Iatrogenic Effects of Orthodontic Treatment

Decision-Making in Prevention, Diagnosis, and Treatment

Roberto Justus

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This book is dedicated to my wife, Yolanda, and my children, Mauricio, Adrian and Tamara, for having made this work possible through their love and encouragement.

Preface

Orthodontic treatment success can be jeopardized by iatrogenic problems created during orthodontic treatment. The most frequent iatrogenic problem is white spot lesions followed by periodontal deterioration and external apical root resorption. This book addresses each of these three iatrogenic problems in individual chapters. Emphasis is given to the orthodontic treatment methods recommended to minimize or prevent these problems from occurring.

Mexico | Roberto Justus

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Contents

Prevention of White Spot Lesions

1

Abstract

The most frequent iatrogenic problem in orthodontics is white spot lesions (WSLs). Maintenance of an adequate and constant presence of fluoride ions in the vicinity of the enamel on the periphery of bracket bases helps protect against the development of WSLs. Resin-modified glass ionomer cements (RMGICs) minimize the development of WSLs due to their continuous fluoride uptake from the environment and re-release, but the perception that orthodontic brackets bonded with RMGICs frequently fail due to low initial bracket shear bond strength persists. This perception is correct if the clinician were to bond these materials as recommended by the manufacturers, which includes conditioning the enamel with an extremely weak 10 % polyacrylic acid instead of the traditional 37 % phosphoric acid etch. In order to successfully use resin-modified glass ionomer cements, it is recommended to first deproteinize the enamel surface by applying 5.25 % sodium hypochlorite for 1 min to remove the acquired dental pellicle (which impedes proper etching of the enamel surface), followed by a 15–30-s etching with 37 % phosphoric acid (so the resulting etch patterns on the enamel surface are types 1 and 2, not type 3, thereby increasing bracket bond strength), and followed by moistening the enamel surface to further increase this strength. In following these recommendations, the clinician will minimize the risk to patients of developing lifelong WSLs and their consequences. In the final analysis the degree of damage provoked by WSLs is vastly more significant on the health of the enamel than the bonding and debonding process. It is the author's hope that this review of the scientific literature will help clinicians achieve the best results for their patients.

1.1 Introduction

Orthodontic treatment success can be jeopardized by the development of enamel white spot lesions (WSLs) on the periphery of, or beneath, orthodontic bracket bases. WSLs are clinically defined as opaque, white areas caused by the loss of

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minerals below the outermost enamel layer [1]. WSLs are the earliest sign of the caries process, which starts with enamel demineralization. The severity of WSLs can be classified numerically using a 4-point scale (Gorelick's scale) in which # 1 shows no enamel demineralization, # 2 slight, # 3 severe, and # 4 cavitation [2].

Brackets and bands create areas on the tooth surfaces which favor the increase of plaque and food accumulation due to the restrictive access for self-cleaning [3]. Carbohydrate fermentation by the bacteria in the dental plaque causes a decrease in the pH. This in turn results in the loss of mineral ions from the enamel to the oral environment, a process known as demineralization. Through the buffering action of saliva, the pH can increase again allowing the teeth to incorporate free ions. This process is called remineralization. There is a constant ionic exchange between the dental tissues and the environment, which will ultimately reach an ionic equilibrium. Progressive demineralization without adequate remineralization results in the development of WSLs [4, 5].

The formation of WSLs remains an unfortunately common complication during orthodontic treatment and is particularly prevalent in patients with poor oral hygiene. The initial lesions can be visible as soon as the 4th week after the placement of fixed orthodontic appliances [6]. Richter et al. [7] reported that nearly 75 % of patients who underwent comprehensive orthodontic treatment developed new WSLs because of prolonged plaque retention on the periphery of bracket bases. Therefore, the first step to prevent WSLs is to educate patients on the importance of maintaining proper oral hygiene throughout their orthodontic treatment. It is the orthodontist's responsibility to minimize the risk of patients developing enamel demineralizations as a consequence of orthodontic treatment. This can be achieved by brushing with fluoride-containing toothpaste after every meal and snack, rinsing daily with fluoride-containing mouthwash and by dietary modification, and limiting contact with sugar-containing products. Unfortunately, patient compliance is generally quite poor, particularly among the adolescent population.

The inhibitory effect of fluoride on bacterial activity and on demineralization of enamel has been well established [8]. The main mechanism by which fluoride works is by maintaining the plaque supersaturated with respect to fluorapatite, hence tipping the balance of the caries process against demineralization and in favor of remineralization [9]. Thus, continuous contact with fluorides is critical to protect the enamel against the development of WSLs during treatment with fixed orthodontic appliances. The presence of fluoride will minimize the ionic loss from the tooth structure until the pH of the plaque becomes as low as 4.5. At that level, even the presence of adequate fluoride concentration in the oral environment will have a minimal beneficial effect on the process of remineralization [10]. But before reaching such a critically low pH level, the availability of fluoride ions in the oral environment will enhance remineralization [11]. Resin-modified glass ionomer cements (RMGICs) can be used to bond orthodontic brackets. They have an anticariogenic effect because they release fluoride into the immediate environment of the bracket base, and they do so in a sustained fashion [12]. Therefore, maintaining an adequate and constant presence of fluoride ions in the vicinity of the enamel is critical to the ability of enamel to remineralize. It has been suggested that fluorides will have a substantial inhibitory effect on the rate of demineralization of enamel even if it is in the sub-ppm level, i.e., as low as 0.02–0.06 ppm [13].

The frequent application of fluorides is the most efficient method for preventing demineralization as well as enhancing remineralization of carious lesions. A potential method of providing a sustained concentration of fluoride ions over a prolonged period is to have a slow fluoride-releasing system incorporated in the bracket bonding material. Furthermore, the ability of some bonding materials for absorbing fluoride and then releasing it, acting as a fluoride pump, will help interrupt the development of WSLs, thus decreasing the risk of caries [14]. As a result, a few fluoride-releasing bonding systems have been developed. The fluoride ions released from these materials penetrate and diffuse into the tooth structure and prevent WSLs by reinforcing the mineral content of the tooth structure. The most effective fluoride-releasing materials in a descending order are glass ionomer cements (GICs), resin-modified glass ionomer cements (RMGICs), and compomers [14].

Resin composites to which fluoride has been added, called compomers, were not found to be effective in providing a sustained rate of fluoride ions [15, 16]. Thus, GICs were originally recommended as bracket adhesives to minimize, or even prevent, WSLs from developing due to their continuous fluoride release, but frequent bracket failure occurred due to their low initial shear bond strength (SBS). The reason for this low initial SBS is that glass ionomers harden through a slow acid-base setting reaction which requires 24 h to complete [17]. To increase the initial SBS of the GICs, 4–6 % photosensitive composite resin was added to be able to obtain a faster initial hardening of the adhesive's resinous portion through photocuring [18]. The addition of this resinous component converted GICs into RMGICs. These hybrid adhesives have allowed orthodontists to take advantage of the positive features of conventional GICs combining them with the mechanical and physical properties of resin composites.

Thus, the use of RMGICs to bond brackets is highly recommended because of their continuous fluoride uptake from the environment and re-release. However, these cements, in spite of the added resinous component, still have a relatively low initial bracket SBS [17].

To increase the initial bracket SBS to clinically reliable levels *when using RMGICs*, removal of organic material (deproteinization) from the enamel surface with 5.25 % sodium hypochlorite is highly recommended [19]. By applying 5.25 % sodium hypochlorite for 1 min, prior to phosphoric acid etching, temporary elimination of the acquired pellicle from the enamel surface occurs. This in turn allows the phosphoric acid to etch the enamel surface more effectively creating better etching patterns which increase bracket SBS [20–22].

The important topic of the acquired pellicle is presented later in this chapter. For the moment suffice to state that professional tooth cleaning by the use of a rubber cup or rotary brush with pumice does not completely remove the pellicle from the enamel surface; that the pellicle layer on the enamel surface confers resistance against chemical dissolution and attack by acidic agents, so 37 % phosphoric acid is not able to etch the enamel surface in areas covered with the organic material of the pellicle; and that temporary elimination (deproteinization) of the acquired pellicle from the enamel surface where the bracket base will be bonded is a must to be able to obtain etching patterns that allow effective bracket bonding with RMGICs.

To further increase bracket SBS, GC Corp., Tokyo, Japan, the manufacturer of Fuji Ortho LC, an RMGIC, recommends moistening the enamel surface with a water-moistened cotton roll before bonding, as verified by Rodríguez [23].

Clinicians typically require that a bonding material have sufficient initial bracket SBS to be able to tie arch wires into the brackets immediately after having bonded them, but since the glass ionomer fraction of RMGICs takes 24 h to set, clinicians prefer to continue using resin composites for bonding brackets to lower the risk of bracket bond failures, even if they do not provide a sustained fluoride release to protect the enamel from developing WSLs.

In the following subchapter, the reader will become aware of how severe and widespread the incidence and prevalence of WSLs are in individuals who had orthodontic treatment and will hopefully decide to incorporate the recommended modified method of RMGIC use to protect orthodontic patients against WSL development.

1.2 Detection

Among the most common methods of detection are clinical inspection and photographs. Quantitative light-induced fluorescence (QLF) has been recently suggested as a more accurate method of detecting WSLs [24]. The QLF method consists of illuminating the teeth with a blue laser light. Tooth dentin contains atoms called fluorophores which fluoresce green when illuminated with a blue laser light. This green light is blocked from exiting the enamel where a WSL is present. Thus, the WSL appears as a black area surrounded by green color. QLF technology is expensive so it is not widely used.

WSL detection can be a challenge when enamel decalcifications are in their initial stages. Before orthodontic treatment begins, the clinician should document the extent and severity of any WSL present through clinical inspection and with the aid of intraoral photographs. These photographs can be used for comparative purposes both during and at the end of treatment for patient education as well as for the documentation of their presence.

1.3 Incidence

A review of the literature indicates that there is a high incidence of WSLs that develop during comprehensive orthodontic treatment. Richter et al. [7], using the photographic method to detect WSLs, found that 72.9 % of 350 orthodontic patients treated with comprehensive orthodontics between 1997 and 2004 in the Department of Orthodontics at the University of Michigan had developed new WSLs. These 350 patients were selected at random from the photographic records of 2,300 patients treated at that institution. Boersma et al. [25], using the quantitative light-induced fluorescence method to detect WSLs, found that 97 % of patients who were evaluated immediately following comprehensive orthodontic treatment were affected with WSLs.

The next subchapter will address the question of WSL prevalence. It is an important subject because some reports indicate that a natural remineralization process occurs after orthodontic treatment which diminishes the prevalence of WSLs.

1.4 Prevalence

A review of the literature reveals that in spite of some WSL natural remineralization occurring post-orthodontic bracket removal, these lesions generally do not disappear. Van der Veen et al. [26] used the quantitative light-induced fluorescence method to determine whether WSLs diminish after orthodontic treatment (through the natural remineralization process). They found that 6 months after bracket debonding, while 33 % of WSLs did remineralize somewhat (lesion regression), the majority of WSLs remained unchanged, and 10 % worsened (lesion progression). Ogaard [27], in a study of 51 patients treated with comprehensive orthodontics, used clinical inspection to detect WSLs and found that the prevalence of WSLs on vestibular surfaces 5 years posttreatment was significantly higher than in a matched control sample of untreated individuals.

The results from the abovementioned studies indicate why methods of prevention or treatment for WSLs must be strongly considered.

1.5 Treatment

Methods to treat WSLs post-orthodontic treatment can be divided, according to Guzman et al. [28], into conservative and aggressive. The conservative treatment methods include oral hygiene instruction, dietary modification, chewing gum to increase salivary output (preferably gum containing xylitol, not sugar), remineralization with fluorides (in dentifrices, in varnishes, in sealants, and in mouth rinses with low-concentration solutions of less than 50 ppm), the use of antimicrobials (chlorhexidine), and casein derivatives (although recent research by Huang et al. [29] casts doubt regarding casein derivatives' effectiveness in remineralizing WSLs).

More aggressive treatment methods suggested by Guzman et al. [28] include external bleaching, micro-abrasion, composite restorations, and porcelain veneers.

Clinicians should recognize that the best policy is to prevent WSLs from occurring since the methods mentioned in the last paragraph are quite aggressive. It is therefore best to allow the natural remineralization process to take place as described in the next subchapter.

1.6 Natural Remineralization

Before attempting to use any of the WSL aggressive treatment methods, Guzman et al. [28] and Bishara and Ostby [30] recommended allowing the natural remineralization process to occur. Saliva contains minerals including calcium, phosphates, and fluoride ions, all of which help to remineralize WSLs [4, 5, 8–14]. During the potential natural remineralization period, good oral hygiene is essential. A reduction of exposure to sugared beverages should be implemented. Chewing sugarless gum is also recommended because it stimulates saliva production. In addition, daily oral rinses with low fluoride concentration and consumption of fluoridated water can be helpful. This should be combined with brushing teeth with low-concentration fluoride dentifrices to promote the remineralization process. Although it remains controversial whether high or low fluoride concentrations should be used, low fluoride concentration is generally recommended so that the external enamel surface remains permeable for the minerals in saliva to penetrate the damaged enamel surface [29].

It has been reported that 33 % of the WSLs improve with time as long as there are no enamel cavitations [26]. Unfortunately, many WSLs persist years after orthodontic treatment, in spite of the natural remineralization process [27]. Based on these facts, prevention or minimization of WSL development during the course of orthodontic treatment should be regarded as a factor of critical importance.

1.7 Prevention

Many methods have been proposed to prevent or minimize WSL development during orthodontic treatment. These can be divided into compliant and noncompliant methods [28].

1.7.1 Compliant Methods

Compliant methods include maintenance of good oral hygiene using fluoride-containing dentifrices, brushing well immediately after every meal and snack, diet modification to limit contact with sugar-containing products, and daily oral rinses containing fluorides. Continuous contact with fluoride is important because it protects the enamel by converting hydroxyapatite into fluorapatite crystals, which have a lower solubility in the oral environment than hydroxyapatite crystals [30].

In a systematic review published by Benson et al. [31], the researchers concluded that there is some evidence that the daily use of .05 % NaF mouth rinse, or bonding brackets with a glass ionomer cement, might reduce the occurrence and severity of WSLs during orthodontic treatment.

Topical application of stannous fluoride in particular may have a plaque-inhibiting effect by interfering with the adherence of plaque bacteria to the enamel surface. Tin atoms in stannous compounds also block the passage of sucrose into bacterial cells, thereby inhibiting acid production and diminishing the acidogenicity of plaque [32].

More recently, it has been suggested that the compound casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) may also reduce the incidence of demineralization. The theoretical basis of this arose from the observation that dairy products are anticariogenic [33]. They work in a way similar to fluoride by maintaining the saturation of calcium and phosphate in plaque fluid, thereby discouraging the dissolution of these elements and also promoting remineralization if they are lost [34].

Unfortunately, compliant methods require patient cooperation, which is frequently lacking. Geiger et al. [35, 36] evaluated patient compliance in a preventive fluoride-rinse program. The degree of compliance with the home-care preventive protocol was poor in half of the patients, and less than 15 % of orthodontic patients used daily fluoride rinses as instructed.

1.7.2 Noncompliant Methods

1.7.2.1 RMGICs

In view of well-documented poor patient compliance, RMGICs have been proposed as bracket bonding materials due to their continuous fluoride-releasing properties throughout the orthodontic treatment.

RMGICs act as fluoride pumps due to the fact that they continuously absorb fluoride from the environment (e.g., fluoride in dentifrice, in oral rinse, and in potable fluoridated water) and subsequently re-release it precisely in the areas most susceptible to WSLs. These are the bracket perimeter and voids beneath the bracket base. In vivo [37, 38], ex vivo [39, 40], and in vitro [41] studies plus systematic reviews [31, 42] have documented that RMGICs do protect the enamel from the development of WSLs. These studies confirm that less demineralization occurs during fixed orthodontic appliance treatment with RMGICs than with traditional resin-based adhesives.

It is the author's opinion that orthodontic care should include protection of enamel from developing WSLs. This implies using fluoride-releasing RMGICs as bracket bonding agents. However, the current recommended method by the manufacturer needs to be modified to increase bracket SBS to clinically reliable levels. This can be achieved by *deproteinizing* the enamel surface with 5.25 % sodium hypochlorite (NaOCl) for 1 min, *etching* the enamel surface with a 15–30-s application of 37 % phosphoric acid, and *moistening* the enamel surface with a water-moistened cotton roll (the rationale for these three steps is explained in the following subchapters). Figures 1.1, 1.2, 1.3, 1.4, 1.5, and 1.6 show posttreatment intraoral photographs of patients who were treated by the author. These patients had bicuspid extractions followed by comprehensive orthodontic treatment using brackets cemented with Fuji Ortho LC, an RMGIC. It can be observed that no WSLs developed.

In addition to the use of fluoride-releasing RMGICs as bracket bonding materials, three other materials that also release fluorides include the application of fluoride-releasing varnish on the periphery of the bracket bases, the use of fluoride-releasing composite resin as a bracket bonding agent, and the use of fluoride-releasing sealants. These products can also be employed to help reduce the development of WSLs.

Fig. 1.1 Posttreatment intraoral right side view of a patient treated with extraction of four first bicuspids and full fixed orthodontic appliances for 24 months using Fuji Ortho LC as a bracket bonding agent. No WSLs can be observed

Fig. 1.2 Posttreatment intraoral left side view of the same patient

Fig. 1.3 Posttreatment intraoral right side view of a patient treated with extraction of four first bicuspids and full fixed orthodontic appliances for 28 months using Fuji Ortho LC as a bracket bonding agent. No WSLs can be observed

1.7.2.2 Fluoride-Releasing Varnishes

Schmit et al. [43] carried out an ex vivo study to evaluate the effect of a fluoride-releasing cavity varnish on inhibition of enamel demineralization adjacent to orthodontic brackets bonded with a composite resin (Transbond XT) and with an RMGIC (Fuji Ortho LC). Brackets were bonded to 48 extracted human third molars. Half

Fig. 1.4 Posttreatment intraoral left side view of the same patient

Fig. 1.5 Pre-treatment intraoral photograph of a patient who had previously been treated orthodontically using non-extraction therapy. The patient complained about having developed a double protrusion. In addition, the patient experienced three WSLs during this first treatment. These can be observed in the cervical third of the crowns of the second maxillary bicuspid and on the first and second maxillary molars

Fig. 1.6 Posttreatment intraoral photograph of the same patient after orthodontic re-treatment with extraction of four first bicuspids and full fixed orthodontic appliances for 30 months using Fuji Ortho LC as a bracket bonding agent. The same WSLs can be observed with no progression whatsoever and no new WSLs