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# A Current Review Of White Spot Lesions In Individuals Seeking Orthodontic Therapy

Dr. I Girish Kumar[1], Dr. N Raghunath[2], Dr. Jyothikiran H[3], Dr. Nidharshana S Nair[4]

Assistant Professor[1], Head & Professor[2], Professor[3], Post Graduate[4]

Department of Orthodontics and Dentofacial Orthopedics, JSS Dental College & Hospital, JSSAHER, Mysore

**Abstract**

Since the purpose of orthodontic therapy is to improve facial and dental aesthetic appearance, decalcification of enamel, which manifests as white spot lesions (WSLs), surrounding fixed orthodontic appliances is a significant issue both during and after fixed orthodontic treatment. Because the areas around orthodontic attachments are harder to clean and more likely to accumulate plaque, it raises the chance of developing white spot lesions. Therefore, applying suitable methods for preventing these lesions during orthodontic treatment and performing appropriate therapies after orthodontic treatment is important for obtaining favorable results and patient satisfaction. Oral hygiene motivation, usage of topical fluoride agents, casein phosphopeptide-more calcium phosphate agents, antimicrobial agents, tooth bleaching, microabrasion, and resin infiltration are current techniques that clinicians can use for the prevention and treatment of white enamel lesions. This review article's goal is to investigate the causes, prevalence, and classification of white spot lesions through preventative and therapeutic measures to manage enamel demineralization.

**Key Words:** White Spot Lesions (WSL), Decalcification of enamel, Fixed Orthodontic treatment, Demineralization

## Introduction

Orthodontists are particularly concerned when white spot lesion (WSL) formation occurs around the orthodontic bracket periphery because it can cause problems with maintaining good oral hygiene, plaque retention around the brackets, and enamel demineralization[1]. White spot lesions (WSL) appear as small lines around the brackets; in some patients, they are visible as large decalcified areas with or without cavitation. Detection of WSLs after the removal of orthodontic appliances is discouraging[2]. WSL is characterized by demineralization or decalcification of the enamel, which, if left untreated, can lead to various cavitation and aesthetic issues. After approximately 6–12 months of orthodontic treatment, the prevalence of WSL among orthodontic patients often increases. WSL is specifically found on the buccal surfaces of the enamel in the gingival areas located around the brackets. Because it may jeopardize a patient's smile following orthodontic treatment, accurate WSL diagnosis and prevention can therefore help reduce and prevent demineralization[3]. This article assesses the current approaches to managing enamel demineralization resulting from orthodontic therapy, along with the risk factors and preventive treatments involved. It also covers the frequency, distribution, and initiation of WSL during and after orthodontic treatment.

**Prevalence of White Spot Lesions and Risk Factors**

Clinically, if poor oral hygiene is present, WSLs may show in the fourth week following therapy initiation and may develop quickly[4]. These decalcifications have been reported to be more common in patients undergoing fixed orthodontic treatment. However, data from various epidemiological studies has shown that their frequency varies greatly, ranging from 2 percent to 97 percent[5]. This variability may be explained by the methods used to identify and characterize them, such as visual inspection, photos, fluorescent methods, and optical modalities like diagnodent, quantitative light-induced fluorescence, and digital image fiber-optic transillumination[6]. Quantitative laser methods produce a higher prevalence rate than the basic visual method because they are more sensitive. Before orthodontic treatment, 15.5 percent -40 percent of patients and 30 percent - 70 percent of patients had such decalcifications on average[7]. A recent meta-analysis found that among the 14 studies analyzed for WSLs, 45.8% of new carious lesions occurred after orthodontic therapy and 68.4% of patients receiving orthodontic treatment had this incidence rate. It was determined that in patients undergoing orthodontic treatment, the incidence and prevalence rates of WSLs are extremely high and concerning, requiring patients and caregivers to pay close attention to caries prevention strategies that are effective[8]. In addition to poor oral hygiene, excessive drinking, frequent use of fermentable carbohydrates, excessive bonding, extended etching times (>15 s), decayed/treated molars, and the length of treatment, other risk factors for the formation of new lesions include WSLs before orthodontic treatment. [9] Three new lesions in 22 months and at least five injuries in 33 months of treatment were documented by Richter et al.[10]

**Etiology**

***a. Environmental Factors***

The uneven shapes of fixed orthodontic equipment inhibit saliva, lips, tongue, and cheeks' ability to self-clean. They also raise the challenge of maintaining good oral hygiene by providing more surface area for plaque adherence. On tooth surfaces that are normally not susceptible to carious attack, these barriers may raise the risk of incipient caries. The lower rate of WSL in orthodontic patients who receive lingual appliances, where the saliva and tongue may better self-clean the tooth surfaces next to the fixed appliances, is a good example of this phenomenon.[11]

***b. Host Factors***

Not all individuals display the same caries risk. Caries progression is a dynamic process that is the result of an imbalance in the natural enamel demineralization/ remineralization cycle. Enamel lesions can progress from initial demineralization to non-cavitated carious lesions, to cavitated lesions. One of the most clinically significant factors of WSL is the potential for rapid formation, with clinically visible lesions developing in as little as 4 weeks. Individual caries risk is multifactorial. It can be puzzling to see a patient with oral hygiene that appears to be acceptable still develop WSL, whereas one who has extremely poor hygiene may develop none. Important drivers of overall caries risk are individual host characteristics, including salivary flow and composition, enamel solubility, immunological response, genetic susceptibility, nutrition, and medication history.[12]

### c. *Cariogenic Bacteria*

It has long been known that acidogenic bacteria are the main causes of dental caries. Particularly, the main microbiological organisms involved in the caries process are Lactobacilli and Streptococcus mutans. Dental biofilms contain a dynamic mix of bacterial species and populations. The dynamic character of the caries process requires a closer examination of the role that pH plays in the ecological shift in dental biofilms. Nonmutant streptococci make up the majority of the microflora on healthy enamel, and the biofilm seldom and mildly becomes acidified. However regular contact with fermentable carbohydrates causes the biofilm to acidify more frequently and intensely. Consequently, the biofilm undergoes adaptive and selective change, favoring more acidogenic and aciduric strains of microflora (Fig 1). The demineralization/remineralization cycle shifts in the direction of a net mineral loss as a result of this negative change in the biofilm. Research has shown that patients with orthodontic treatment have higher levels of cariogenic bacteria in their plaque than patients without orthodontic treatment, which causes caries to progress more quickly in orthodontic patients than in patients without permanent appliances.[13]

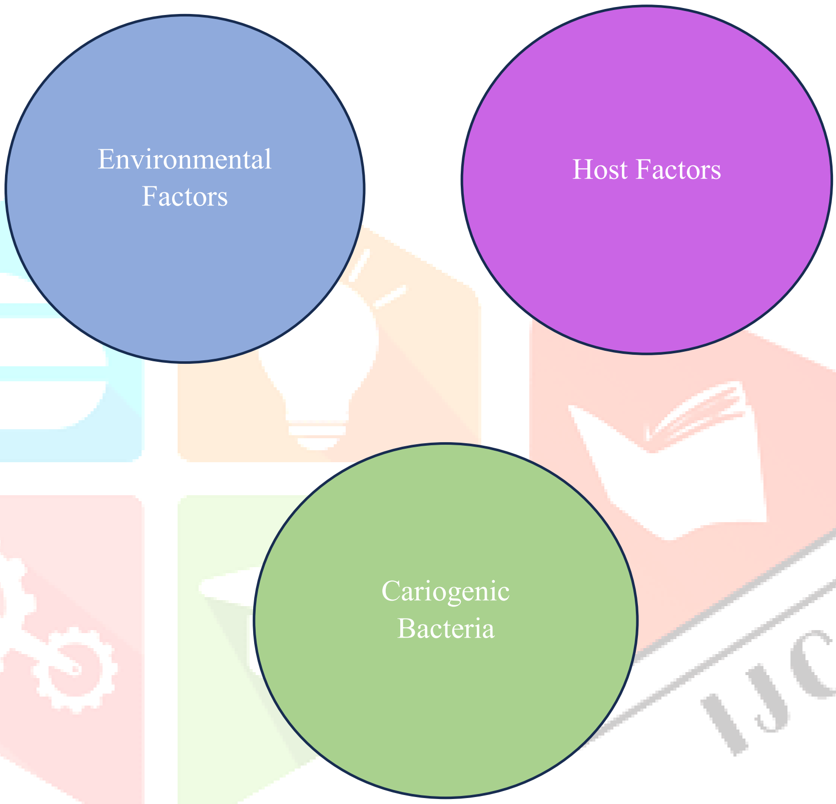


**Figure 1:** Etiological factors that lead to white spot lesions (WSL)

**Classification of white spot lesions**

I. In the field of orthodontics, white-spot lesions were initially categorized based on their visual dimensions.[14] The following was the classification based on the width of opacity that developed on the enamel surface:

- Class 0: Opacity of 0 or less than 1 mm
- 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

II. Another classification made by Gorelick, et al.[15] which considers both the size and intensity of lesions 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

III. International Caries Detection & Assessment System (ICDAS) classification, which is created by combining the most successful features of all detection and evaluation systems used in the detection of caries by Ekstrand et al.[16] In ICDAS II, radiographic images of enamel and dentin lesions are also included in the classification. It is divided into five classes as follows:

- E1: Lesion that reaches the outer half of the enamel
- E2: Lesion that has advanced to the inner half of the enamel
- D1: Lesion that is limited to the outer one-third of the dentin
- D2: Lesion that has advanced to the middle third of the dentin
- D3: Lesion that has advanced to the inner one-third of the dentin

**Diagnosis of White spot lesions (WSL)**

***Visual Examination***

Visual examination is the most common diagnostic technique used by dentists in their daily work. A visual assessment of white spot lesions can reveal whether a lesion is active or inert. Smooth and shiny surfaces are suggestive of an inactive lesion, but chalky and rough surfaces show that the lesion is active.[17] After cleaning with pumice, the tooth surface needs to be dried with air for at least five seconds before being visually checked with a light and mirror. When examining white dots visually, light is crucial. The enamel tissue seems translucent because the refractive index of 1.62 indicates that the pores on the solid enamel are micro-scale(Fig 2). This refractive index, however, decreases as a result of the ongoing demineralization-induced rise in micro-porosity. These pores fill with 1.33 refractive index water when the enamel surface becomes moist. Water's refractive index is very similar to that of healthy enamel, therefore the lesion cannot be identified or its opacity seen on the enamel surface. On the other hand, once the lesion's pores fill with air, which has a refractive index of 1.0, the opaque enamel lesions become visible and distinguishable from the healthy enamel surface following the air-drying process. This

**Figure 2:** White spot Lesions spotted on the surface of the tooth after debonding of orthodontic brackets

method's main drawback is that it is difficult to standardize, despite its benefits of being affordable, easy to use, and clinically valid.[18]

### *Assessment with Digital Photography*

The conventional visual inspection does not provide a physical/numerical record of the teeth examined. Using a method for remote discussions, such as photography, could substantially improve dental education and case discussion. One would be able to discuss clinical situations at a distance by sharing the examination results with professionals based at different locations. Health services are gradually adopting this concept in telemedicine and teledentistry initiatives, with encouraging results, especially in educational and diagnostic applications.[19] Digital dental photography is a field that requires technical sensitivity and education, considering the dark, small, and moist mouth environment as well as the interaction of soft and hard tissues with light. Along with the training, it is recommended to use a light system, such as lateral twin flash or ring flash, and a camera that allows macro lens and lens replacement. The disadvantages of this equipment are that they are big and heavy and their cost is high. However, these disadvantages can be eliminated, thanks to the camera and photo-shooting features of smartphones, which have become very popular today.[20]

### *Fluorescence Techniques*

The autofluorescence feature of the enamel decreases because of demineralization. These optical changes are directly related to the mineral content of the enamel. Therefore, the autofluorescence principle is used in early caries diagnosis to show mineral loss. Clinically, the brands that use the fluorescence feature are DIAGNOdent and quantitative light-induced fluorescence (QLF).

- ***Quantitative light-induced fluorescence (QLF)***

In general, carious lesions allow light to propagate far more quickly than healthy tooth tissues. As a result, there is less light absorption and fluorescence near carious lesions. Measures of light emission can thus be used to assess the depletion of minerals. The QLF approach utilizes the fluorescence principle. Therametric Technologies, Inc., Noblesville, IN, USA has released FluoreCam, a portable gadget that uses the QLF concept and is easy to use and carry. Using specialized software, it stimulates the tooth surface with bright light and evaluates the fluorescence image that results. Three numerical statistics, representing the size, density, and impact of the demineralized enamel lesion, emerge from the evaluation. It is simpler to use since, unlike QLF devices, there is no need for a darkroom during measurement.[22]

- ***Laser Fluorescence***

The DIAGNOdent pen has been developed for early diagnosis of carious lesions on occlusal and flat surfaces of teeth. This device emits a visible light of 638–655 nm wavelength using a diode laser, which is absorbed by organic and inorganic substances in the tooth structure, thereby the structures creating infrared fluorescence photons. A photodiode that displays scores ranging from 0 to 99 displays the filtered fluorescence signals, which are acquired via a separate fiber bundle at the same tip that generates the light. The depth of the lesion is directly correlated with the density of the recovered photons. There are various lesions present when the score is between 20 and 25. Greater values correspond to deeper caries penetration. The laser fluorescence method was effective in detecting the first demineralization in enamel, it was not effective in monitoring the progress of the lesion and was found insufficient to measure small changes in the mineral content. To improve this situation, the idea of examining the initial enamel lesion with laser fluorescence method after dying the lesion with a fluorescent dye was born and found successful.[23]

### *Electronic Caries Monitor (ECM)*

The foundation of ECM is the electrical resistance of the tooth structure measured under controlled drying conditions. The porosity of the measured tooth region, the volume of fluid in the porous area, temperature, the fluid's movement in the porous area, and the concentration of ions all affect a tooth's electrical resistance value. Measurements in the range of 1 kW to >10 GW are possible with the ECM. According to reports, proximal and flat surfaces are more conducive to effective ECM than occlusal surfaces.[24]

***CarieScan PRO***

Rather than using a single frequency as in ECM, the CarieScan PRO alternating current impedance spectroscopy approach uses many frequencies. The functioning principle stems from the observation that tooth tissues, both healthy and diseased, react differently to resistance testing at various frequencies. However, in a recent study, the CarieScan's sensitivity values were the lowest when measured against the SoproLife camera, DIAGNOdent pen, and ocular inspection.[25]

***Fiber optic transillumination–digital fiber optic transillumination (FOTI–DIFOTI)***

The light transmission coefficient of caries differs from that of healthy teeth structures. During demineralization, which disrupts the dense hydroxyapatite content of the enamel, light photons scatter while trying to pass through the tooth and an optical distortion occurs. Since the light transmission coefficient of the intact enamel is higher than that of carious lesions, dark shadows are observed along the dentinal tubules when the carious tissues are examined with a fiber optic device. Initial caries lesions can be distinguished according to the intensity of the shadows formed by the light power of the device.

DIFOTI is a caries diagnosis technique that makes up for FOTI's shortcomings by combining it with a digital camera. This technology uses infrared radiation with a wavelength of around 780 nm in place of a white light source. Because this new diagnostic technique is non-invasive, uses no ionizing radiation, and is more sensitive than radiography in identifying early demineralization, it offers hope for the identification of beginning caries and the assessment of lesion severity.[26]

***Near-infrared light transillumination (NILT)***

To identify caries in posterior teeth, a photo-optical, X-ray-free technique known as near-infrared light transillumination (NILT) was introduced. This approach yields a high contrast between carious lesions and sound tissue. A 780 nm wavelength light emitting NILT camera system called DIAGNOcam was released onto the market in 2012. Light is sent by the optical fiber arms of this apparatus from the gingival and alveolar bones to the tooth's root and ultimately to the crown. Next, an image is produced from the occlusal surface using a charge-coupled device sensor. According to a recent study, when compared to alternative approaches, the DIAGNOcam system accurately detected hidden developing enamel and dentin cavities in primary and permanent teeth.[27]

**Risk Assessment**

A risk evaluation should be completed before appliance placement, and patients should be categorized as either high-risk or low-risk. No one method works for all situations when determining risk because WSL is multifaceted. (Table 1). The risk group is established by the authors' method, which is predicated on the identification of risk and protective factors. A patient will be categorized as high-risk if they exhibit two or more characteristics of the high-risk group. Patients who experience a WSL during treatment will be immediately categorized as high-risk. [28]

| Low Risk | High risk |
|---|---|
| No previous WSL | Existing WSL |
| Good oral hygiene | Poor oral hygiene |
| Low dietary sugar exposure | High dietary sugar exposure |
| Short treatment time | Long treatment time |
| Controlled etching | Excessive etching |
| Lingual appliances | Labial appliances |
| No/minimal DMFT | High DMFT score |
| No intra-treatment lesions | Intra-treatment lesions |

**Table 1:** Risk evaluation is categorized by low-risk and high-risk

**Prevention and Treatment Methods**

***Remineralization of White Spot Lesions***

By reducing dental caries and lengthening the period of protective substances in the mouth, the physiological cycle can be shifted in the direction of remineralization. Remineralization is often a natural healing process, while numerous techniques have been used to enhance it.

***Providing Oral Hygiene***

Tooth caries is a serious issue that impacts not just the individual but also the health economy, social institutions, and institutions. A large issue like this also comes with a large price tag, so nations are searching for community-level solutions that are affordable. One way to address dental caries is to become more conscious of personal oral hygiene practices, such as cleaning your teeth twice a day with fluoride toothpaste. Encouraging patients to practice proper oral hygiene by brushing and flossing their teeth is the most efficient way to modify the composition of bacteria in plaque and, in turn, alter the creation of white spot lesions.[29]

***Regulation of the Diet***

In addition to the existence of bacterial plaque, food also plays a role in the development of caries. Not only do dietary foods prevent cavities from forming, but they are also one of the factors that lead to caries. Certain foods, such as those with tough, fibrous components, can aid in mechanical cleaning, while other foods have an anti-caries effect by increasing salivary flow and volume through flavor and aroma. Calcium, chocolate, tea, and proteins like milk and cheese alter the metabolism of cariogenic bacteria, which has a bacteriostatic impact. On the other hand, frequent consumption of fermented carbohydrates may lead to dental cavities.[30]

***Use of Antimicrobial Agents***

Chlorhexidine was released to the public for the first time in the USA in the form of 0.12% mouthwash for periodontal treatments of patients who belonged to a high-risk group. It reduces Streptococcus mutans count and accelerates remineralization. It is recommended to use chlorhexidine mouthwash for 30 seconds just before bedtime because the reduced saliva flow rate at night helps in attaching chlorhexidine more easily to the structures inside the mouth. When chlorhexidine mouthwash is used in this way for 2 weeks, it reduces the number of Streptococcus mutans below the level potential for caries formation, and the effect of this decrease lasts between 12 and 26 weeks (6).

***Fluoride Applications***

There are three distinct ways that fluoride works to prevent dental cavities. First, fluoride significantly boosts the synthesis and build-up of fluorapatite, which is created in saliva by the reaction of phosphate and calcium ions. Because fluorapatite is soluble, it can replace carbonate and manganese-containing salts, which dissolve readily and are lost to demineralization. Fluorapatite also strengthens enamel's resistance to acids. The remineralization of the original cavity lesion with the fluorapatite crystals is the second mechanism. Fluoride ions' antibacterial action is the final and third mechanism. The glycosyltransferase enzyme cannot be produced in low fluoride concentrations. The enzyme glycosyltransferase promotes bacterial adherence and supplies glucose for the production of extracellular polysaccharides. Topical fluoride applications directly harm oral bacteria, such as mutans streptococci, at high concentrations (12,000 ppm). Applications of fluoride are divided into topical and systemic categories.[31]

***Systemic Applications***

Systemic applications are useful techniques, particularly for people who are at a high risk of developing dental cavities and for populations with minimal fluoride utilization. Water fluoridation is one systemic application that exhibits both systemic and topical effects. According to the World Health Organization (WHO), taking one milligram of fluoride daily is good for your health. Fluoridating drinking water, salts, and milk as well as adding fluorinated tablets or drops to food are examples of systemic applications of fluoride.[31]

***Topical Applications***

It was long believed that systemic fluoride consumption was beneficial before the direct tooth application phase. Today, it is acknowledged that topical fluoride therapy is more advantageous for teeth that are still developing and maturing. When topical fluoride is given professionally in dental clinics at high doses (12,000 ppm), it directly kills mouth bacteria like Streptococcus mutans (6). Fluoride varnishes were created to extend the time of contact, strengthen the binding with the enamel, and delay the rapid loss of fluoride following application. Varnishes act as a reservoir for gradual release, promoting increased absorption of fluoride.[32]

***Bleaching Applications***

White spot lesions on tooth structure may become less noticeable due to a camouflage effect caused by bleaching the tooth structure surrounding the lesion. It is important to keep in mind that bleaching does not cure the lesion; rather, it merely enhances the aesthetic aspect of WSL by creating a camouflage effect. According to a recent comprehensive analysis, bleaching WSL can reduce color differences between carious and unaffected areas, but the researchers also noted that there was little assurance in the results and that more prospective in vivo trials are required.[33]

***Laser Applications***

Through the process of recrystallization of hydroxyapatite crystals, modification of the organic matrix composition, and differentiation of the surface structure and physical properties of the enamel, laser treatment modifies the tooth surface and increases the tooth structure's resistance to dissolution during demineralization. In comparison to no treatment and fluoride treatment alone, Alqahtani et al. demonstrated that diode laser irradiation plus topical fluoride application greatly raised the hardness and improved the aesthetic appearance of WSLs.[34] Molaasadollah et al., on the other hand, found that applying 1.23 percent acidulated phosphate fluoride gel in addition to Er, Cr: YSGG laser irradiation did not significantly alter the remineralization of WSLs when compared to applying fluoride gel alone. The varied kinds of lasers employed in these two investigations could be the reason for the differences between them.[35]

***Casein phosphopeptide–amorphous calcium phosphate (CPP–ACP) applications***

ACP is a tricalcium phosphate that has an amorphous form and contains calcium and phosphate ions. ACP rapidly transforms into a stable structure, like apatite or octacalcium phosphate, when it comes into contact with a solution. Eighty percent of the proteins in cow's milk are made up of the phosphoprotein casein. The most crucial function of casein is to retain phosphate and calcium ions inside protein complexes. These ions are very persistent because they break down into smaller peptides like CPP. Casein molecules serve as a transporter of calcium and phosphate ions, which the tissues—such as teeth and bones—can employ to remineralize. According to Mendes et al using CPP–ACP was an effective substitute for remineralizing lesions with white spots. When used in conjunction with fluoride, this substance can enhance the remineralization process. Studies have demonstrated that, while treatments like fluorides and CPP–ACP can effectively halt the advancement of dental caries, they are insufficient to significantly enhance tooth appearance, as per the ICDAS.[36]

***Ozone***

According to reports, applying ozone can lower the numbers of Streptococcus mutans and Streptococcus sobrinus on glass beads covered with saliva. Nevertheless, the outside half of enamel lesions are the only areas where this therapeutic approach may eradicate the microbes and halt the demineralization process. Before the use of ozone can be regarded as a feasible substitute for the present approaches for the management and treatment of dental caries, additional data, and pertinent research are required, according to a newly revised systematic review.[37]

***Resin Infiltration***

It is well known from histological investigations that the microporosity of early enamel lesions grows in various layers. These expanded intercrystalline regions and porous apertures serve as pathways and sites of propagation for dissolved minerals and acids. This evidence suggests that the idea of filling the porous structure with low-viscosity resins will not only minimize the micropore structure but also mechanically maintain the enamel tissue, in place of entirely eradicating the first carious lesions as in usual procedures.[38]

***Microabrasion Applications***

In addition to the porous enamel layer, stains clinging to these places are removed in the microabrasion technique by applying an acid and abrasive particle mixture to the tooth surface with a rubber cap under low pressure, which is comparable to the pumice and water mixture used during polishing. Using this technique, the damaged or discolored enamel tissue is removed by combining the erosive and abrasive acid particles. In this case, microabrasion is a minimally invasive therapeutic method rather than non-invasive. According to Gu et al, microabrasion enhanced the WSLs' aesthetic appeal and demonstrated adequate durability over 12 months. After a year, resin infiltration outperformed microabrasion in terms of aesthetic improvement.[39]

**Conclusion**

Before the development of irreparable cavitations, carious lesions must be identified and treated. Caries progression can be identified and stopped in white spot lesions. Using minimally invasive procedures is the best course of action for treatment, as the histological structure of these lesions is investigated and comprehended. With the appropriate application, caries progression in certain lesions can be stopped and even reversed. Numerous techniques have been put forth to identify and manage these lesions. As was previously noted, less invasive techniques ought to be used for treating white spot lesions. These and other factors prompted the quest for novel methods and materials. These investigations led to the introduction of remineralization techniques using CPP–ACP and fluoride, microabrasion techniques, and most recently, resin penetration techniques. When treating these lesions, the best course of action should be determined by the specific circumstances. The appropriate treatment, or combination of treatments, should be selected after taking the lesion's depth, creation period, and etiology into account.

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