Prevention of white spot lesion formation during treatment with fixed orthodontic appliances

The efficacy of using a fluoride rinse and repeated oral hygiene instructions

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CHAPTER 1

GENERAL INTRODUCTION
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Orthodontics is the area of dentistry concerned with the growth of the craniofacial complex, the development of occlusion and the treatment of dentofacial abnormalities. Orthodontic treatment involves three aspects of the craniofacial complex, namely the dentition, the craniofacial bones—mainly the jaws—and the muscles of face and jaws. Attempts to correct malocclusion go back to the times of the Greek and Etruscans. It was not until around 1900 that Edward Angle developed the concept of occlusion and the classification of malocclusion (Angle, 1899). As time passed by it became clear that an excellent occlusion alone was unsatisfactory, because of aesthetic and stability problems. Thus, in orthodontic treatment the dental and facial aesthetics are nowadays more important than the details of orthodontic occlusion alone. Orthodontic treatment is common amongst both juveniles and adults. Most patients are treated for aesthetic reasons, only a small number of patients receive treatment because of medical or dental indications (Ackerman et al., 2007). Treatment usually occurs with removable or fixed appliances.

White spot lesions in orthodontics

Before start of treatment, potential risk factors such as increased cariogenic challenge, must be considered. Removable appliances, such as a functional activator or an expansion plate, do not directly affect oral hygiene. Fixed orthodontic appliances can impair oral hygiene, and thus unwanted side effects as caries can occur. The first signs of decay around the brackets are called White Spot Lesions (WSL) and are subsurface enamel porosities (fig. 1). WSL are not only aesthetically unfavourable but may progress into cavitated lesions and are therefore an unwanted side effect of clinical relevance. The overall prevalence of WSL after treatment with fixed appliances ranges from 50%-97% (Gorelick et al., 1982, Boersma et al., 2005, Julien et al., 2013). This number varies depending on the examination technique used, the length of the study and also the length of the orthodontic treatment plays a role. The highest incidence of WSL is found on the maxillary lateral incisors and mandibular molars, followed by the maxillary canines, premolars and central incisors (Chapman et al., 2010, Lucchese and Gherlone, 2013).

Figure 1. Image of the teeth of a patient with several WSL one week after removal of the fixed orthodontic appliances.
WSL can develop within four weeks after placement of fixed appliances (Øgaard et al., 1988). The environment of the oral cavity changes after placing the fixed appliances. There is an increased number of plaque retention sites and thus more plaque accumulation (Naranjo et al., 2006). This is due to the fact that the appliances hamper mechanical cleaning on surfaces normally showing low caries experience. There is also a shift in the plaque to a more periopathogenic population next to more accumulation (Naranjo et al., 2006).

Cariogenic species such as *Streptococcus mutans* and *Lactobacillus* species and the subsequent decalcification of enamel were the main fields of interest around the 1980’s (Mattingly et al., 1983, Forsberg et al., 1991, Rosenbloom and Tinanoff, 1991). Later on the complex system of periopathogenic microbes, more prominent after placing fixed appliances, became the main topic of interest. Naranjo et al. (Naranjo et al., 2006) observed a transition in sub-gingival dental plaque after placement of fixed appliances. The plaque index and the gingivitis index increased significantly and *Porphyromonas gingivalis*, *Prevotella intermedia*, *Prevotella nigrescens*, *Tannerella forsythia*, and *Fusobacterium* species were significantly elevated in the experimental group after placement of brackets compared to a non-bracketed control group (Liu et al., 2004, Naranjo et al., 2006, Lucchese et al., 2018). These modifications are also enhanced by the intake of carbohydrates; frequently used by adolescents (Jepsen et al., 2017). The changes in oral microbiology are clinically expressed in most patients with an increase in gingival inflammation and, regardless of the level of oral hygiene, a gingival enlargement (Zachrisson and Zachrisson, 1972, Boyd and Baumrind, 1992, Gastel J et al., 2008, Pinto et al., 2017). Increased signs of inflammation, gingival swelling and pseudo pocket formation, particularly at the proximal areas are seen as a reaction. Overall the changes in gingival conditions produced by fixed appliances are transient with no permanent effect on periodontal parameters (Zachrisson and Zachrisson, 1972, Alstad and Zachrisson, 1979).

In contrast, the WSL developed during treatment with fixed appliances, were shown to have limited ability to regress after removal of the appliances. WSL are still visible over one year after debonding, with a small number that progress into cavitated lesions (Mattousch et al., 2007, Beerens et al., 2015, Beerens et al., 2018). Orthodontically treated patients had a significantly higher prevalence of WSL than a control group of non-treated subjects even five years after treatment (Øgaard, 1989). Reducing the formation of WSL is, therefore, essential and this is called primary prevention. Orthodontists recommend their patients to brush their teeth at least twice daily with fluoridated toothpaste and to use additional dental aids, such as a proxy brush. Next to this, extra products are prescribed, such as rinses or varnishes containing fluoride or chlorhexidine. Orthodontists also recommend diets that avoids foods that may accidentally debond the brackets or increase the risk of dental caries or erosion (Oosterkamp et al., 2016). When a WSL is detected, secondary prevention is needed to avoid or reduce further demineralization and increase remineralization of the enamel. A novel method to longitudinally follow WSL and to make plaque visible is the use of Quantitative Light-induced Fluorescence (QLF).
WSL & plaque assessment: Quantitative Light-induced Fluorescence

The QLF technique is based on the property of tooth-tissue to autofluoresce when illuminated by visible light. Changes in mineral content of tooth-tissue can be made visible because of an altered fluorescence radiance resulting in a reduced green fluorescence (fig. 2) (de Josselin de Jong et al., 2009). Concentrations of porphyrins in bacterial plaque show an enhanced red fluorescence (fig. 3). One of the main advantages of QLF is that lesions may be detected earlier than through conventional visual inspection (Heinrich-Weltzien et al., 2005). QLF can be used for longitudinal assessment of WSL, and it has been shown to detect and quantify early demineralization of enamel (Hafstrom-Bjorkman et al., 1992, Boersma et al., 2005, Mattousch et al., 2007). In non-bracketed population QLF can be used for monitoring lesions over time (Tranaeus et al., 2002). Orthodontic studies showed that QLF images captured under the same circumstances, that is using the same camera angle, can be reproducibly quantified in vitro (Benson et al., 2003, Pretty et al., 2003, Aljehani et al., 2004).

Studies also demonstrate that by sharing visual QLF images with patients, and pointing out lesions, patients are motivated to improve oral hygiene (Tranaeus et al., 2001). In research environment QLF has proven to be a reliable tool for assessing plaque accumulation in vivo on non-bracketed teeth (Tranaeus et al., 2001, Pretty et al., 2005, de Josselin de Jong et al., 2009). For measuring WSL it is known that lesions adjacent to the gingiva or affected by a swollen gingiva are more difficult to analyze. This may also be a problem in orthodontics for the plaque assessment.

Figure 2. A QLF image using an intra-oral QLF camera (QLF/Clin; Inspektor Research Systems, Amsterdam, the Netherlands). A WSL is seen as reduced green fluorescence just cervical to the place where the bracket had been situated. This camera was used for the study presented in chapters 2 and 3.

Figure 3. A QLF image using a QLF-digital Biluminator camera (QLF-D Biluminator™ 2; Inspektor Research Systems, Amsterdam, the Netherlands). The mature plaque is seen as red fluorescence around the brackets. This camera was used for the studies presented in chapters 4 and 5.
Primary prevention of WSL: fluoride

Fluoride is important in the prevention of dental decay in the general population (ten Cate, 2013) and should be used in high caries risk patients. In the Netherlands, many orthodontists recommend the use of a daily fluoride mouthrinse throughout treatment with fixed appliances (Kerbusch et al., 2010). Various forms of fluoride administration may be prescribed during orthodontic treatment. These include topical fluorides as mouthrinses, gel or varnishes or fluoride-releasing materials as glass ionomer for bonding brackets.

A Cochrane review concluded that the use of a topical fluoride varnish applied professionally every six-weeks during orthodontic treatment reduces the incidence of WSL formation (Benson et al., 2013). Also, after using topical fluoride there is a reduction in lesion severity (Stecksen-Blicks et al., 2007). Furthermore, the use of a high-fluoride toothpaste instead of regular fluoride toothpaste resulted in fewer WSL (Sonesson et al., 2014). Research concerning the daily use of a fluoride mouthrinse is less convincing and well conducted evidenced based research is lacking, as concluded by the authors of the Cochrane review. In general dentistry the use of a fluoride mouthrinse is advocated for high caries risk patients (Marinho et al., 2003). An often-mentioned problem of this daily use of a rinse is the compliance, especially for adolescents. In orthodontics it is shown that more compliant patients have fewer WSL, but also that the compliance of fluoride rinse usage was about 50% (Geiger et al., 1988).

Primary prevention of WSL: oral hygiene instructions

Assessing a patient’s oral hygiene at each visit is part of the routine oral examination for the dentist and orthodontist. Regular oral hygiene reinforcement can be used to prevent the formation of WSL during fixed appliances. For the improvement of oral hygiene several techniques are used. Clinical investigations have shown that repeated oral hygiene instructions reduce the plaque accumulation (Acharya et al., 2011, Lalic et al., 2012). Likewise, the use of visual aids, such as an image of the severe consequences of biofilm accumulation (Peng et al., 2014) or showing photographs taken intra-orally during treatment (Miller et al., 2016), can decrease the plaque accumulation. Methods used for this chairside motivation and feedback also include the use of plaque disclosing methods or Quantitative Light-induced Fluorescence (QLF).

Since plaque is generally colorless, it can be stained for a better assessment and visibility. Common disclosing agents used are erythrosine, a pink-dye (E127), sometimes combined with a blue-dye (E133). These disclosing agents adhere to the plaque and which remains visible for the patient after water rinsing. Studies have shown that oral hygiene instructions together with plaque self-visualization through disclosing agents and a mirror resulted in an improvement of oral hygiene and gingivitis in non-orthodontically treated children (Bellini et al., 1974, Telford and Murray, 1974).
Outline of this thesis

The overall topic of this PhD thesis was the prevention of White Spot Lesions formation during orthodontic treatment. The first chapters describe a Randomised Controlled Clinical Trial about the effects of the use of a fluoride rinse on the formation of white spot lesions and the microbiome during treatment with fixed appliances.

In chapter 2 the RCT is outlined. This study aimed to compare daily uses of a placebo rinse versus a fluoride rinse during treatment with fixed appliances. To measure the WSL a QLF device was used. QLF images of buccal surfaces of all teeth in upper and lower jaw from second premolar to second premolar were captured before, during and after treatment with fixed appliances. Besides to the formation of WSL bleeding scores were assessed.

Chapter 3 focuses on the changes in the microbiome of same sample presented in chapter 2. The microbial changes were measured using next-generation sequencing of the bacterial 16S rRNA gene at different moments: before treatment, the first three months into treatment with fixed appliances, immediately before removal of the appliances and until three months after debonding.

Since the use of QLF during treatment with fixed appliances appeared to be difficult, because of movement of the teeth and the presence of a bracket, wire and other accessories, chapter 4 describes an in vitro study about the reproducibility of QLF measurements and orthodontics. QLF images of WSL were captured directly cervical of a bracket on extracted incisors and canines. Different angles of rotation towards mesiodistal and buccolingual were simulated, and images with bracket, with a wire and elastic ligature and without a bracket were made to test the reproducibility of the WSL measurement.

Besides a fluoride-rinse, proper oral hygiene during treatment is very important to prevent the formation of WSL. Therefore, in chapter 5 a study is presented on the effect of three different repeated oral hygiene instructions using 3 different feedback methods. The feedback methods used were 1; showing the plaque on QLF images of the teeth of the patient, 2; using erythrosine as disclosing agent to make the plaque present visible and 3; showing the patient in a mirror using a probe to point out the presence of plaque.

In chapter 6 a general discussion is presented and advices are given on how to prevent the formation of WSL during orthodontic treatment with fixed appliances.
REFERENCES


