosis, remineralization, white spot lesions

1. Introduction

White spot lesion (WSL) is the demineralization of the enamel surface and subsurface that is devoid of cavitation [1–3]. They are a result of the imbalance between mineralisation and demineralization, which if not intervened, may further lead to irreversible damage [1, 2]. In early lesions the mineral content in the affected area is reduced, which in turn affects the translucent feature of the enamel, and the colour of these areas appear more opaque white, hence, they are termed as white spot lesions. They are the first visible findings in caries formation and are considered as initial lesions by many clinicians. However, it should be remembered that, for demineralization to be visible, it must have a minimum depth of 300–500 μm implying that a considerable amount of damage to sound tooth structure has already begun [4–7].

These lesions are commonly associated with poor oral hygiene and increased plaque accumulation. In addition to the above other risk factors such as poor dietary habits, high DMFS (Decayed, Missing or Filled Surfaces) index, and lack of preventive measures during orthodontic treatment always prevail.

A white spot may be intrinsic or extrinsic in origin [2], enamel defects such as fluorosis, hypomineralisation, hypomaturation of enamel, hypoplastic defects can lead to noncarious intrinsic white spots of the enamel. These developmental

anomalies are greatly influenced by genetic aberrations, environmental variations, metabolic diseases, drug abuse, use of chemicals, radiation and trauma [4]. The differential diagnosis is imperative to the treatment plan.

An early enamel lesion can easily be identified as a white opaque spot when air-dried and is the most efficient way to detect it [5]. What may appear to be a smooth, shiny, non-carious lesion under light may be a rough, opaque and porous lesion on cleaning and drying [6]. It is challenging for a clinician to detect these in a regular check-up, and the diagnosis can only be established subjective to the clinician. Since these discolorations may be a result of several factors, it is usually challenging to arrive at an accurate diagnosis for the same.

2. Aetiology/causes

WSL usually has a multifactorial manifestation. It is vital to ascertain the causes, before planning and providing treatment options to the patient. This is because the results of the treatment will vary depending on the substructure available [8–12].

Causes of WSL include,

- high fluoride intake in childhood
- complications in pregnancy
- trauma
- poor oral hygiene

2.1 Fluorosis

During the phase of enamel mineralisation, if there is excessive fluoride exposure, and as a result the enamel would become hypomineralized, leading to a condition called fluorosis. Studies conducted by McKay and Black [11] conclude, that fluoride can be beneficial or harmful depending on certain factors, like the age, dosage, and health of the patient [13]. In preventive measures, many times a dentist uses fluoride to reinforce the enamel, hence a controlled dosage is required to make the use of fluoride extremely beneficial (**Figure 1**).

It is observed that fluorosis generally appears symmetrically and can present itself in 3 ways i.e., white spots, brown spots or pitting. In milder cases, it presents itself as narrow white lines, following the perikymata, cuspal snow capping or snowflaking whereas, in severe cases the brown discoloration is apparent due to the infiltration of chromophoric proteins [3] (**Table 1**). In any case, WSL and fluorosis are two different entities and can be differentiated as follows [14]:

WSL:

- Occurs due to the hypomineralization of enamel.
- Surfaces appear translucent when the tooth surface is moist and, opaque white when the surface is air-dried.
- The surface of WSL is softer and rougher with easy dental plaque formation.

Fluorosis:

- Occurs due to hypomineralization because of excessive incorporation of fluoride during the formation of enamel.

- In the early phase, the surfaces have convergent horizontal white lines leading to a "Parchment-like" appearance along with irregular chalky areas. Then the colour changes to brown, due to the infiltration of exogenous chromophoric proteins.

- Histopathologically, fluorosis occurs on the sub-surface of the external third of enamel.

Figure 1.
Mild fluorosis.

Classification	Criteria—description of enamel (teeth not air-dried)
Normal	No evidence of fluorosis
Questionable	Enamel discloses slight aberrations from the translucency of normal enamel, ranging from a few white flecks to occasional white spots. This classification is utilised in those instances where a definite diagnosis is not warranted and a classification of 'normal' not justified
Very mild	Small, opaque, paper-white areas scattered irregularly over the tooth involving up to 25% of the tooth surface. Frequently included in this classification are teeth showing up to 1–2 mm of white opacity at the cusp tips of the premolars or second molars
Mild	More extensive white opaque areas in the enamel of the teeth involving up to 50% of the tooth surface (**Figure 1**)
Moderate	All enamel surfaces of the teeth are affected and are at risk of attrition. Brown stain is frequently a disfiguring feature
Severe	All enamel surfaces are affected and the hypoplasia affects the general form of the tooth. The major diagnostic sign of this classification is discrete or confluent pitting. Brown stains are widespread and teeth often present with a corroded-like appearance

Table 1.
Dean's fluorosis index [12].

2.2 Traumatic hypomineralization

It is not unusual to find white spot lesions due to trauma in the primary dentition stage. An incidence rate of 74.1% is seen [15] following which the succeeding tooth may be hypoplastic, or display discoloration (**Figure 2**).

Traumatic hypomineralization is usually asymmetric in presentation and involves a single tooth with unusual patches.

Physical trauma such as a break or fracture of the tooth or chemical trauma such as a periapical infection of the primary tooth can cause a severe periapical inflammation which disturbs and influences the underlying mineralisation of the tooth, resulting in accelerated deposition of minerals. These are commonly seen as punctiform lesions of the dental crowns or the incisal one thirds [16].

2.3 Demineralization

Enamel demineralization is a complication associated with poor hygiene during orthodontic treatment. When there is prolonged and excessive plaque accumulation, in the course of treatment, WSLs are seen along the appliance margins at various sites. 46–73% is the prevalence rate of demineralization following orthodontic treatment and this poses a grave challenge to the clinicians [17]. The subsurface demineralization is a predisposing factor to caries formation and is commonly seen around the bracket attachments and underneath the molar bands.

These areas are mostly noticed in orthodontic patients who are unable to adequately clean the tooth surface with the toothbrush which later appears as white spots. They are white chalky in appearance and unusually located (**Figure 3**).

2.4 Molar incisor hypomineralization (MIH)

Weerheijm et al. introduced the term molar-incisor hypomineralization (MIH) [18], wherein they defined it as a hypomineralization of systemic origin, which presented itself as a demarcated, qualitative defect of the enamel of 1–4 first permanent molars, frequently associated with enamel opacities. In these cases, due to the qualitative defects, the teeth exhibit post-eruptive breakdown of the enamel. This causes rapidly progressive caries and severe sensitivity of the teeth.

The causes of MIH are still not clear, it is thought that there is a systemic disruption of amelogenesis which includes, malnutrition, hypoxia, common childhood illness and use of antibiotics before the age of 3 years that causes this effect [16].

Figure 2.
Traumatic hypomineralization.

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Figure 3.
Demineralization with braces.

Clinically they are seen as white-creamy or yellow-brown opacities, usually larger than 1 mm and post-eruptive breakdown of at least one first permanent molar.

A history of illness in the first three years, difficulty during birthing, or prenatal illness helps with the diagnosis.

3. Diagnosis

3.1 Importance

The clinical manifestation of WSL starts as early as 4 weeks in case of orthodontic treatment. Unnoticed WSL can lead to the disintegration of enamel surface followed by carious lesion which may require aesthetic restorations or in more advanced cases a prosthodontic intervention. This is more commonly seen in high caries risk individuals. In people with low caries activity, the repair mechanisms help in the potential healing of the lesion.

Hence, it is important to plan the treatment according to the caries activity in individuals after a proper diagnosis. The emphasis given to new technologies has made it possible to detect initial lesions before they turn into irreversible cavitation [19].

3.2 Methods

The ideal method for the detection of WSLs should have a high level of sensitivity (the ability to detect disease when present) and specificity (the ability to confirm that disease is absent).

3.2.1 Conventional methods

The conventional methods of diagnosing WSLs are visual examination, tactile examination with probing and digital photographic examination. These methods are simple to use, inexpensive, and clinically valid.

3.2.1.1 Visual examination

For visual examination, the tooth surface must be air-dried for at least 5 s after cleaning with pumice under adequate light to visualise the WSLs. The opacities on the enamel surface will not be visible and the lesion cannot be distinguished the enamel gets wet. Because the micro pores in the surface are filled with water and the refractive index of enamel becomes 1.33, which is close to that of healthy enamel. On the other hand, after the air drying, the pores within the lesion will be filled with air, which has a refractive index of 1.0. Hence, the opaque enamel lesions become evident and distinct from the healthy enamel surface [20].

3.2.1.2 Photographic examination

The recommended specifications for taking intraoral images are 100 mm macro lens with a small aperture of 25. While taking a photograph the teeth should be inaccurate axial position i.e. the occlusal plane should be parallel to the horizontal plane. Although, these methods are useful in the detection, they do not quantify the depth of the lesions [21].

3.2.2 Contemporary methods

They are more consistent and enhanced sensitivity towards lesion diagnosis when compared to the conventional methods. This can be classified as:

3.2.2.1 Electric resistance (electronic conductance and impedance)

An intact enamel surface is a good electrical insulator due to its high inorganic content. Demineralization causes loss of minerals, resulting in increased porosities filled with saliva, this acts as a conductive pathway for electric current. The electric conductivity is directly proportional to the amount of demineralization [22].

E.g., Electrical Caries Monitor, Caries Meter L, CarieScan Pro.

3.2.2.2 Fluorescence

The autofluorescence of tooth tissue decreases as the demineralization activity increases .This could be attributed to protoporphyrin, a photosensitive pigment present in demineralized dental tissues that are generated due to bacterial metabolic activity [23].

E.g., Fibre-Optic Transillumination (FOTI), Digital imaging Fibre-Optic Transillumination (DIFOTI), Near-infrared digital imaging transillumination (NIDIT), Laser fluorescence (LF), Quantitative light-induced fluorescence (QLF), and Multiphoton imaging

3.2.2.2.1 Fibre-Optic Transillumination (FOTI)

The concept of transillumination for the detection of WSL is based on the refractive index of different tooth structures [23]. The refractive index will vary when light is passed through different tissues. The demineralized enamel appears as a grey hue

whereas dentin gives an orange-brown or a bluish hue. Due to the intra and inter-observer disparity, Digital imaging FOTI (DIFOTI) was developed in the 1990s. In DIFOTI the images are captured and stored by a CCD camera. Another advanced method is near-infrared digital imaging transil-lumination (NIDIT). In this technique two near-infrared laser diodes are used, which allows superior light to spread into the dental tissues and get better picture quality than visible light [23].

3.2.2.2.2 Laser fluorescence (LF)

LF uses a red wavelength of 655 nm for caries detection [23]. It is based on the principle when light is applied to the tooth surface, the caries-related changes in the tooth tissues lead to an increase in fluorescence. This can be translated into numeric values, which can vary from 0 to 99.

For example, in DIAGNOdent pen scores from 0 to 10 are interpreted as healthy, while scores above 30 indicate a lesion that requires restorative treatment [23].

3.2.2.2.3 Quantitative light-induced fluorescence (QLF)

It measures the percentage of fluorescence change in demineralized enamel. This technique allows us to detect the lesion activity as well as to predict the lesion progression. Since demineralized tissue has limited penetration of light, it gives a dark image in QLF [24].

3.2.2.2.4 Multiphoton imaging

Unlike conventional fluorescence imaging, it uses two infrared photons simul¬taneously to excite a fluorescent compound in the tooth. Caries will appear as a dark form within a bright fluorescing tooth. It also helps to collect information from carious lesions up to 500 μm of depth [25].

3.2.2.3 Thermography

The concept of thermography for the detection of early enamel caries has been discovered by Kaneko in 1999. It measures the lesion activity rather than its presence or absence. This is based on the principle of change in thermal radiation energy that occurs when fluid is lost from a lesion by evaporation just as in WSLs [25].

E.g., Infrared thermography, Frequency-domain infrared photothermal radiometry and modulated luminescence (PTR/LUM).

3.2.2.4 Terahertz imaging

Terahertz parametric imaging (TPI) has great potential in the diagnosis of WSL [25]. Terahertz radiation is located between the high-frequency microwave and long-wavelength infrared region of the spectrum. This helps identification of infected tissue inside the tooth followed by 3D plotting which can be applied to obtain the depth of the demineralized tissue. It can also be used to measure the remineralization of enamel [25].

3.2.2.5 Based on the optical behaviour

3.2.2.5.1 Midwest caries ID probe

It works on the principle of difference in the optical behaviour inside the tooth. The probe when placed on the tooth surface emits 635–880 nm wavelength and the light reflected from the surface of the tooth converts it to electrical signals [25].

3.2.2.5.2 Optical coherence tomography (OCT)

It is a novel, non-irradiative, non-invasive imaging technique. The concept of OCT is based on the differences in the optical absorption and scattering properties of the dental tissue. It uses infrared light to produce a real-time cross-sectional image of dental tissue. Demineralized tissue can be distinguished from sound tissue based on the following principles:

- Increased light scattering in porous demineralized tissue and
- Depolarization of incident light by demineralized tissue.

Enamel caries appear brighter on grayscale OCT images whereas dentin caries gives the image a continuous bright area throughout the enamel into the dentin [26].

3.3 Evaluation

Conventional methods: [21]

1. Visual examination: on visual examination, if the lesion is active or inactive can also be determined. If the tooth surfaces are chalky and rough, it indicates active lesions. If the tooth surfaces are smooth and shiny, it indicates inactive lesions. Different methods are used for evaluation on clinical examination. They include:

- Ekstrand assessment scale (1995)
- The Nyvad system (1999)
- The Dundee Selectable Threshold Method for Caries Diagnosis (DSTM in 2000)
- The International Caries Detection and Assessment System (ICDAS in 2004) [26].

The scores are given in **Table 2**.

2. Photographic examination: for the evaluation on photographic examination, frontal and lateral photos are taken and it's done using the Gorelick index. The scoring is done on the labial surfaces of incisors, cuspids and buccal surfaces of premolars. The inference is given in **Table 3**.

Contemporary methods [21]

1. Electrical conductance measurement (Caries meter L):

The tooth surface is inserted with conducting gel and is gently air-dried. Every tooth surface is dampened between the measurements to establish proper contact between the electrode and tooth surface. The device has colour codes to indicate the extent of caries as given in **Table 4**.

Ekstrand system	Nyvad system	DSTM system	ICDAS system
0—no/slight changes in enamel translucency after prolonged air dry (5 s)	0—healthy tooth	G—healthy tooth	0—sound
1—opacity/discoloration distinctly visible after air drying, hardly on wet surfaces	1—active (intact)	W—white spot lesion	1—first visual change in enamel
2—opacity/discoloration distinctly visible without air drying	2—active (surface discontinuity)	B—brown spot lesion	2—distinct visual change in enamel
3—localised enamel breakdown in opaque or discoloured enamel and/or greyish discoloration from the underlying dentine	3—active (cavitated)	E—enamel cavitation	3—localised enamel breakdown
4—cavitation in enamel exposing the dentine	4—inactive (intact)	D—dentine lesion (non-cavitated)	4—underlying dark shadow from dentine
	5—inactive (surface discontinuity)	C—dentine cavity	5—distinct cavity with visible dentine
	6—inactive (cavity)	P—pulp involvement	6—extensive distinct cavity with visible dentine
	7, 8, 9—presence or absence of caries which might be active or inactive in the filling or restorations	A—arrested dentinal decay F—filled surfaces contiguous with the upper types of lesions	

Table 2.
Different systems for evaluation on clinical examination.

Score	Inference
0	No lesion
1	Thin rims of white spot lesion
2	Thick bands of white spot lesion
3	Cavitation due to white spot lesion

Table 3.
Gorelick index scoring.

2. Quantitative light fluorescence (QLF):

According to Rodrigues et al. in 2011, there are two devices used in QLF. They are DIAGNOdent device and DIAGNOdent pen. The device consists of a laser diode, photo diode and a long pass filter [27]. A tip is placed on the tooth surface at a certain angle and fluorescence values are calculated as in **Table 5**.

3. Light-emitting diode fluorescence:

LED fluorescence is based on the principle of difference in optical property. There are two available systems: Midwest caries (MID) and Vista Proof (VP). MID probe is a small battery-operated device with a portable handpiece and a probe [27]. When the probe touches the demineralized tooth surface there is an audible signal with a colour change from green to red as given in **Table 6**.

4. Frequency-domain infrared photothermal radiometry and modulated luminescence (PTR/LUM) [21]:

A recent technology called the Canary system has been introduced in the year 2011. This system consists of a laser tip along with an intra-oral camera. The laser tip is placed on the tooth surface that has to be examined and the WSL is recorded based on the scoring from 0 to 100 on the digital display. The scores and inferences are given in **Table 7**.

Colour	**Inference**
Green	No caries
Yellow	Caries in enamel
Orange	Caries in dentine
Red	Caries reaching pulp

Table 4.
Colour codes and inference of caries meter L.

Readings	**Inference**
0–14	Absence of caries
15–20	Caries present in enamel
21–99	Caries present in dentine

Table 5.
Scoring of DIAGNOdent device.

Score	**Inference**
0	Green light without any signal indicates healthy tooth
1	Red light with medium signal indicates enamel caries
2	Red light with rapid signal indicates dentinal caries

Table 6.
Scoring of Midwest caries device (LED fluorescence).

Score	Inference
0–20	Healthy tooth
21–70	Demineralization and caries
71–100	Advanced caries

Table 7.
Scores and inference of PTR/LUM.

4. Remineralization and white spot lesions

The pathophysiology of dental caries is a continuous process of demineralization and remineralization wherein a net mineral gain is required to prevent lesion progression. To achieve this, the balance between the pathological factors such as fermentable carbohydrate ingestion, salivary function inhibition, acidogenic bacteria and protective factors like antibacterial agents, composition and rate of flow of saliva, fluoride and diet needs to be maintained [28]. Fermentation of carbohydrates leads to formation of organic acid by acidogenic bacteria that cause diffusion of calcium and phosphate ions out of the tooth leading to the formation of white spot lesions at an early stage, which further progresses to cavitation if the process continues [5]. This can be prevented by remineralization or mineral gain which is defined as the process whereby calcium and phosphate ions are supplied from a source external to the tooth to promote ion deposition into crystal voids in demineralized enamel [29].

Saliva is the major source of these minerals consists of calcium (Ca), phosphate (P), fluoride (Fl) ions in addition to salivary proteins such as proline-rich proteins, statherin, histatins which increases the concentration of calcium ions and salivary enzymes such as lysozymes and peroxidases. Normally the saliva is supersaturated with calcium and phosphate ions but when the pH decreases (<5.5) due to the fermentation of carbohydrates, as mentioned above, this equilibrium is lost and demineralization starts. To prevent this, saliva acts as a remineralizing agent by providing Fl ions to regain homeostasis and thereby acts by preventing demineralization, promoting remineralization and having an antibacterial effect. Therefore, a variety of treatment modalities are available to treat initial carious lesions also known as white spot lesions based on the above theory, which will be discussed in the upcoming treatment modalities [30].

5. Treatment

5.1 Various methods of treatment

There are various treatment options available to treat WSLs depending on their extent and severity [31] (**Table 8**).

5.1.1 Micro-abrasion

Micro-abrasion is the application of an acidic and abrasive compound to the surface of the enamel. The micro abrasion process removes small amounts of surface enamel but also leaves a highly polished enamel surface. The micro-abraded enamel surface does not have the ideal enamel surface appearance as interprismatic spaces would be absent.

White spot lesion	Presentation	Treatment options
Fluorosis	Can vary from symmetrical lesions, presence of white lines, 'snowflake appearance', to pitting and mottling in severe cases	• Whitening • Micro-abrasion • Resin infiltration • Restorations
Traumatic hypomineralisation	Presents as a punctiform lesion on the incisal 3rd of the crown, usually asymmetrical	• Whitening • Resin infiltration • Restorations
MIH	Condition where there is hypomineralised permanent first molars along with or without the incisors, presenting yellowing of the teeth, mottling and post eruptive breakdown of molars	• Chemical remineralisation • Micro-abrasion • Whitening with/without CPP-ACP • Restorations • Extraction
Demineralisation	Presents as faint white lesions around the orthodontic brackets	• Chemical remineralisation • Whitening • Resin infiltration • Micro-abrasion
WSL (natural)	Presents itself as isolated white spots with a diameter less than 0.5 mm on the incisors	• Whitening

Table 8.
Various WSLs and their treatment options.

The micro-abrasion process abrades surface enamel while compacting calcium and phosphate into the interprismatic spaces. This polished surface reflects light differently than natural enamel. Therefore, a portion of the whitened enamel is removed and a portion is camouflaged by the highly polished surface.

Following this procedure, a 4-min 2% sodium fluoride treatment is recommended. If the micro-abrasion technique does not produce optimal aesthetic results, and if the whitened enamel is still prominent, vital tooth bleaching should be considered [32].

5.1.2 Whitening

Also known as vital tooth bleaching or bleaching. It is the process of lightening the colour of enamel. To date, there are two techniques of tooth whitening that have been prescribed:

a. Ambulatory—that requires an intraoral device/tray to apply a gel of peroxide, which can be done at home and is more cost-effective. It must be kept in mind that major changes are not observed before the 7th day.

b. In-office method, which requires a professional to perform the procedure, uses photoactivation, where the changes of colour in the enamel can be witnessed from the first session [33].

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5.1.3 Resin infiltration

Also known as an ICON (infiltration concept) was designed as a minimally invasive resin infiltration system for treating incipient caries in patients of all ages. The low viscosity unfilled resin, developed by the company DMG (Germany) camouflages white spots using optical manipulation, and no tooth tissue removal is strictly necessary (**Figure 4**).

The clear resin flows into the demineralized enamel, and has similar optical properties (similar refractive index) to the enamel, therefore reflecting light to match the tooth's natural shade [34, 35].

5.1.4 Chemical remineralization

CPP-ACP (Casein Phosphopeptide-Amorphous Calcium Phosphate) also known as the stabilised ACP, was developed based on the idea that CPP being saliva biomimetic solubilises the nano complexes readily, and creates a diffusion gradient that allows them to localise in supragingival plaque [36].

Low pH conditions that arise during a cariogenic attack, facilitate the release of Ca and P ions, inhibiting demineralization and favours the remineralization of the incipient lesions by precipitation of the released ions. This subsurface remineralization pattern produced by CPP-ACP has shown significant improvement in the aesthetics, and strength of the remineralized white spot lesion [29]. Some of the commercially available products are GC tooth mousse, flouride varnish, nanohydroxyapatite system and bioactive glass.

5.1.5 Restorations

Dental restorations also known as dental fillings are treatments used to restore the function, integrity and morphology of the missing tooth structure. Dental restorations include glass ionomer cement, composites (light-cured, chemically cured or dual-cure), giomers, compomers and veneers.

Restorations are done in cases where aesthetics is of major concern and when there are lesser chances of reversing the damage. Restorations are also considered as a permanent solution [37].

Figure 4.
ICON treatment: pre and post treatment.

6. Prevention

Without a doubt, enamel decalcification/demineralization is a major clinical problem. Once the lesions are established, it is hard to achieve complete remineralization. Fluoride is a major ingredient that is cariostatic and is capable of arresting the lesion. Hence judicious use of fluoridated toothpastes and mouthwashes are advocated. Newer agents like CPP-ACP, hydroxyapatite systems, bioactive glasses are also being experimented [2]. Optimal oral hygiene is necessary to evade white spot lesions. Regular dental visits and the use of oral prophylactic aids are not negotiable. Patients undergoing fixed orthodontic treatment are required to maintain their oral hygiene and use oral hygiene products that would help in remineralizing the demineralized enamel.

7. Conclusion

Prevention of enamel demineralization is of utmost importance. Should enamel demineralization occur (white spot lesions), early diagnosis and intervention are appropriate. Improved brushing with fluoridated dentifrice and over-the-counter fluoride rinses would be the first recommended intervention.

Patients may also develop demineralized enamel during orthodontic treatment, which exhibits itself as white spot lesions adjacent to brackets and the free gingival margin area. As previously discussed, topical fluoride therapy is appropriate to be sure remineralization of enamel has occurred. Mild whitened enamel can often be camouflaged by bleaching with standard tray-based whitening systems used overnight or with the hydrogen peroxide-impregnated polyethylene strips. If 2 to 4-week bleaching with these regimens is ineffective at camouflaging this whitened enamel, microabrasion followed by bleaching is recommended.

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