Chapter

Preventive Methods and Treatments of White Spot Lesions in Orthodontics

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Abstract

The aim of orthodontic treatment is to improve the esthetics of the teeth and face, to provide a beautiful smile, and an adequate and permanent chewing function. In individuals with insufficient oral hygiene, demineralization begins in the mouth with a very low pH value, and as a result, white spot lesions formed by decalcification of the enamel layer can be seen during orthodontic treatment. Since lesions are the first stage of caries formation, it is possible to stop caries development at this stage. Many methods, such as improving oral hygiene, regulating diets, fluoridated agents, laser, casein phosphopeptide, and microabrasion, are used in the treatment of white spot lesions. Preventive methods are of great importance in terms of preventing future tooth loss and reducing the treatment process. The purpose of this article is to manage white spot lesions in orthodontic treatment and to examine risk factors and preventive methods based on the latest evidence.

Keywords: white spot lesion, orthodontic treatment, conservative methods, demineralization

1. Introduction

The improvement of modern living conditions, the increase in life expectancy, and the propensity of looking younger and more beautiful have led to an increase in the need for esthetic treatments. Thanks to the orthodontic treatment, as long as the periodontal tissues are healthy, an esthetic smile can be served in all age groups of individuals. Regarding the esthetic involvement in the orthodontic practice as well as the treatment outcomes metallic colored brackets, tooth-colored brackets, lingual brackets, and aligner treatments have been performed in the clinical practice. Attachments and appliances used in the treatment create an area for plaque involvement at various levels.

Enamel discoloration and initial caries lesions are the most prominent clinical problems in patients undergoing orthodontic treatment. As a result of the decrease in the oral pH value, the diffusion of calcium and phosphate ions from the enamel becomes easier and a color change occurs on the enamel surface as a result of decalcification. Irregular surfaces of brackets, wires, bands, and other attachments limit naturally occurring self-cleaning mechanisms, such as the movement of saliva and its intraoral muscles. Increased incidence of these lesions has been found in patients after orthodontic treatment due to long-term plaque accumulation and inadequate

oral hygiene [1]. In order to prevent the formation of white spot lesions that cause both demineralization and discoloration of the teeth, and to prevent their progression by treating them at an early stage, it is recommended to take the necessary precautions before and during the treatment and to choose the appropriate diagnostic methods and apply the necessary treatment methods [2].

2. Etiology of demineralization

2.1 Oral hygiene

The presence of orthodontic attachments in the mouth paves the way for plaque formation on the tooth surface and makes tooth cleaning more difficult [3]. The plaque develops as a result of bacterial infection, modified from dietary carbohydrates and saliva. In the presence of carbohydrates, demineralization begins when the pH of the mouth drops below 5.5 and creates white spot lesions. *Streptococcus mutans* and lactobacilli bacteria are mainly effective in colonization and also caries development [4]. The plaque on the tooth surfaces prevents the remineralization of the enamel layer with calcium and phosphate ions. In addition, it facilitates the production of acid from the sugar taken with food. It is observed that the amount of decalcification is also higher in the brackets and near the gingiva, where plaque accumulation is greater in orthodontic patients [5].

2.2 Diet

It has been stated that frequent consumption of carbohydrate-rich, sugary foods and beverages facilitates the formation of caries. During 20 minutes following sugar intake, the pH of the plaque drops below the critical level of 5.5°. In addition, another factor is the difficulty in removing food residues from the teeth due to orthodontic attachments [6].

2.3 Appliance type and design

The larger the area covered by orthodontic attachments on the enamel surface, the more difficult it is to clean the remaining tooth surface. Archwire design also affects the accumulation of plaque and food debris [7].

In a study evaluating the difference in white spot lesion (WSL) formation between conventional bracket treatments and aligner treatments, it was reported that approximately 1.2% of aligner patients developed WSL compared to 26% of conventionally treated patients. The number of developing WSL is also significantly ($P < 0.001$) less in aligner patients. In patients treated with conventional braces, moderate or poor pretreatment oral hygiene, worsening of hygiene during treatment, preexisting WSL, and longer duration of treatment ($P < 0.05$) significantly increased the risk of developing WSL during the treatment [8].

In a randomized prospective controlled study, aligner and conventional bracket treatments were compared with quantitative light-induced fluorescence. According to the results, WSL formation was observed in both treatments. In aligner treatments, the lesions are shallower and cover a larger area. Traditional braces had deeper lesions, but their area was smaller. Plaque accumulation is also greater with conventional brackets [9].

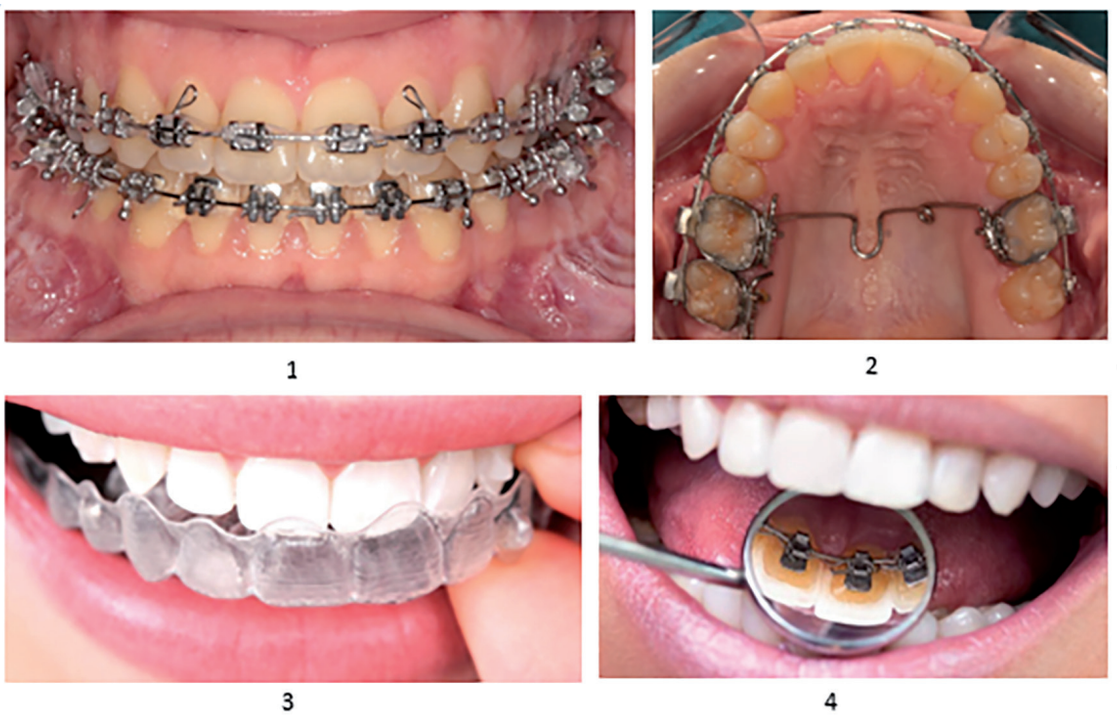

Figure 1.
Different appliance designs used in orthodontic treatment. (1) Traditional buccal metallic brackets, (2) transpalatal arch appliance, (3) clear aligner, and (4) lingual brackets.

According to a study examining the difference in WSL between lingual brackets and labial conventional brackets, patients treated with lingual brackets had significantly less development of WSL [10].

Figure 1 shows different orthodontic appliances.

2.4 Bonding technique

Composite resin remaining around orthodontic attachments prepares the ground for plaque accumulation. Therefore, the composite resin around the bracket must be cleaned [7, 11].

3. Diagnostic methods

It is very important to detect enamel demineralizations associated with orthodontic treatment at an early stage. Pitts [12] stated that the tools and methods used in the diagnosis of caries lesion should be easy to apply, reliable, reproducible, and noninvasive.

Diagnostic methods can be classified as follows [13]:

1. Traditional methods: visual inspection, Sonde examination, and radiographic examination.

2. Current technologies: laser fluorescence, digital radiography, electrical conductivity, and fiber-optic transillumination (FOTI).

3. Newly developed technologies: alternating current impedance spectroscopy, quantitative laser light-induced fluorescence, and ultrasonography.

3.1 Traditional methods

3.1.1 Visual inspection

It is an intraoral examination under light with the help of a mirror. In addition to being a frequently used method, it is insufficient to diagnose caries formations at the initial stage [14].

3.1.2 Examination with probe

In addition to light and mirror, it is the examination made by contacting the caries surface with the probe [15]. However, probe examination can cause iatrogenic damage by accelerating the progression of occlusal caries in the initial stage or by carrying caries-causing bacteria from the infected area to other areas. Probing with light pressure could cause cavitation in white, opaque lesions. The use of blunt-tipped periodontal probes is recommended to control the surface structure of the lesion [16].

3.1.3 Radiographic examination

Caries lesions can be easily recognized at an early stage due to the increase in radiological density on X-ray [17]. Panoramic X-ray examination before orthodontic treatment is shown in **Figure 2**.

3.2 Current technologies

Today's diagnostic methods measure physical signals. These physical signals are X-rays, laser light, visible light, electrical current, ultrasound, surface changes, etc., which can be obtained using the following methods [18].

3.2.1 Digital radiography

Digital radiographs have been indicated as an effective method in the diagnosis of caries without a cavity. In addition, the radiation dose received by the patient is reduced, archiving and reproducing images becomes easier [14].

3.2.2 Laser fluorescence

Developed to detect and numerically measure occlusal caries. Working with the laser fluorescent method, the commonly known brand is DIAGNOdent (DD) (KaVo Dental Corporation, East Main Street Lake Zurich, IL) [19].

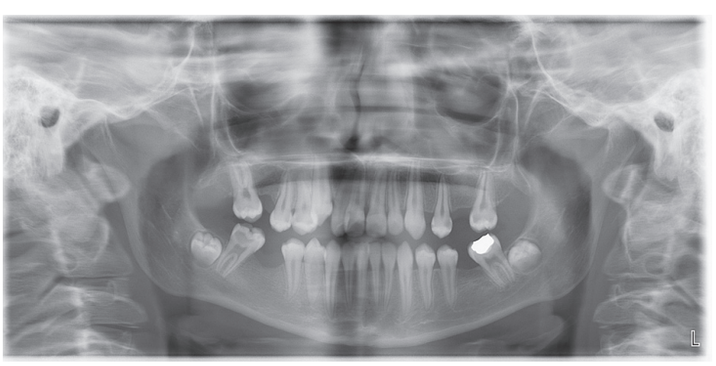

Figure 2.
Decayed tooth that can be identified on panoramic X-ray.

3.2.3 Electrical conductivity

This technique is based on the difference in conductivity in healthy and decayed tooth tissues. The electrical conductivity of the tooth tissue is sensitive enough to vary even in the case of demineralization but no loss of material on the surface [20]. Electronic caries monitor (ECM) and caries meter L devices operating based on electrical conductivity have been developed [14].

3.2.4 Fiber-optic transillumination (FOTI)

With the fiber-optic transillumination device, light scattering is prevented, and the tooth can be examined in detail due to the use of strong white light. DIFOTI (digital fiber-optic transillumination; Electro-Optical Sciences, Irvington, New York) method is a method in which FOTI and digital camera are combined to reduce the shortcomings of FOTI. DIFOTI includes two handpieces. One of them is used for caries detection on occlusal surfaces and the other on flat surfaces. Although it cannot be used to determine the depth of lesions, it gives as good results as radiographs in detecting approximal caries [21].

3.3 Newly developed technologies

3.3.1 Alternating current impedance spectroscopy

This method measures with a large number of frequency sweeps. It is reported that it has 100% sensitivity even in the diagnosis of enamel lesions without cavitation due to the use of the electrical property of the tooth [22].

3.3.2 Quantitative light-induced fluorescence

Benedict was the first to state in his research that the organic components of human teeth show fluorescent properties. In addition, he also mentioned the difference between the fluorescent properties of healthy and carious enamel in his studies [23]. The purpose of the QLF device is to determine caries at an early stage. This device can also be used for imaging lesions in remineralization treatments. The resulting image can be saved by transferring it to the computer. On the other hand, it is insufficient in imaging lesions in the approximal area [24].

3.3.3 Ultrasonografi

The basic principle of ultrasound is the application of high-frequency waves (1–20 MHz) generated by the device to the biological tissue, the returning waves are absorbed and converted into electrical impulses and detected as echoes. Each tissue has a unique internal echo level. Changes recorded at the echo level of the tissue indicate that pathological changes have occurred in the tissue [25]. It has been shown by studies that ultrasonic methods give good results in the diagnosis of early caries [26].

4. Studies evaluating the prevalence of white spot lesions

According to the first studies in this area, buccal and lingual surface lesions were found to be higher in individuals who received orthodontic treatment than in individuals who did not receive treatment. On the other hand, no significant difference was observed in the number of caries [27].

In another study, it was stated that the prevalence of decalcification among patients ranged from 2 to 96%. The reason for this great difference; the variety of methods used to assess the presence of decalcification, the presence of idiopathic lesions, and the use of a fluoride agent during treatment are indicated. Because in cross-sectional study design (orthodontic patients after treatment compared with another group of patients who have not had orthodontics), it is difficult to differentiate between idiopathic white spots and decalcification, which artificially increase the prevalence [7].

Though Zachrisson et al. [28] was the one who examined newly formed white spot lesions with the prevalence ranging from 15 to 89. In the study using photo reviews in assessment [29, 30], the prevalence of WSL was found to be 0–24%. The distribution of affected teeth has been studied [31] and has found that the maxillary incisors and the mandibular first molars to be the teeth with the highest prevalence. In another study [32], it has been stated that the lesions are concentrated in the cervical and middle third of the vestibule surface. In another study, the prevalence of WSL was found to be highest in permanent first molar teeth [33]. Contrary to these findings, in another study [34], it was stated that maxillary lateral and canines were affected too much.

In the literature, the effect of the material used to bond orthodontic bands on enamel has been investigated, but it has been stated that the main reason for WSL formation is the loss of cement integrity and the accumulation of bacteria in the area [35].

Gorelick et al. conducted a study on the incidence of white spot lesions at 6 and 12 months in patients undergoing orthodontic treatment. In their study using the visual examination technique, they reported that 50% of the patients had one or more BNL at the end of the treatment [31]. Boersma et al. [36] investigated the prevalence of white spot lesions after orthodontic treatment using quantitative light fluoroscopy and reported that 97% of patients had one or more lesions. A total of 38% of the patients had BNL 6 months after the treatment. It was stated that this rate increased to 46% in the 12-month group. Only 11% of the control group had at least one occurrence of WSL. Most patients undergoing orthodontic treatment had at least one white spot lesion in a mild form, however, a few patients presented with moderate or severe demineralization.

5. Preventive and therapeutic methods of white spot lesion

After the completion of the orthodontic treatment process, demineralization is expected to slow down. Although demineralized enamel surfaces may partially remineralize after treatment, white spot lesions have been noted to be irreversible. **Figure 3** shows white spot lesions after orthodontic treatment. However, WSL formation can be prevented by ensuring the oral hygiene of the patients during the treatment [2]. Once WSL is diagnosed, it is important to treat the cause. Social, medical, and dental histories of the patients should be taken, and caries risk assessment should be done.

While taking anamnesis; systemic and topical fluoride intake, dietary habits, snacking frequency and foods consumed between meals, bottle use, reflux, vomiting and eating disorders, salivary flow, drugs used by the person or the effect of health status on saliva flow, socioeconomic status, information status about dental diseases, dental treatment needs, value given to oral health, efforts to change habits, dental history, regular check-ups, and the amount of caries should be evaluated [37].

Numerous studies have been conducted to ensure oral hygiene of patients undergoing orthodontic treatment and to increase the resistance of teeth to demineralization. In these studies, fluorine mouthwashes, fluorinated gels and polishes, chlorhexidine

Figure 3.
White spot lesion in individuals after orthodontic treatment.

mouthwashes, chlorhexidine polishes, and gels, fluorine or non-fluoride sealants covering the enamel surface around the bracket, xylitol lozenges, fluorine-releasing elastomers, and fluorine-releasing bracket bonding materials were used [38–40].

In the study investigating the effects of resin-based sealant, fluorine-containing sealant, fluorine polish, and glass ionomer cement on the initial caries lesions and the proximal surface of the adjacent tooth, it was determined that the most effective material was glass ionomer cement. The effectiveness of the other materials was determined as fluorine polish, fluorine-containing sealants, and sealants, in order from most effective to less effective [41].

The risk of enamel demineralization in patients undergoing fixed orthodontic treatment can be reduced or prevented by the following:

1. Plaque control methods
    - Mechanical plaque control methods and improving the patient's oral hygiene
    - Chemical plaque removal
    - Reducing plaque retention by the appliance
2. The use of various agents containing fluoride
    - Mouth rinsing
    - By increasing enamel resistance to microbial acid with topical fluoride
    - Fluoride containing etchant
    - Fluoride containing bonding adhesives
    - Fluoride releasing modules
3. Teeth whitening
4. Pit and fissure sealers
5. Argon-laser tooth enamel surface weakening
6. Microabrasion
7. Use of amorphous calcium phosphate of casein phosphopeptides [7].

5.1 Plaque control methods

5.1.1 Mechanical plaque control

It is very important to use the right brushing technique to control dental plaque. Flossing as a modification of the standard toothbrush can help patients achieve oral hygiene. Compared to a manual toothbrush, using an electric toothbrush in conjunction with a manual toothbrush or regular washing with water could be a more effective way to prevent dental plaque. On the other hand, no evident superiority has been found for electric brushing [42, 43].

Bracket attachment with direct attachment exposes proximal surfaces to enamel demineralization due to the difficulty of maintaining oral hygiene with the archwires in place. Flossing has been proven to be helpful in interproximal cleaning. The floss threader would also be used to thread the floss under the archwire. The soft rubber interdental stimulator could also be helpful in interproximal cleaning and massaging the interproximal areas [44].

5.1.2 Chemical plaque removal

The material to be used for plaque removal by the chemical method should not support resistant microorganisms and should not be toxic in order not to disturb the balance of the oral microflora. Chlorhexidine antiseptic, one of the chemical plaque prevention methods, is the most effective, because of its absorption onto the acquired pellicle, which prolongs its presence and effect in the mouth.

Given these stringent requirements, it is surprising that any product has been developed as a chemical antiplaque agent. However, long-term use of chlorhexidine causes brown staining on the teeth.

Lundstrom and Krasse (1987) investigated the effect of chlorhexidine mouthwash on *Streptococcus mutans* in patients receiving fixed orthodontic treatment and stated that they found the use of chlorhexidine less beneficial [45].

5.1.3 Reducing plaque retention by the appliance

The larger the area covered by orthodontic attachments on the enamel surface, the more difficult it is to clean the remaining tooth surface. Archwire design also affects the build-up of plaque and food debris [5].

5.2 The use of various agents containing fluoride

5.2.1 Mouth rinsing

Two approaches have been developed to protect the enamel surface. The first is aimed at strengthening enamel and reducing acid solubility, that is, the use of topical fluoride agents during and after orthodontic treatment. The second involves the use of materials that protect the tooth surface around and below the orthodontic attachment with a protective coating [5].

In another study, mouthwashes containing 250 ppm fluoride twice a day were used to provide remineralization of the initial lesions on the approximal surfaces to patients undergoing orthodontic treatment. It has been reported that this method significantly increases remineralization [46].

Thuy et al. Lari, on the other hand, reported that the remineralization amount of solutions containing fluorine increased the effect of each other when used together with strontium (Sr) [47]. Tange et al. Lari stated in their *in vitro* study

on primary teeth that when xylitol and sodium fluoride are used together, they increase the remineralization effects of each other [48].

5.2.2 Increasing enamel resistance using topical fluorides

The use of fluoride agents has been shown to be effective in preventing WSL formation. The use of fluoride in reducing caries; acting as a kind of catalyst that promotes the formation of high-quality hydroxyapatite; by assisting remineralization during pH fluctuations, it acts by inhibiting the glycolysis of plaque bacteria [49]. The cariostatic effect of topical fluoride is mainly based on calcium fluoride (CaF) depending on the formation. Oral hygiene maintenance combined with daily topical fluoride use has been shown to significantly reduce enamel decalcification.

In patients who have received fixed orthodontic treatment, high concentration fluoride application provides remineralization in the superficial layer of enamel, yet it is not effective in the deeper layers. Low-concentration fluoride application is recommended as it allows slower penetration of calcium and fluorine ions from saliva following orthodontic treatment [50].

Applying fluoride polishes to the tooth surface surrounding the bracket to protect the enamel surface from the acid attack has been suggested as another technique to prevent enamel demineralization [51]. A split-mouth design study reported that Ultraseal XT Plus clear sealant provided a significant reduction in enamel demineralization in individuals undergoing fixed orthodontic treatment. After the study, six lesions were observed on the sealant applied surfaces, while 22 lesions were observed on the non-applied surfaces. Of the teeth detected with white spots, 19 lesions (68%) were found in the maxillary arch, and nine lesions (32%) were found in the mandibular arch. The highest white spots were seen in maxillary laterals and canines without sealant. It has been stated that this product effectively seals the enamel surfaces adjacent to orthodontic brackets and resists mechanical wear and is recommended for use by clinicians [52].

In a study by Derks et al., it was observed that the use of toothpaste, gel, or these materials containing 1500–5000 ppm fluorine together with chlorhexidine can inhibit demineralization. It was observed that coating the brackets with polymeric material did not have an inhibitory effect on demineralization [53].

5.2.3 Fluoride containing etchant

Thornton (1986) et al. stated that the addition of fluoride to phosphoric acid etch had little or no protective effect in an *in vitro* study. Because it dissolves on the enamel surface and does not show any permanent effect when rinsed [54].

5.2.4 Fluoride containing bonding adhesives

Fluoridated glass ionomer and composite resin materials are used to reduce demineralization [55]. It has shown that glass ionomer cement protects the underlying enamel, as well as around an orthodontic attachment from decalcification. However, it has been shown that the glass ionomer has a weaker bond strength than the composite but the retention is sufficient [56].

5.2.5 Fluoride releasing modules

The study of Marini et al. [57] was carried out by placing an intraoral material that releases 0.04 mg of fluoride per day during the orthodontic treatment. It was observed that caries and white spot lesions did not occur within 6 months. In another

study, it was determined that the lesions were reduced by 54% at the end of 4 weeks in those using a high amount of fluorine-containing topical gel (12,500 ppm F) and toothpaste (1450 ppm F), while there was a 44% reduction in those using only toothpaste. However, no statistically significant difference was found [58].

5.3 Teeth whitening

Teeth whitening demineralization is not a therapeutic method, however, if topical fluoride application does not produce the esthetic results desired by the patient after orthodontic treatment, vital teeth whitening should be considered. In white spot lesions, this process would make the lesions less apparent [50].

5.4 Pit and fissure sealers

It has been stated that light-curing pit and fissure sealants applied to the enamel surface adjacent to orthodontic brackets are effective in preventing enamel demineralization without the need for patient compliance. Benham and colleagues reported that micro-abrasion resistant and highly filled flowable composites greatly reduced white spot lesions when applied to pits and fissures [52].

Salar et al. examined 45 extracted third molars by dividing them into three groups. Conventional sealant without fluoride (Group 1), fluoride-releasing sealant (Group 2), or glass ionomer sealant with high fluoride release (Group 3). According to the results, ProSeal provided increased demineralization inhibition compared with a conventional sealant containing no fluoride, but less than that observed by a glass ionomer sealant [59].

5.5 Argon-laser tooth enamel surface weakening

Argon laser can be used to prevent enamel decalcification by changing the crystal structure of enamel. It has been reported that when argon laser is applied to the enamel surface. Argon laser causes the surface properties of the enamel to change by creating micro-voids that stabilize the ions on the enamel surface during the acid attack. Phosphate, calcium, and fluoride ions in saliva could subsequently precipitate into these cavities, increasing the resistance of tooth enamel to demineralization and increasing mineral uptake from saliva [60].

5.6 Microabrasion

The esthetic appearance of WSL, which has been going on for a long time, can be improved with the microabrasion method. It has been suggested to use the microabrasion technique in the treatment of white spot lesions that occur during dental treatment [61]. Researchers stated that when a mixture of 18% hydrochloric acid, pumice, and glycerin was applied to the tooth surface for 3–5 minutes with an electric toothbrush, mild lesions disappeared completely, while severe lesions reached a satisfactory color. They also stated that the brown-yellow discoloration on the tooth surface disappeared, and smooth enamel surfaces were obtained.

5.7 Amorphous calcium phosphate of casein phosphopeptides

Another material used for the remineralization of decalcifications on the enamel surface is casein phosphopeptide, which is obtained from the milk protein casein. The solution form, which is prepared by dissolving in water, acts by stabilizing calcium and phosphate ions.

In an alkaline medium, casein phosphopeptide combines with calcium phosphate to form CPP-ACP compound. Today, this compound is combined with fluorine ions and used as CPP-ACFP (casein phosphopeptide-amorphous calcium fluoride phosphate) [62].

Researchers working on the remineralization of fluorine and CPP-ACP have shown that toothpaste containing 2% CPP-ACP provides a similar remineralization amount to toothpaste containing 2800 ppm fluoride. In addition to 2% CPP-ACP, it was determined that the best results were obtained in the toothpaste with 1100 ppm fluoride added [63].

In a study, the higher amount of remineralization effect of CPP-ACP applied topically to the initial lesions for 14 days was visualized with an electron microscope, and it was found to be statistically significant [64].

In the study on the remineralization of initial enamel lesions, a 7% reduction in lesion depth was observed when toothpaste containing fluoride (1100 ppm) was applied alone, and a 10% reduction was observed when using toothpaste containing CPP-ACP. It was observed that there was a 13% reduction in lesion depth when toothpaste containing CPP-ACP was applied after the use of fluoridated toothpaste. Since casein is a milk protein, care should be taken in its use in patients with milk allergies [65].

6. Conclusion

White spot lesions could be detected at an early stage with various diagnostic methods, and the formation of lesions could be prevented with appropriate treatments. Studies have shown that none of the caries diagnostic methods developed today is as effective as clinical examination and radiographic examination. It would be more beneficial to use these two diagnostic methods together. In the first months of orthodontic treatment, it is of great importance to evaluate the oral hygiene of patients and to apply preventive measures to stop demineralization. In the treatment of white spot lesions, the factors affecting the formation of the lesions should be eliminated first, and patient education and information should be emphasized. In the treatment of white spot lesions, it is aimed to occur remineralization in the lower layer of the lesion. For this purpose, improvement of oral hygiene, regulation of diet, calcium, fluoride, milk proteins, laser beams, chemical, and mechanical abrasion methods should be applied. If white spot lesions are not treated, cavitation may occur in the lesions and cause esthetic problems. Effective prevention, diagnosis, and treatment of lesions will minimize caries formation and tooth discoloration and also provide an esthetic smile. The most appropriate, cheapest, and easiest-to-apply treatment method should be preferred for the patient.

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