Biofilm on orthodontic retention wires
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Chapter 1

General introduction and aim of the thesis
Orthodontic treatment is very common amongst both juveniles and adults and the number of orthodontic patients is still increasing every year.\(^1\) During orthodontic treatment one of the greatest challenges is to prevent biofilm related complications such as gingivitis, gingival hyperplasia and white spot lesions.\(^2\)\(^-\)\(^4\) Orthodontic appliances provide extra retention sites for biofilm formation and make removal of the biofilm through natural cleansing and tooth brushing more difficult.\(^5\) Despite all efforts to prevent these biofilm related complications, they are still quite common: gingivitis occurs in almost all orthodontic patients\(^2\) and white spot lesions occur in about 60% of orthodontic patients.\(^3\)\(^,\)\(^6\)

After active orthodontic treatment, some form of retention of the dentition is required to maintain the treatment result, since long-term stability cannot be guaranteed.\(^7\) Different types of retention methods can be applied, such as the use of removable acrylic plates, vacuum formed retainers or bonded retention wires. It is increasingly common to place permanent bonded retention wires behind the anterior teeth.\(^8\) This means that after a lengthy orthodontic treatment, a much longer phase of retention treatment follows. Bonded retention wires are generally very effective in preventing the teeth from relapsing to their pre-treatment position,\(^9\)\(^,\)\(^10\) but the drawback of these retainers is that biofilm and calculus accumulate along the wires,\(^11\) leading to a greater incidence of gingival recession, increased pocket depth and bleeding on probing.\(^12\)\(^,\)\(^13\) With a growing number of orthodontic patients, prevention of biofilm related complications becomes more and more important in patients both under active treatment as well as when in the retention phase of treatment.

Mechanical removal of the biofilm remains the most important way to establish oral hygiene. However, orthodontic appliances and retention wires provide many crevices and niches in which biofilm can grow out of reach for mechanical removal. In general, powered toothbrushes provide better biofilm removal than manual toothbrushes\(^14\) and they can mechanically disrupt a biofilm from a distance due to strong fluid flows,\(^15\) air bubble inclusion\(^16\) and acoustic energy transfer. Nevertheless in orthodontic patients the beneficial effect of powered brushing is much smaller, if even present.\(^17\) In both orthodontic as well as in non-orthodontic patients, 100% biofilm removal can never be achieved\(^18\) and a part of the biofilm will always be left behind at locations out of reach for mechanical removal.

Chemical control of oral biofilms is an approach, additional to mechanical biofilm control, in preventing biofilm related complications. Various oral antimicrobials are available in the form of toothpastes, gels and mouthrinses, such as chlorhexidine, cetylpiridium chloride, stannous fluoride, triclosan and essential oils.\(^19\)\(^,\)\(^20\) Planktonic bacteria are much more susceptible to antimicrobials than bacteria growing in a biofilm.\(^21\) In the oral cavity bacteria are mainly present in a biofilm mode of growth. Oral biofilms are diverse communities of microorganisms, embedded in a self-produced matrix of extracellular-polymeric-substances.\(^22\) The
extracellular matrix acts not only as a glue for the biofilm, ensuring adhesion to a substratum and integrity of the biofilm itself, but also hampers penetration of antimicrobials into the biofilm to offer protection to organisms in a biofilm mode of growth.

Previous studies have shown that after a single self performed brushing, about 40% - 50% of the biofilm is left behind. This biofilm is potentially harmful, but once antimicrobials have penetrated the biofilm, it can also act beneficially as a reservoir for oral antimicrobials, ensuring their prolonged action. The antimicrobials absorbed in biofilm left behind can be released over time in effective amounts, preventing new biofilm formation. This demonstrates that penetration of antimicrobials into oral biofilm is very important for both direct and prolonged action in controlling the biofilm. By mechanically disrupting the biofilm and therewith simultaneously altering its structure and viscoelastic properties, absorption of antimicrobials will be enhanced. Due to the crevices and niches in orthodontic appliances and retention wires, mechanical disruption of the biofilm is difficult by manual brushing, but is likely to occur through non-contact brushing with a powered toothbrush.

In this thesis we focus only on biofilms formed on orthodontic retention wires. Many different types of retention wires are available, as can be divided in two groups: single-strand wires and multi-strand wires. Multi-strand wires provide additional flexibility compared to single-strand wires, which allows physiologic movement of the bonded teeth instead of fixing them all as one unit. Therefore multi-strand wires are bonded to all front teeth, whereas single-strand wires are generally only bonded to the canines. From a clinical point of view, multi-strand wires are preferred, since their long-term effectiveness in preventing incisor irregularity is higher than that of single-strand wires.

We hypothesise that the amount of biofilm formation is dependent on the wire type, since the crevices and niches in the multi-strand wires provide a protected environment for biofilm growth. For this same reason, we hypothesise that the effect of manual removal of the biofilm and chemical control through oral antimicrobials is reduced for multi-strand wires compared to single-strand wires. Furthermore we hypothesise that to improve antimicrobial penetration into the biofilm of the multi-strand wires, it is beneficial to mechanically disrupt the biofilm by powered toothbrushing that has been proved to provide the energy necessary for disrupting the structure of the biofilm.

The general aim of this thesis is to verify the above hypotheses through evaluating the factors that play a role on biofilm formation on orthodontic retention wires and to determine how biofilm formation and antimicrobial penetration into the biofilm can be influenced.
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