UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU

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Performance of giomer-based resin composites under erosive wear and its influence on the adjacent enamel alteration: *in vitro* study

Desempenho de resinas compostas a base de giomer submetidas ao desgaste erosivo e sua influência na alteração do esmalte adjacente: estudo *in vitro*

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Dissertação apresentada a Faculdade de Odontologia de Bauru da Universidade de São Paulo para obtenção do título de Mestre em Ciências no Programa de Ciências Odontológicas Aplicadas, na área de concentração Odontopediatria.

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“Seja a mudança que você quer ver no mundo”

Mahatma Gandhi

ABSTRACT

Performance of giomer-based resin composites under erosive wear and its influence on the adjacent enamel alteration: *in vitro* study

BERGANTIN, Bianca Tozi Portaluppe. **Performance of giomer-based resin composites under erosive wear and its influence on the adjacent enamel alteration: *in vitro* study.** 2019. 35 p. Dissertação (Mestrado em Ciências Odontológicas Aplicadas) – Faculdade de Odontologia de Bauru, Universidade de São Paulo, Bauru, 2019.

Erosive tooth wear is the permanent loss of hard dental tissue by the frequent action of chemical and mechanical challenges. This condition has shown an increase in its prevalence in recent years, requiring intervention in the process, ideally through preventive therapies, however, these lesions often need restorative therapies. The objective of this study was to test the use of Giomer-based resins under conditions of erosive tooth wear and its effect on adjacent enamel compared to conventional composite resin and glass ionomer cement by means of an in vitro evaluation, leading to taking into account its differentiated recharge and fluoride release technology, satisfactory aesthetics and resistance and its ability to neutralize acid pH. For that, 120 specimens of bovine teeth were obtained, selected and randomly distributed in 12 groups (n = 10): GI: Composite Nano-Hybrid Resin with Giomer technology (EROSION); GII: Composite Nano-Hybrid resin with Giomer technology (EROSION + ABRASION); GIII: Resin Composed of single increment with Giomer technology (EROSION); GIV: Composite resin of single increment with Giomer technology (EROSION + ABRASION); GV: Micro-Hybrid Composite Resin (EROSION); GVI: Micro-Hybrid Composite Resin (EROSION + ABRASION); GVII: Single-increment Micro-Hybrid Composite Resin (EROSION); GVIII: Single-increment Micro-Hybrid Composite Resin (EROSION + ABRASION); GIX: Conventional Glass Ionomer Cement - CIVC (EROSION); GX: Conventional Glass Ionomer Cement - CIVC (EROSION + ABRASION); GXI: Resin Modified Glass Ionomer Cement - CIVMR (EROSION); GXII: Resin Modified Glass Ionomer Cement - CIVMR

(EROSION + ABRASION). In each enamel specimen a cavity was made and the restorative material was inserted under study according to the manufacturer's specifications. The initial profile was then performed, with scans of the material and the adjacent enamel (at 100, 200, 300, 600 and 700μm). During 5 days, 6 erosive challenges were performed with citric acid for 2 minutes and in the EROSION + ABRASION groups the brushing was performed for 1 minute in a simulated brushing machine, immediately after erosion and washing. Subsequently the final profile was made in the same locations of the initial, for graphic overlap and analysis of loss of material and enamel. The data were evaluated for normality and homogeneity by two-way ANOVA and then the Tukey test was used for comparison between groups, considering $p < 0,05$. When subjected to erosion, the GIX and GXI groups presented greater loss of material compared to the other groups. Up to 300μm away from the restoration, the GIC groups and Giomer-based resins were able to promote less enamel loss than the conventional resin. For erosion associated with abrasion, Giomer-based resins showed intermediate loss of material, with greater loss in ionomeric groups and lower loss in conventional resin, with no difference between adjacent enamel in these conditions. It was concluded that Giomer-based resins are a good alternative for restorative treatment of erosion lesions.

Keywords: Dental Erosion. Tooth Wear. Dental Materials.

RESUMO

BERGANTIN, Bianca Tozi Portaluppe. **Desempenho de resinas compostas a base de giomer submetidas ao desgaste erosivo e sua influência na alteração do esmalte adjacente: estudo *in vitro*.** 2019. 35 p. Dissertação (Mestrado em Ciências Odontológicas Aplicadas) – Faculdade de Odontologia de Bauru, Universidade de São Paulo, Bauru, 2019.

O desgaste dentário erosivo é a perda permanente de tecido dental duro pela ação frequente de desafios químico e mecânico. Essa condição vem apresentando um aumento na sua prevalência nos últimos anos, necessitando intervenção no processo idealmente por meio de terapias preventivas, entretanto, muitas vezes essas lesões necessitam de terapias restauradoras. O objetivo deste estudo foi testar a utilização de resinas a base de tecnologia Giomer, sob condições de desgaste dentário erosivo e seu efeito no esmalte adjacente em comparação com a resina composta convencional e cimento de ionômero de vidro por meio de uma avaliação in vitro, levando em conta sua tecnologia diferenciada de recarga e liberação de flúor, estética e resistência satisfatórias e sua capacidade de neutralizar o pH ácido. Para tanto, 120 espécimes de dentes bovinos foram obtidos, selecionados e randomicamente distribuídos em 12 grupos (n=10): GI: Resina Composta Nano-Híbrida com tecnologia Giomer (EROSÃO); GII: Resina Composta Nano-Híbrida com tecnologia Giomer (EROSÃO + ABRASÃO); GIII: Resina Composta de incremento único com tecnologia Giomer (EROSÃO); GIV: Resina Composta de incremento único com tecnologia Giomer (EROSÃO + ABRASÃO); GV: Resina Composta Micro Híbrida (EROSÃO); GVI: Resina Composta Micro Híbrida (EROSÃO + ABRASÃO); GVII: Resina Composta Micro Híbrida de incremento único (EROSÃO); GVIII: Resina Composta Micro Híbrida de incremento único (EROSÃO + ABRASÃO); GIX: Cimento de Ionômero de Vidro Convencional - CIVC (EROSÃO); GX: Cimento de Ionômero de Vidro Convencional – CIVC (EROSÃO + ABRASÃO); GXI: Cimento de Ionômero Vidro Modificado por Resina – CIVMR (EROSÃO); GXII: Cimento de Ionômero Vidro Modificado por Resina – CIVMR (EROSÃO + ABRASÃO). Em cada espécime de esmalte foi confeccionada uma cavidade e

inserido o material restaurador em estudo de acordo com as especificações do fabricante. A seguir foi realizado o perfil inicial, com varreduras no material e no esmalte adjacente (a 100, 200, 300, 600 e 700µm). Durante 5 dias foram realizados 6 desafios erosivos com ácido cítrico durante 2 minutos e, posteriormente, nos grupos EROSÃO + ABRASÃO foi realizada a escovação por 1 minuto em uma máquina de escovação simulada, imediatamente após a erosão e lavagem. Posteriormente foi feito o perfil final nos mesmos locais do perfil inicial, para sobreposição gráfica e análise de perda de material e esmalte. Os dados foram avaliados quanto à normalidade e homogeneidade por meio do teste ANOVA a dois critérios e então foi feito o teste de Tukey para comparação entre os grupos, considerando $p<0,05$. Quando submetido à erosão, os grupos GIX e GXI apresentaram maior perda de material comparado aos outros grupos. Até 300µm de distância da restauração, os grupos de CIV e resinas a base de Giomer foram capazes de promover menor perda de esmalte que a resina convencional. Para erosão associada à abrasão, resinas a base de Giomer demonstraram perda de material intermediária, sendo vista uma maior perda nos grupos ionoméricos e menor perda na resina convencional, não havendo diferença entre o esmalte adjacente nessas condições. Conclui-se que resinas a base da tecnologia Giomer são uma boa alternativa para o tratamento restaurador de lesões de erosão.

Palavras-chave: Erosão Dentária. Desgaste Dentário. Materiais Dentários.

SUMÁRIO

INTRODUCTION

1 INTRODUCTION

Erosive tooth wear is defined as a chemical-mechanical process involving a gradual loss of dental hard tissue by the action of intrinsic and extrinsic acids of non-bacterial origin. The decrease in the local pH generates a mineral loss on the enamel surface, which leads to a superficial softening. This enamel softened by erosion is extremely brittle and more susceptible to mechanical forces, such as abrasion by brushing (GRIPPO; SIMRING; SCHREINER, 2004), which, when frequent, lead to such wear (TEN CATE; IMFELD, 1996; CARVALHO et. al., 2015; ATTIN et. al., 2000).

This condition has been showing an increase in its prevalence in recent years (TSCHAMMLER et. al., 2016; SALAS et. al., 2015; BRUSIUS et. al., 2017), probably because of a greater exposure to its causal factors. These factors are associated with the presence of acids of intrinsic origin, such as gastroesophageal reflux or bulimia, and acids of extrinsic origin, such as acidic foods and beverages. The quantity, frequency and mode of consumption of these acidic foods and beverages influence its erosive potential. In addition, medications and supplements may also be erosive when in the form of chewable tablets or effervescent tablets, because they have acidity and may in some cases promote a decrease in salivary flow (HELLWI; LUSSI, 2014).

Saliva is considered an individual erosion protection factor because of its ability to form a dental film acquired on the dental surface, dilute acids and neutralize oral pH. Thus individual characteristics such as saliva are considered important factors in the etiology of dental erosion, since individuals exposed to similar erosive challenges present different tooth compromises, some of which do not present lesions of erosive dental wear, demonstrating that biological factors play a protective role crucial in the development of erosion lesions (CARVALHO et. al., 2015; LUSSI; CARVALHO, 2014).

In view of the greater exposure to causal factors that lead to an increase in the prevalence of dental erosion (LUSSI; CARVALHO, 2014; NUNN et. al., 2003), there is a need for intervention in the erosive process, ideally through preventive therapies

that, as a priority, must be present when given the diagnosis of dental erosion (NUNN, 1996), by changing the patient's habits, reducing erosive challenges and increasing protective factors, restoring balance. However, it is observed a difficulty in interfering with these habits (LUSSI, 2006; SERRA; MESSIAS; TURSSI, 2009), leading to the progression of lesions and consequent need for restorative therapies (LUSSI; CARVALHO, 2014; ZERO; LUSSI, 2005), which are determined by the complexity of the case, varying according to the sequelae caused by erosive tooth wear, whether they are symptomatic, functional or aesthetic (PEUZFELDT; JAEGGI; LUSSI, 2014). With the advent and improvement of adhesive systems, these erosion lesions can be restored in a less invasive manner using materials such as glass ionomer cements (conventional and resin modified) and composite resins.

The choice of material should be related to the longevity of the restoration, which depends on the level of tooth destruction and the durability of the material, which is related to its properties, such as wear resistance or biodegradation and durability at the interface between tooth and restoration (PEUZFELDT; JAEGGI; LUSSI, 2014, ROLIM et. al., 2016). Additionally, depending on the area of the impacted tooth, ideally, the material should exhibit favorable aesthetic properties. In addition, an advantageous preventive feature would be the material ability to inhibit the erosion of the adjacent dental structure, helping to maintain the patient's oral health (PEUZFELDT; JAEGGI; LUSSI, 2014), similarly to caries lesions when applying glass ionomers cements (GIC), which, because of its ability to recharge and release fluoride, decrease the chance of recurrence of secondary caries around the restoration (ALGHILAN et. al., 2015; RIOS et. al., 2007; TYRAS, 1991; FORSTEN, 1993). In erosion, there are controversial results regarding the prevention of erosive wear around restorations, where we have some studies showing that there is less wear around GIC (ROLIM et. al., 2016, ALGHILAN et. al., 2015) and others showing no significant difference between materials (RIOS et. al., 2007; FRANCISCONI et. al., 2008).

Literature shows that restorative materials can also be affected by erosive acids, decreasing their clinical performance and longevity (ALGHILAN et. al., 2015, HONÓRIO et. al., 2008). The composite resin presents smaller changes in its surface under erosive challenges when compared to GIC, however, another important property to be observed is the adhesion and formation of micro infiltration of

materials (HONÓRIO et. al., 2008), in which the Conventional GIC shows better results (WALIA et. al., 2016).

There is on the market a group of restorative materials known as "Giomer" or pre-reactive glass ionomer (PRG) from SHOFU. Giomer's technology is characterized by hybrid glass ionomer compounds whose particles consists of pre-reactive fluorosilicate with polyacrylic acid and are incorporated into a resin matrix (KOOI et. al., 2012). Bonding agents bind the particles to the resin matrix and catalysts are added to initiate polymerization of the material (KOOI et. al., 2012). These materials require adhesive and photopolymerization agents, are easy to handle (KOOI et. al., 2012), with various physical and chemical properties, such as anti-plaque effect reducing the risk of caries (YONEDA; SUZUKI; HIROFUJI, 2015; YONEDA et. al., 2012; NISHIO; YAMAMOTO, 2002), releasing and recharging of fluoride (SUZUKI et. al., 2015; TOKUNAGA et. al., 2013; GORDAN et. al. 2014), maintenance of its long-term properties and resistance (KUROKAWA et. al., 2015) restoring function (AKIMOTO et. al., 2011) and aesthetics (NAKAMURA et. al., 2009), besides its ability to neutralize acidic pH, preventing demineralization of new subsurface lesions of caries its surrounding (KAGA et. al., 2014; SHIIYA et. al., 2012; KAWASAKI; KAMBARA, 2014; SHIMAZU; OGATA; KARIBE, 2012; SHIRAI et. al., 2015). Considering this last property, this material could be beneficial to patients with dental erosion, because its use could prevent new lesions around these restorations, due to their ability to neutralize the acidic pH, so there would be an action in the acid and not in the structure of enamel, different from the mechanism of action of fluorides. However, the use of Giomer as restorative material in erosion lesions is still unknown.

Thus, the aim of this study was to test the effect of giomer technology on the enamel adjacent to the material and the wear of the material itself subjected to erosive and abrasive challenges compared to the composite resin and glass ionomer cement by means of an in vitro evaluation.

DISCUSSION

2 DISCUSSION

With the decrease in the prevalence of caries, there is a greater permanence of dental elements in mouth, and, associating this fact with an increase in the life expectancy, manifestations of erosive, abrasive and fatigue processes are more frequently observed (NUNN, 1996; ADDY; SHELLIS, 2006). It is believed that, clinically, these processes occur simultaneously, leading to a separation between the concepts "dental erosion" and "erosive tooth wear" (SHELLIS et. al., 2011; HUYSMANS; CHEW; ELLWOOD, 2011).

The term erosion is used to name the process of loss of structural integrity and mechanical resistance caused by the effect of acids of intrinsic and extrinsic origin, without involving microorganisms, on the surface of the tooth, corresponding only to a superficial softening without loss of structure in height (SHELLIS et. al., 2011; HUYSMANS; CHEW; ELLWOOD, 2011; LUSSI; JAEGG; ZERO, 2004; LUSSI; HELLWIG, 2006). On the other hand, dental wear refers to a great loss of dental structure, caused by the initial softening and subsequent removal of this soft tissue through abrasive actions (SHELLIS et. al., 2011; HUYSMANS; CHEW; ELLWOOD, 2011), being the process we can see clinically. Due to this increase, several studies have been directed to erosive dental wear, in order to prevent its formation or to contain its progression (AMAECHI; HIGHAM, 2005). However, it is observed a difficulty in interfering with the patient habits (LUSSI, 2006; SERRA; MESSIAS; TURSSI, 2009), leading to the progression of lesions and consequent need for restorative therapies (LUSSI; CARVALHO, 2014; ZERO; LUSSI 2005), objectifying to reduce symptomatic, functional and aesthetic problems (PEUZFELDT; JAEGGI; LUSSI, 2014).

Within the necessity of restoring these lesions, the purpose of this study was to test and evaluate the giomer-based resins under erosive wear and its ability to protect the adjacent enamel compared to resins and ionomers.

The present study followed an in vitro methodology, since it is an initial study on this subject, requiring a shorter period of time, low operational cost and not dependent on the volunteers' collaboration.

About the material itself, the results showed that there was less wear on the resin groups; this lower susceptibility is due to its three basic components: resin matrix (organic content - Bis-GMA / TEGDMA – responsible for the slight softening of the material), fillers (inorganic part) and coupling agents (YONEDA et. al., 2012; NISHIO; YAMAMOTO, 2002). In the resin groups, there was no statistic difference between conditions, since the values of wear on erosion alone were similar to erosion + abrasion; because the stable bond between the filler and the matrix increases the abrasion resistance of the restorative material (YONEDA et. al., 2012).

The glass ionomer cements showed the highest loss. Previous studies explain these results by the dissolution of the peripheral matrix to its glass particles, which could result from dissolution of the siliceous hydrogel layer (SUZUKI et. al., 2015; TOKUNAGA et. al., 2013; GORDAN et. al. 2014). Since the dissolution of this matrix and this degraded layer cause a softening of the material, being easily removed by toothbrush abrasion as we can see on the study conducted by Hao Yu et. al. (2009), explaining the significant difference found between conditions.

The Giomer group is a hybrid composite restorative material, also known as “pre-reacted glass ionomer”(S-PRG), it contains fluoro-alumina-silicate glass, which reacts with polyalkenoic acid in water before being incorporated into a silica-filled urethane resin, presenting the fluoride release and recharge properties of glass-ionomer (ZIMMERLI et. al. 2010), Kooi et. al. (2012) demonstrated that the Giomer’s hardness and roughness are more affected than in composite resin, being significantly degraded by citric acid, attributed to the greater susceptibility of fluorosilicate glass fillers to degradation by weak acids (KOOI et. al., 2012). Apart from that, composites with small filler particles are more wear resistant, with further homogeneous and less prominent particles on the surface (KOOI et. al., 2012), still the giomer composites are significantly higher than the resin composites, which could explain it higher susceptibility for erosion + abrasion than the resin; however, this wear was still lower than the ionomer groups. A study conducted by Walia et. al. (2016) comparing the compressive strength of various materials showed that the resin-based PRG fillers and cross-linked polymer matrices result in the higher compressive strength than the acid-base reaction in glass ionomers.

The type of acid chosen can also influence on the amount of wear. In this study the citric acid (pH 2.5) was chosen for simulating vegetables, fruits, candies, syrups and certain beverages [17], yet Guedes et. al. (2018) showed that the hydrochloric acidic solution (pH 2.0) caused largest changes in surface roughness and micro hardness of restorative materials when compared with the Soft drink (pH 3.6), confirming that the gastric juice has a more severe erosion potential, which could produce a greater wear in the present study.

According to the current literature, enamel present higher wear when compared to restorative materials (NISHIO; YAMAMOTO, 2002; EL-BADRAWY; MCCOMB, 1998). In caries, there is a capacity of protection on the adjacent enamel by ionomer restorations and Giomer-based resins (ALGHILAN et. al., 2015; RIOS et. al., 2007; TYRAS, 1991; FORSTEN, 1993; TURSSI et. al., 2002; YU et. al., 2009; GONULOL; OZER; SEN TUNC, 2015; WALIA et. al., 2016; ALBUQUERQUE GUEDES et. al., 2018; WONGKHANTEE et. al., 2006). However, there is no agreement on the protective ability of the ionomer in the adjacent enamel under erosive challenges. In the present study, a significant lower wear was found on the enamel adjacent of the glass ionomer and giomer restorations up to 300µm under erosion condition.

Different from Rios et. al. (2008), that tested the in situ effect of erosion on the amalgam, composite resin and glass ionomer cement and on the enamel adjacent to them likewise Francisconi et. al. (2008) in an in vitro study, also testing these materials, by means of perfilometry and percentage of hardness loss and as a result did not observe significant difference between the groups, presenting a minimal alteration on micro hardness and similar alteration on perfilometry, that could be explained by the quantity of erosive challenge, which were submitted three times a day for seven days and in this study was performed six times a day for five days; besides the type of beverage they used, Cola drink, that shows lesser reduction in surface hardness compared to citric acid (ALIPING-MCKENZIE; LINDEN; NICHOLSON, 2004).

On the other hand a study conducted by Rolim et. al. (2016) in order to evaluate the percentage of mineral loss on the surface around different restorations under the use of highly fluoridated dentifrices, using also the Cola drink, but

submitting the specimens for four erosive challenges per day for five days and showed that the use of a high-F dentifrice on teeth restored with conventional GIC provided an additional protection against enamel erosion. Similarly, Alghilan et. al. (2015) investigated the effect of erosion on restorative materials and enamel adjacent to them, considering different salivary fluxes, simulating a greater exposure to risk factors, they used citric acid and also submitted the specimens for four erosive challenges per day for five days and found that fluorine-containing materials presented less loss of surface under acidic challenges. An explanation for the observed erosion protection around fluoride-containing restorations is about the highly erosive conditions. Since the difference between materials was only observed when up to four challenges per day, like in the present study.

The protective effect of Giomer-based resins on the adjacent enamel is statistic similar to glass ionomer cements. This can be explained by the modest quantities of Silicon, Strontium, Aluminum, Boron, Sodium, and Fluoride ions, involved in neutralizing and subsequent reducing the enamel demineralization (KAGA et. al., 2014). Attention should be given to the capacity of Strontium to enhance remineralization, with a synergistic effect when applied in conjunction with Fluoride, with an advantageous of replacing hydroxyl and calcium ions in the apatite structure (THUY et. al. 2008).

The fluoride release of glass ionomer cements and the giomer-based resins didn’t show a protective effect on erosion + abrasion condition on enamel. That is because in erosion the demineralization is limited to the surface, but when the erosive challenge continues, usually added to the abrasion, the softened tooth surface is easily lost, leaving a little time and opportunity for the fluoride act on the remineralization (MAGALHÃES et. al. 2011), as long as the protective effect of fluoride on demineralization is seen when using high-concentration or with polyvalent metal fluorides, but both offer a short-living protection, not enough for a high erosive plus abrasive challenge like in the present study (HUYSMANS; YOUNG; GANSS, 2014).

Considering the distance of protective effect from glass ionomer and giomer, we can see a restricted protection of the enamel up to 300µm of distance to the

material, which implies clinically in a smaller formation of micro leakage, reducing biofilm retention as well as the action of future acids.

CONCLUSION

4 CONCLUSION

Given the limitations of this in vitro study, giomer-based resins have showed to be a potential alternative for the restorative treatment of patient with erosive tooth wear, due to its higher resistance to erosive and/or abrasive wear than glass ionomer cements, and its effective protection of enamel loss near to the restoration.

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