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Fixed orthodontic retainer coating and antimicrobial treatment: A review article

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Aim: Permanent retention is strongly recommended by several studies as an essential measure to prevent relapse in the long run. The use of orthodontic appliances upsets the oral environment's delicate balance and increases the amount of pathogenic germs linked to demineralization of the enamel and periodontitis. However, antibacterial toothpaste and mouthwash, as well as modified adhesives sandwiched between the enamel surface and the bracket base, have a limited ability to inhibit microorganisms. These materials cannot offer a consistent, long-lasting antibacterial effect. Orthodontic appliances have to be altered to incorporate an antibacterial element in order to give a consistent, long-lasting result. In this review, we look for articles that use coating and treatment to increase the antimicrobial effect of fixed orthodontic retainers. Fixed retainers may be utilized unless there are certain reasons not to, such as active cavities or periodontal disease, poor dental hygiene, an anterior deep bite that requires maxillary retention, abnormal morphology of the lingual teeth, or inadequate therapy.

By reviewing the previous articles concerning the coating and antimicrobial treatment of fixed orthodontic retainer from different journals in PubMed and Google scholar, Identifying the existing correlation between coating and antimicrobial activity of fixed orthodontic retainer.

Keywords: Resin materials, denture cleansing tablets, surface roughness.

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Introduction

The preservation of teeth in their ideal functional and cosmetic positions could be a practical definition of retention in the context of orthodontics. [1] For many years, removable appliances have been utilized to aid in retention. Fixed retainers were first used in the 1970s to stop lower incisor relapses. [2] Because they are aesthetically pleasing and comfortable for patients to wear over time, orthodontists are increasingly choosing these retainers that are bonded to the lingual faces of the teeth. [3] According to a 2002 survey, 5% of orthodontists favored fixed retainers in the maxilla, whereas one-third chose fixed retainers in the mandible. [4] Another study from 2011 found that 11% of orthodontists in the maxilla and 42% of orthodontists in the mandible choose permanent retainers. [5] With the exception of the requirement for more thorough dental hygiene surrounding the retainers, the main benefit of the fixed retainer procedure over detachable retainers is that patient compliance is not required. [6] The most common issue is the increased risk of plaque and calculus formation due to inadequate cleanliness practices. This is caused by limited access to the region and difficulties with flossing between teeth. [7]

The four points listed below have already been covered in relation to FRs and periodontal health: 1. FRs increase the buildup of calculus and plaque. [8] 2. Shirasu et al. (2007) [9] found that plaque buildup around FRs promoted periodontal tissue difficulties; 3. Torkan et al. (2014) [10] found that FR type effects periodontal issues; and 4. Spending more time with FR is more important than using a certain sort of wire. Periodontal tissues may be damaged directly by FRs, which may manifest as a buildup of plaque and calculus, recession of the gums, gingival crevicular fluid volume (GCFV), pocket probing depth (PPD), loss of attachment, and/or a reduction in bone level. [2]

The accumulation of calculus and biofilm around retention wires is a potential downside of these devices. This may lead to deeper pockets, bleeding when probing, and an increased risk of gingival recession. [11]

In vitro studies have shown that the shape of the retention wire affects the number of live organisms in the biofilm.[12]. In comparison to biofilms preformed on single-strand wires, those preformed on multi-strand wires were able to produce a higher number of viable organisms after a single exposure to a sodium lauryl sulphate toothpaste slurry and an essential oil mouthrinse. Biofilms developed on multi-strand wires don't appear to be as susceptible to oral antimicrobials as those on single-strand wires. Biofilms protect their hosts from antimicrobial agents throughout their growth [13], and this protection may be enhanced when biofilms grow in the tight spaces around retention wires. So far, it is unclear how differences in oral biofilm sensitivity to different wire shapes in vitro transfer to biofilm development in vivo when antibacterial healthcare products, such as toothpastes or mouthrinses, come into play, are used. [14] It was necessary to create fixed retainers with local site antibacterial qualities in order to benefit from them and prevent periodontal issues as a side effect. This is also because the balance of normal flora must be maintained, which means that antibacterial gargles cannot be taken daily for an extended period of time.

Recently, dangerous microorganisms have developed resistance to antimicrobial drugs, posing a serious threat to the healthcare sector. [15] Thanks to developments in nanotechnology and biological sciences, intelligent surfaces that reduce infection rates can now be created. The ideas brought forward here, which are based on nanotechnology, might be helpful in creating materials that prevent or reduce the generation of airborne virus droplets when used in biomedical equipment and protective gear for medical staff. [16] Multiple studies have shown that antimicrobial coatings made of metal ions or metal-based compounds, such as Au-NPs, Se-NPs, Ag-NPs, MgO-NPs, CuO-NPs, TiO2-NPs, or ZnO-NPs, are effective. The precise mechanism of action of metal-oxide nanoparticles as antibacterial agents remains unknown. According to Salem (2022) [17], potential ways to combat bacteria include varying ion concentrations, oxidative stress, reactive oxygen species (ROS), and damage to their membranes. Nanoparticles' antibacterial mechanism is yet unknown, however there is exciting evidence that suggests they may pass through microbial membranes, block metabolic pathways, and alter the shape and function of membranes when they come into contact with germs. When inside the cells, these nanoparticles change the levels of gene expression, damage proteins, induce oxidative stress and electrolyte imbalance, and obstruct the production of enzymes. [18]

The effects of electrodeposited polyethylene glycol on titanium biofilm adhesion were investigated by Tanaka et al. in 2010. [19] Protein-resistant coatings for titanium have been researched to prevent the formation of biofilms. The researchers in this work biofunctionalized titanium (Ti) surfaces via electrodeposition of poly(ethylene glycol, or PEG). After that, the surfaces were tested in a simulated mouth setting to see how well they formed biofilms. A quantitative and topological analysis was conducted on surfaces that had been electrodeposited with titanium (Ti) or PEG and had been inoculated with the early oral biofilm colonizer Streptococcus gordonii. After being given sucrose for 20 hours, Streptococcus mutans, a late colonizer often observed in dental plaque, also formed biofilms on the surfaces of Ti and PEG-Ti. The biofilms were then separated using sonication. The findings showed that PEG-Ti surfaces suppressed S. gordonii adhesion relative to Ti, and that S. mutans biofilm was easier to remove from PEG-Ti surfaces than Ti ones. Proteins from saliva were also less adsorbed when PEG was electrodeposited onto the Ti surface. It seems that the biofilms had a poor base adhesion to the electrodeposited surfaces, as the inhibition of salivary protein adsorption was correlated with the degree to which the biofilms separated from PEG-Ti. To prevent bacterial contamination of metal surfaces, it may be beneficial to regulate protein adsorption during the early stages of biofilm growth in dental and orthopedic applications.[19]

Research has shown that retention wires can lead to biofilm growth, gingival recession, bleeding when probed, and deeper pockets around bonded retainers. [12] What this means in terms of the biofilm formation on the stainless steel and gold wires used in bonded retainers and how sensitive these materials are to oral antimicrobials in both controlled and uncontrolled environments. We examine the susceptibility of in vitro biofilms to oral antimicrobials and conduct an analysis of the biofilm development on various wires used in bonded retainers, both in vitro and in vivo. In comparison to multi-strand wires, his research found that single-strand wires only slightly decreased the quantity of biofilm that was attracted to them in vitro. In contrast to biofilms on multi-strand and single-strand gold wires, those on stainless steel single-strand wires were much more vulnerable to antimicrobials found in mouthrinses and toothpaste slurries. Furthermore, single-strand wires demonstrated much lower biofilm in vivo compared to multi-strand wires. In terms of effect on biofilm microbial composition, the wire type was less influential than the volunteer. According to his findings, single-strand stainless steel wires are more vulnerable to antimicrobials and do not attract as many biofilms in vitro as multi-strand wires. Furthermore, multi-strand wires have a reduced in vivo biofilm attraction compared to single-strand wires. The therapeutic implications of his findings suggests that single-strand wires are preferable to multi-strand ones due to the fact that biofilms on the former are less protected from antimicrobials than those in the latter's niches and crevices. [12]

In their study, Ryu et al. (2012) looked at the antibacterial characteristics of a silver-platinum coating for orthodontic tools. The goal was to develop a long-lasting coating for stainless surfaces using silver-platinum alloys. The coatings demonstrated substantial antibacterial action against Streptococcus mutans and Aggregatibacteractinomycetemcomitans strains when immersed in phosphate-buffered saline, in addition to releasing an adequate amount of Ag ions. However, there was no negative impact on human gingival fibroblast cells. During active orthodontic treatment, Ag-Pt coatings on the surfaces of load-bearing orthodontic brackets can offer appropriate antibacterial activity.

In 2013, Arango et al. were provided with a synopsis of the surfaces treatment and coating methods used for orthodontic metallic biomaterials. They came to the conclusion that orthodontic surface therapy is a significant and ongoing field of study. The surfaces of dental materials have been altered using a wide range of materials and methods. Only a small number are now utilized in clinical orthodontics, particularly in areas like bacterial adhesion reduction and friction management. Multidisciplinary research has supported bridging the gap between clinical practice and material surface engineering in recent years. As a result, more novel products have been released, which have improved treatment times and decreased biological and financial expenses [20]. Researchers Morita et al. (2014) [21] looked at how a silver ion coating on orthodontic retainers that are permanently placed in the mouth affected the growth of bacteria that cause oral diseases. We tested the impact of covering orthodontic retainer wires made of titanium and stainless steel with Ag ions on the pathogenicity and frequency of common oral infections. The study examined three kinds of bacteria that cause periodontal disease and two species of bacteria that cause cavities. Also examined were biofilms of Streptococcus sobrinus and two volatile sulfur compounds (VSCs) produced by P. gingivalis. Statistically significant differences ($p<0.05$) were seen between uncoated and Ag ion-coated wires in terms of their robust antibacterial capabilities. Radial diffusion studies revealed that all wires coated with Ag ions, whether they were Ti+ or SS+, had zones around them that were resistant to bacterial growth that were larger than 2 mm in diameter. No harmful effects were seen in the 24 hours of Ag ion release, which was 0.043 ± 0.005 ppm. Thus, our results suggest that basic Ag ion coating on pure titanium and stainless steel wires may reduce the growth and destructive activities of oral pathogenic bacteria even in the early stages of culture. [21]

Research by Rahmani et al. (2017) looked at the impact of orthodontic fixed retainers coated with silver ions on the health of rabbit gums from a clinical, histological, and histomorphometric perspective. The results demonstrated that the four groups differed significantly with respect to lymphocytic infiltration. Gingival irritation caused by plaque accumulation may be reduced by applying silver ions to the surface of fixed orthodontic retainers.

In 2017, Kuroiwa and his colleague coated an orthodontic resin with titanium dioxide (TiO_2), a UV-responsive photocatalyst. Investigations were conducted on the mechanical, hydrophilic, and antibacterial effects of the TiO_2-coated resin on oral microorganisms. The light source was ultraviolet A (UVA) light, which has a wavelength of 352 nm. Irradiation and antibacterial activities were compared. Following irradiation for varying lengths of time, measurements of early colonizers and the cariogenic bacterial count, or colony forming units (CFU), were made. Water contact angle measurements were used to assess hydrophilic characteristics. The three-point bending test was used to quantify flexural strength in order to evaluate mechanical attributes. The CFU were much lower in the coat(+)light(+) samples than in the control samples. Following irradiation, the water contact angle of the coat(+)light(+) samples reduced. The long-term irradiated specimen's flexural strength was higher than the necessary standard value, suggesting that the irradiation's influence was minimal. They propose that the creation of orthodontic resin with antibacterial qualities can benefit from coating with the UV-responsive photocatalyst TiO2. [22] With Treponema denticola as their target, Santoso and Purbiati (2019) [23] studied the antimicrobial effects of silver nanoparticles on permanent retainer glue. Using flowable composites reinforced with AgNPs in fixed retainers reduced the quantity of T. denticola bacterial colonies, they found. Fixed retainers may provide the added benefit of preventing periodontal disease, which is a common side effect of these types of orthodontic appliances. The results of this study might serve as a foundation for future investigations into the use of antibacterial compounds to modulate permanent retainer adhesive. The addition of AgNPs has a clear antibacterial effect. Santoso and Purbiati (2019) [23] note that further research is necessary before this formula may be applied to people. Composite resins used in fixed orthodontic retainers containing nano-silver (NAg) particles were studied in 2021 for their antibacterial efficiency by Mirhashemi et al. In order to determine NAg's antibacterial activity, we used the biofilm inhibition test (with biofilms that were three days old), the disk-diffusion agar test (after 48 hours), and the eluted components test (on days 3, 15, and 30). Findings included antibacterial activity in NAg-containing composites, an increase in antibacterial effects with increasing NAg content, and a substantial drop in colony counts of S. mutans, S. sanguis, and L. acidophilus in NAg-containing composite resins. No zone of inhibition for growth was seen at 1% and 2% NAg concentrations. Nevertheless, a concentration of 5% was shown to have this effect. The addition of NAg particles to orthodontic fixed retainer composite resins seems to provide generally beneficial antibacterial characteristics. The specific features of the mouth, such as the presence of saliva, temperature fluctuations, food with different pH levels, etc., restrict the applicability of this experimental finding to real-world clinical situations. The effectiveness of composite resins containing NAg on clinical problems needs more research. [24, 29] Antimicrobial compounds are being researched and used in orthodontic appliances and auxiliaries in a variety of ways to lessen plaque buildup. As nanotechnology has advanced, nanoparticles (NPs) have been used in orthodontic materials to reduce the buildup of tooth plaque because of their superior antibacterial qualities. This article provides a comprehensive overview of the history, development, biocompatibility, and applications of antibacterial nanoparticles in orthodontic materials as of the year 2022. In the course of orthodontic treatment, bacteria accumulation is a common problem. Dental cavities and periodontal disease are among the negative consequences of orthodontic equipment and auxiliary devices, which encourage the buildup of supragingival and subgingival biofilms and impair oral hygiene. [25] Various practitioners have used various bonding methods for fixed lingual retainers over the years. Because it might be difficult to stable the wire during bonding, many orthodontists employ several materials to support the wire in order to achieve precise bonding[26]. Metalic and non metallic lingual retainer had been used for retension and each type expit different advatages and disadvatades. [27, 28]

It was examined how chitosan affected the coating of silver oxide nanoparticles' adherence to SS 316L. Results from the adhesion test and light microscopy analysis of the treated samples indicated that 7.5 g/L, 30 V, and 2 minutes of deposition time produced the best results. We used a range of values for the EPD coating method's three parameters—concentration, duration, and voltage—at room temperature. XRD analysis of the coated samples revealed no phase transition. Since EPD is an inexpensive and simple coating technique, the outcomes in the medical field are encouraging. [18]

Coating materials, like nanoparticles, need more research to validate their efficacy over the long term and address any safety issues (toxic effects) related to their size.

Conclusion

While most of the published studies only looked at the physical or antibacterial properties for a short period of time (a day or two at most), the application of nanoparticles and surface treatment in orthodontic fixed retainers may improve the materials' antimicrobial and physical qualities. Recognizing the limitations of research that are primarily in vitro is also crucial.

Author contributions

Responsibility for the manuscript's content and similarity index rests with all authors, who have all seen and accepted the final version.

Conflicts of Interest

No conflicts of interest

Ethical Clearance

This review has no ethical approval (no new materials were used).

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