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# NEW GENERATION OF ANTIMICROBIAL RESINOUS MATERIALS FOR BRAQUETTING: A SOLUTION FOR REDUCING WHITE SPOT LESIONS?

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## INTRODUCTION

Nowadays, the growing demand for aesthetics motivates many patients to visit the dental office in order to change tooth positions, angles, shapes, colors and functions[1]. Since the beginning of the development of orthodontic treatments, it was known that the teeth could have their positions modified and corrected, through the application of forces idealized by different types of devices for carrying out tooth movement.

Among some components necessary for orthodontic practice, there are brackets that, with the arrival of adhesive systems, are no longer welded to metal bands and today have structures that allow direct or indirect bonding to the surface of the teeth. Orthodontic bonding with light-curing resinous adhesive materials and systems was first reported in 1979 by Tavas and Wats[2].

The advantage offered by this type of cementation is to allow the clinician enough working time to perform the desired positioning of the orthodontic brackets, reduce the risk and incidence of cross contamination and also allow an easy removal of excess material after the idealized positioning. However, despite all current developments, demineralization around these appliances continues to represent a major problem for patients undergoing treatment with fixed appliances. Often, with the bonding of brackets and the use of accessories such as buttons, ligatures and wires, cleaning by patients is difficult. With the accumulation of plaque and biofilm around the brackets, the dental surfaces become rougher and more irregular, providing oral conditions that will favor the colonization and development of cariogenic bacteria in these regions[3].

These bacteria, once developed, will be responsible for the production of organic acids capable of inducing the demineralization of the dental enamel[4,5] and then lead to the formation of caries, most commonly in the form of white spot lesions on the labial surfaces[6,7]. The literature reports a prevalence of 50% to 70% of these types of injuries after fixed orthodontic therapies, and that their development may take only 1 month to occur[1,3].

Faced with this challenge, the search for methods that can reduce the incidence of white spot lesions, that can prevent the development of possible periodontal diseases and improve oral health during orthodontic treatments, remains constant. Among the commonly used therapeutic efforts, we find activities such as: patient awareness of the importance of proper oral hygiene; modification in the diet seeking a low content and low frequency of carbohydrate intake; treatment with topical and controlled application of fluorides[8]. These methods, already established in the literature, however, which depend on the patient's cooperation and may not be the most reliable[9].

Thus, in view of the current scenario, efforts in the industry have intensified in the search for and improvement in the development of materials with properties that can act in therapeutic activity, and also independently of patient collaboration, that is, bonding agents that can act repellent and/or prevent bacterial growth, also promising to inhibit demineralization adjacent to existing orthodontic brackets[3].

Within this class of materials are included formulations using different concentrations and different antibacterial agents; formulations that present better mechanical properties in order to reduce failures arising from micro infiltrations, avoiding the formation of carious lesions adjacent to the brackets10 And also, the development of materials that facilitate a simplification of the technique, facilitating the execution and reducing the failure rate by methods clinical operations performed incorrectly[11]. (Malavasi, CV 2015)

Thinking about the constant changes in the development of the different materials used in orthodontic bonding, the objective of this work is to present a critical review regarding the new technologies existing in the market and the new trends that develop in the scientific field.

## LITERATURE REVIEW

### DEFINITION

Dental caries is one of the most common diseases, especially in childhood. The caries formation process is characterized as a cycle of remineralization and demineralization with several stages, being reversible or irreversible[12]. White spot lesions (WSLs) are defined as enamel surface and mineralized subsurfaces, without cavitation. These manifestations may represent the first clinical observation of a progression of dental caries, with the possibility of being reversed[10].

White spot lesions develop as a result of prolonged accumulation of plaque on surfaces usually due to poor oral hygiene[13,14]. If these conditions are maintained, the acids produced by cariogenic bacteria diffuse through the enamel and begin to promote demineralization. If this process is not stopped, the intact enamel surface eventually collapses and a cavity is formed[12,15].

These lesions are characterized by an opaque white appearance and are commonly located in pits, fissures, and smooth surfaces of teeth. However, after the placement of fixed orthodontic appliances, there is an increasing number of plaque retention sites due to the presence of brackets, bands, wires and other accessories, which can make cleaning difficult for patients[10,16].

Clinical features of these lesions include loss of normal translucency, an opaque white appearance, particularly when dehydrated; a brittle surface layer susceptible to drilling damage, particularly in pits and fissures; increased porosity, particularly of the subsurface, with greater potential for absorbing stains; that can be detected radiographically, with transillumination or with modern laser detection devices [17].

### MATERIALS USED FOR BRAQUETTING

The first and most popular resins used for the bonding mechanism were self-healing chemical systems. A major disadvantage of these self-curing systems is the inability to manipulate the working time of the polymer[2], which is why, currently, the systems are more commonly presented in the form of light-cured resins.

Comparing the composition of the different resins, differences can be observed mainly regarding the type of filler, the amount of filler and their molecular weight. The main difference found in traditional composite resins in relation to those used for orthodontic purposes may be the amount of load, which leads to changes in viscosity and different mechanical behavior of these materials.

Self-etching adhesives were the most recently introduced in operative dentistry and orthodontics. The elimination of acid etching, washing and surface drying steps can reduce the risk of cross-contamination[18]. These self-etching materials combine properties of acid etching agents and adhesive properties.

### MATERIALS WITH ANTIBACTERIAL PROPERTIES

#### Modified materials

Concomitantly with the development of simplified materials, there are many materials that present therapeutic activities. These materials are being increasingly used in direct restorative procedures and also as bonding agents for orthodontic brackets and/or brackets.

### Resin-modified glass ionomer cement

Resin-modified glass ionomer cements (RMGIs) were used and still are options of choice in orthodontic cementation because of their fluoride (F) releasing capabilities and because of their ability to bond orthodontic braces with bonding forces considered acceptable[19]. Less bacterial colonization and less plaque accumulation can reduce enamel demineralization and white spot lesions. However, studies have already reported that RMGIs could accumulate more bacteria when compared to other types of materials. This is due to the relatively rough surfaces, high surface free energy and polarity of these materials[20]

Furthermore, studies indicated that the duration of F release was short-term. Ions released from RMGIs begin with an initial burst upon binding, but are preceded by a rapid fall over time. Another key factor in this dynamic is the maintenance of adequate oral hygiene. Plaque accumulation around brackets keeps pH levels below 4, such a low pH hinders the remineralization process, so more F ions are not able to produce a better cariostatic effect[21,22].

### Giomer

This new class of materials emerged adapting and associating the technologies found in glass ionomers and composite resins. Giomers are materials that seek to overcome the disadvantages of glass ionomer cements, being the result of a recent composite resin technology as a direct aesthetic restorative material to be used in anterior and posterior tooth restoration, presented as the true ionomer hybridization glass and composite resin[23,24].

The giomers feature particles filled with a pre-reacted surface of glass ionomer inside an organic composite resin matrix, combining the release and recharge capacity of fluorine ions found in GIC, presenting better mechanical resistance, aesthetic quality, better physical properties and better handling of the material: facilitating insertion during the operative stage performed by dentists[25].

### Addition of antimicrobial nanoparticles in resins

In addition to the creation of new monomers, new polymeric formulations and the development of different polymerization methods in order to improve the properties of resinous composites[26], many studies have focused on the pre-treatment of inorganic fillers and the addition of nanoparticles to the polymer composition[27,28]. Thermal treatments of polymerization and post-polymerization are able to increase the degree of conversion of monomers and improve the resistance of composites, and nanofillers and fibers act as the main reinforcing fillers in the composition of these materials[29].

With the great development of nanotechnology and nanometer-phase materials, much attention is directed towards the production of a nanocomposite with improved mechanical and physical properties compared to fillers with microparticles, hybrids and microhybrids. Furthermore, the use of multiple nano fillers instead of a single additive is capable of developing a high performance compound30. The mechanical properties of nanocomposites strongly depend on the dispersion and adhesion of fillers at the resin matrix interface; and also the surface treatment of the fillers in a compatibility agent between the filler and the matrix[28,29].

Zirconium oxide (ZrO2) and titanium dioxide (TiO2) nanoparticles have mechanical, physical and photocatalytic properties that make them interesting additives; The titanium dioxide (TiO2) nanofiller has an antibacterial effect, features biocompatibility and minimal toxicity. These nanofillers along with the antibacterial effect are also suggested as reinforcing particles[31]. Zirconium oxide (ZrO2) has also been quoted for its biocompatibility and the fact that it is white in color reduces the chance of cosmetic changes occurring in these. In a study carried out by Felemban[28], ZrO2 and TiO2 nanoparticles (at 1% and 0.5% w/w) were found to be better than single unit additives, mainly due to the difference in size between titanium and zirconia.

Other commonly tested and studied substances are quaternary ammonium methacrylates (QAMs), already considered effective anti-biofilm agents. However, the antibacterial activity of QAM in an orthodontic cement is limited to the surface of the material due to the "contact inhibition" mechanism of action. It is beneficial for orthodontic cement to kill not only the biofilms on its surface, but also the biofilms close to it far from its surface, because the accumulation of plaque in the proximity of the bracket can still produce acids capable of causing lesions in the white spot[32].

Silver (Ag) is an antibacterial ion with broad action against microorganisms. Previous studies have developed composite resins containing silver nanoparticles (NAg) with potent antibacterial activity[33]. The NAg particle tested in a resin-modified glass ionomer, in fact, also inhibited the biofilm that was distant from its surface, without compromising the color of the material used, due to the low concentration of Nag.

In addition to the development of these reinforcements, there are several other antibacterial components added to the composite resin and adhesive system, seeking to disinfect the area around the restorations for a prolonged period of time. Substances such as dodecylamine, bipyridine, tannic acid derivatives, polyhexanide, amphilic lipids, silver, sodium chloride gluconate and fluorides, also incorporating TiO2 into the orthodontic adhesive, have been shown to improve the antibacterial effect and have also shown the ability to reduce roughness surface of the materials, consequently reducing the retention of plaque\biofilm around the orthodontic adhesives[29].

## DISCUSSION

Previous studies[5,34,35,36], show that patient cooperation in preserving good oral hygiene is always a challenge during orthodontic treatment, therefore, materials with therapeutic activity, which are capable of preventing caries and white spot lesions, are being increasingly used and perfected in industries.

However, it must be taken into account that, despite the composition of orthodontic cements being similar to restorative composites, these materials require some adjustments in the rheological conditions and variation in the amount of filler in their composition. It is idealized that orthodontic cements present characteristics, such as: flow to fill the mesh of the brackets; bond strength and chemical stability, which must be strong enough to support the bracket attached to the tooth throughout the treatment, while minimizing the risk of dental fracture and damage to the enamel; ease of removal of residues before polymerization of the material; biocompatibility; satisfactory roughness to avoid plaque accumulation; be available at a reasonable cost[37].

In addition to these factors, it is idealized that these materials present a good performance for the clinician, that is, during the positioning of the bracket on the tooth, the cement must offer sufficient rigidity and not allow the accessory to move from the desired location. To reach this objective, an orthodontic cement must have an adequate level of inorganic load. Faltermeier et al[37], studied the effects of different compositions of resin cements and concluded that composite resins with a high filler concentration and with particles of different sizes show better results in terms of mechanical properties.

Ujigo et al[38], analyzing the influence of filler content on wear resistance of restorative resin cements, found that those whose percentage of filler was less than 70% by weight had lower wear resistance than those whose percentage was higher than this value. Moszner and Salz[39] report that a resin that has an amount greater than 80% of inorganic phase may compromise its mechanical properties, making the material friable.

Therefore, the fact that orthodontic resins present a greater amount of charge, provides a greater viscosity in these materials. As a disadvantage, the lower flow can make it difficult to adequately fill the mesh at the base of the bracket with the porosities on the surface of the tooth enamel.

Due to this deficiency, some authors[40,41] also consider the use of low-viscosity resins, flowable or flowable, for cementation of brackets. These resins have a low cost, low modulus of elasticity and high fluidity, also allowing a better adaptation in the anchorage areas and demineralized region around the dental enamel. However, according to Bishara[42], these materials are not recommended because they have lower bond strength values than the others. This fact occurred due to the polymerization contraction of these polymers, thus capable of leading to marginal infiltrations, and to an early rupture of the adhesive layer.

Other options for adhesive materials in orthodontics include resin cements used for cementing prosthetic parts, which can be simplified (self-etching and/or self-adhesive) or not. These materials are capable of forming a bond with enamel, dentin, porcelain, metal and composites, and are often used concomitantly with other bonding agents[43]. The great advantage of simplified materials is to provide a reduction in working time and a reduction in errors during the application of the technique, since they present a smaller number of steps in the clinical procedure[11].

The literature reports that most of the remaining cement after debonding remains at the resin-bracket interface [6]. This occurs due to incomplete polymerization of the cement below the base of the metal bracket, as light is not able to reach the cement behind the bracket mesh. In an attempt to improve these bond strength values, a new design of the bracket base was developed, which consists of a thin layer of multifunctional methacrylate derived from Bis-GMA. These systems are known as APC or pre-coated, and are presented as APC I, II and Plus (3M Unitek, Monrovia, USA). The composite present in this base is considered similar to Transbond (3M Unitek, Monrovia, USA), however it presents small changes in the proportion of the components and must be light-cured at the time of use.

In orthodontics, resistance to shear forces is considered one of the main factors that must be analyzed in view of the evolution of the most recent bonding materials[42]. Studies demonstrate that bond strengths between 5.9 - 7.8 MPa are enough to withstand orthodontic treatment and mastication forces exerted on the oral cavity[44]. Bishara et al[45], compared the bond strength of a self-etching primer used with composite resin with a conventional-type bonding system, and found mean bond strengths of 10.4 and 11.8 MPa, respectively. It is reported that depending on the acidity level of the self-etching primers, these materials can have a bond strength ranging from 2.8 to 16.6 Mpa[44].

Based on this, there are many factors that must be taken into account when stipulating whether a particular bonding agent may or may not be suitable for orthodontic use. In addition to all the analysis of existing antimicrobial capacity, a new generation of materials with therapeutic capacity, which must be deeply analyzed in relation to physical, chemical and adhesive properties. Since antimicrobial adhesive materials can be either self-etching or conventional, it is known that their composition changes and their characteristics change.

Resin materials, in addition to adequate adhesion capacity, must maintain an aesthetic quality on their surface, as it is known that materials with high roughness end up accumulating more biofilm[11], favoring the demineralization process and the development of white spots and caries lesions.

## CONCLUSION

Faced with changes and the constant emergence of new dental materials, it is interesting that the dental surgeon is aware of the main developments that have occurred. The development of modified techniques and materials can be beneficial and can be an interesting alternative for better control over the incidence of white spot lesions and caries. However, mastering the technique is essential. The correct use of the material is of fundamental importance for the success of each treatment performed, regardless of the type of material, both in orthodontics and in operative dentistry.

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