INFLUENCE OF BLEACHING TREATMENT ON FLEXURAL RESISTANCE OF HYBRID MATERIALS

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ABSTRACT

The aim of this study is to evaluate the flexural resistance of three types of restorative materials: compomer (Freedom), resin-modified glass-ionomer (Vitremer) and composite resin (Esthet-X), observing whether the application of bleaching agent can cause alterations of their flexural properties. Sixty samples were made using a 10x1x1 mm brass mold, and divided into three groups: G1- Freedom (SDI); G2- Vitremer (3M ESPE); G3- Esthet-X (Dentsply). On half of the samples of each group (10 samples) the bleaching treatment was applied and the other half, used as control, was stored in distilled water at a temperature of 37ºC. Whiteness HP Maxx bleaching system was applied on the sample surface following the manufacturer's recommendations, simulating the bleaching treatment at the clinic. After this period, a flexural strength (three-point bending) test was conducted using (EMIC DL 1000) machine until the samples fractured. The data were submitted to ANOVA and Tukey tests. Of the restorative materials studied, G3-(87.24±31.40MPa) presented the highest flexural strength, followed by G1-(61.67±21.32MPa) and G2-(61.67±21.32MPa). There was a statistical difference in flexural strength after the bleaching treatment. It was concluded that the use of a beaching agent can promote significant alteration of the flexural strength of these restorative materials.

Key words: strength, composite resins, compomers.

INFLUÊNCIA DO TRATAMENTO CLAREADOR NA RESISTÊNCIA FLEXURAL DE MATERIAIS HÍBRIDOS

RESUMO

O objetivo deste trabalho foi o de avaliar a resistência flexural de três tipos de materiais restauradores híbridos; compômero (Freedom), cimento de ionômero de vidro modificado por resina (CIV-RM) (Vitremer) e resina composta (Esthet-X) verificando se a aplicação do agente clareador promove alterações em suas propriedades flexurais. Foram confeccionadas 60 amostras, com auxílio de uma matriz metálica 10x1x1mm, as quais foram divididas em três grupos: G1- Freedom (SDI); G2- Vitremer (3M ESPE); G3- Esthet-X (Dentsply). Em metade das amostras de cada grupo, ou seja, 10 amostras, foi realizado o tratamento clareador permanecendo as demais armazenadas em água destilada 37°C. Utilizou-se o sistema de clareamento Whiteness HP Maxx sobre a superfície das amostras seguindo as orientações do fabricante, simulando assim, o tratamento clareador realizado em consultório. Decorrido este período, foi realizado o ensaio mecânico de resistência à flexão de 3 pontos na máquina de testes universal (EMIC DL 1000) até a fratura dos espécimes. Os dados foram submetidos aos testes ANOVA-2 fatores e Tukey. Observou-se diferença estatisticamente significante entre os materiais, sendo que G3-(87,24±31,40MPa) apresentou a maior resistência flexural seguida pelo G1-(61,67±21,32MPa) e G2-(21,04±8,94MPa), e após a realização do tratamento clareador. Concluiu-se que há diferença estatísticamente significante entre a resistência flexural da resina composta, compômero e o CIV-RM, sendo a aplicação do agente clareador capaz de promover alterações na resistência flexural destes materiais.

Palavras chaves: materiais dentários, resinas compostas, compômeros, branqueadores.

INTRODUCTION

The development of dental materials has enabled direct treatments to restore areas subject to great masticatory effort.

Following the diagnosis and determination of the restorative treatment needed, some materials can be used to satisfy the demand for good physical appearance as well as function. Class V restorations are indicated for restoring areas of non-carious lesions (abrasion, erosion and abfraction)[1] as well as carious lesions.

Glass-ionomer cements have gained widespread acceptance as dental restorative materials for cervical restoration[1,2] and restoration of primary teeth, especially because of their biocompatibility and fluoride release[3,4]. In order to increase the mechanical properties of glass-ionomer cements, some polymerization functional groups have been added to the material formulation, acting on the polymerization[3,4]. McLean et al.[4] (1994) describe the categories of dental materials using basic glass and acidic polymer. In this group some terms have been used for the hybrid

Table 1: Hybrid materials used

Material	Commercial Name	Composition	Manufacturer
Compomer	Freedom	Freedom contains strontium glass which is chemically and biologically similar to calcium. Strontium glass is less electropositive than barium glass, and therefore less likely to decompose the resin bonds and break down the resin. The longer resin chains in Freedom resist breakdown and enhance stability in the oral environment. It does not contain BisGMA nor its byproduct Bisphenol A.	(SDI)
RM-GI	Vitremer	Vitremer core buildup/restorative is a two part, powder/liquid composition. The powder is a radiopaque, fluoroaluminosilicate glass. The liquid (HEMA – 2.hydroxyethylmethacrylate) is a light-sensitive, aqueous solution of a modified polyalkenoic acid. This material will set by exposure to visible light.	(3M ESPE)
Composite resin	Esthet-X	The matrix contains Bis-GMA adduct, Bis-GMA and the filler TEGDMA. The composite resin has Photo initiators and stabilizers. The fillers are formed bybarium fluoro alumino boro silicate (mean particle size < 1µm) and highly dispersed nanofiller silicon dioxide (particle size 0.04 µm). The percentage by volume of total inorganic fillers is 60%, the percentage by weight is 77%.	(Dentsply)
Dental Beaching System	Whiteness HP Maxx	35% hydrogen peroxide.	(FGM)

cements such as *resin-modified glass ionomer* (RM-GI), which have an acid-base reaction as a part of their overall curing process. The materials that may contain either or both of the essential components of a glass-ionomer cement but at levels insufficient to promote the acid-base cure reaction in the dark should be referred to as *polyacid-modified composite resins* or *compomers*. Due to their capacity to adhere to the dental structure, composite resins are indicated in various cases of esthetic restoration.

Hybrid dental materials, such as *resin-modified glass ionomer* and *polyacid-modified composite resins/compomers* usually have greater microhardness values than the conventional glass-ionomer. It was also observed, from the surface-roughness measurements that hybrid materials are rougher than resin composites, especially after toothbrush abrasion[5].

Although bleaching treatment has been universally accepted, some clinicians still express concerns about its effects on oral tissues and dental materials previously used to restore dental structures[6]. Carbamide peroxide and hydrogen peroxide are described in the literature as materials used to promote the bleaching of dental structures. Swift & Perdigão[6] (1998) mention that even 10% carbamide peroxide can promote alterations of dental materials such as dissolution of glass ionomer and that further research is necessary to elucidate the effect of these materials on teeth and dental materials.

Thus, the aim of this study is to verify three kinds of dental materials (composite resin, resin-modified glass ionomer and compomers), comparing their flexural strength before and after home bleaching using 35% hydrogen peroxide. The null hypothesis of this study is that there are no differences between the flexural strengths of these three kinds of materials and there are no differences in the flexural strengths before and after bleaching treatment.

MATERIALS AND METHODS

The dental materials tested in this study are described in Table 1.

The 60 specimens were prepared in customized stainless steel molds (10 mm length x 1mm width x 1mm height). The materials were handled according to the manufactures' instructions. The restorative materials were placed in the mold, which was positioned on top of a glass slide. A second glass slide was then placed on top of the mold and gentle pressure was applied to extrude excess material from the mold. A polyester strip was also used between the mold and the glass slide to help its removal.

The materials were cured with halogen light XL 3000 (3M), with 550 mW/cm^2 output and according to the curing time specified by the manufacturers. After their removal from the molds, the test specimens were stored in distilled water at 37 ± 1ºC for 24 h.

Three experimental groups were formed; G1 - Freedom (SDI); G2- Vitremer (3M ESPE); G3- Esthet-X (Dentsply). Half of the test specimens of each group (10 specimens) were prepared to be bleached and the other half stayed stored in distilled water as the control group. The bleaching dental system Whiteness HP Maxx (FGM) was applied three times on the test surfaces, following the manufactures' instructions, simulating the bleach treatment that is used in a dental clinic.

At the end of the treatment period, the flexural three-point bending test was carried out using an Instron Universal testing machine (EMIC DL 1000), at a cross speed of 0.5 mm/min until the specimens fractured. The maximum load exerted on the specimens was recorded and flexural strength was calculated in megapascal (MPa).

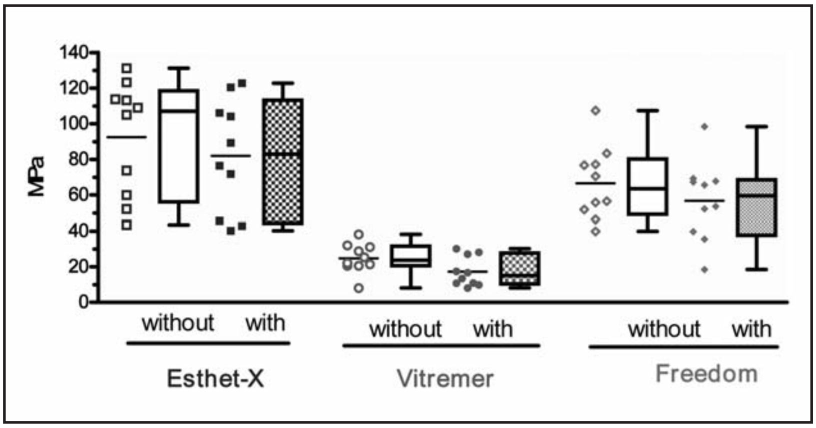

Fig. 1: In the column dispersion diagram (Dot plot and Box plot) of the three points flexural values (MPa) obtained around the mean values with and without treatment.

Table 2: ANOVA (two-way) test of the data on flexural resistance (MPa), after logarithmic transformation.

Source	DF	SS	MS	F	p
Restorative material	2	4.33	2.17	65.15	0.00*
Bleaching agent	1	0.16	0.16	5.05	0.03*
Interaction	2	0.035	0.01	0.53	0.59
Error	54	1.79	0.03		
Total	*59*	*6.34*			

*n = 10

Experimental plan

This study follows a factorial scheme. The experimental variables, or study factors, were the restorative materials (Esthet-X Freedom and Vitremer) and the bleach agent (present and absent).

The outcome variable was the flexural strength value obtained in the mechanical test. The experimental units were the rectangular customized specimens, which were randomly assigned to the experimental condition relative to the exposure to the bleaching agent.

Statistical analyses

Sixty data were submitted to statistical analysis using the software MINITAB (Minitab. version 14.0.2004) and GraphPad Prism (GraphPad. version 4.00. 2003). The descriptive statistics in this study were the mean and standard deviation calculations and the inferential statistics were the two-way analyses of variance ANOVA followed by with the Tukey's multiple comparison test ($P < 0.05$).

RESULTS

The flexural values for the experimental groups are presented in Figure 1.

Fig. 1 shows that flexural values of the groups differ in their symmetry and dispersion in relation to their mean. The data obtained, after logarithmic transformation, when submitted to the ANOVA two-way test shown in Table 2, lead us to reject the null hypothesis that refers to the interaction effect of restorative material versus bleaching agent.

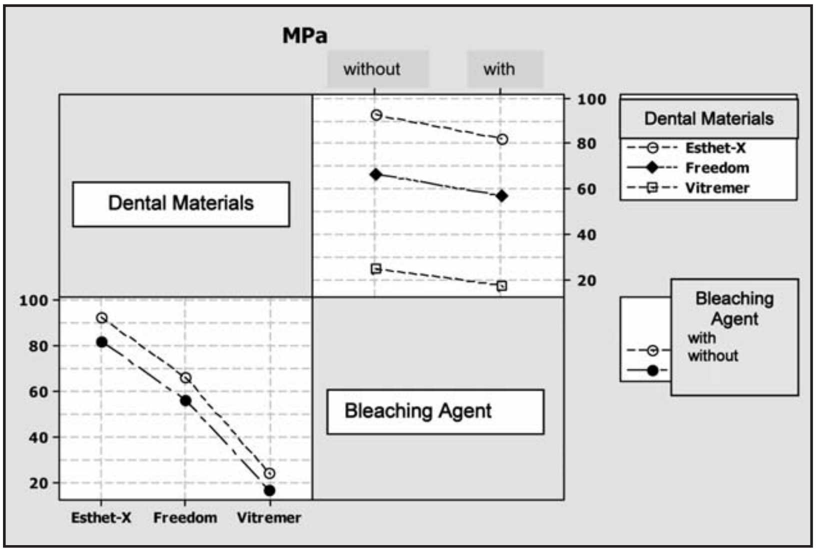

Fig. 2: Graph of mean of flexural strengths for the four experimental conditions.

Table 3: Tukey test (5%) for the flexural data (MPa) obtained for all experimental conditions.

Restorative material	Mean standard deviation	Similar group
Esthet-X	87.24 ± 31.40	A
Freedom	61.67 ± 21.32	B
Vitremer	21.04 ± 8.94	C

The analysis of variance test shown in Table 2 shows no significant difference in the interaction effect. There is the same relationship between the conditions of presence and absence of bleaching agent for each of the dental materials (Fig. 2).

From the results of the ANOVA statistical test, in Table 2, it was observed that the main effect (Restorative Material) was statistically significant. From Tukey's test (5%) is possible to verify that the groups are different from each other (Table 3).

Observing the bleaching effect, using the ANOVA test (Table 2), it is verified that the presence of bleaching agent (52.02±34.90 MPa) has a different effect compared to the absence of bleaching agent on restorative material.

DISCUSSION

When class V restorations are needed, the following dental materials may be indicated: composite resin, resin-modified glass ionomer and compomers[1]. The increasing demand for attractive appearance and white teeth has led to the bleaching treatment being more and more frequently used and studied by professionals.

The flexural strength test has been used in research[7,8,9] probably because it is a joint result of all kinds of stresses that act simultaneously on teeth, due to the dynamic nature of forces existing during mastication [10].

Flexural strength is known to be a mechanical property that can be related to clinical performance. Therefore, the results of the flexural test enable some prediction of the behavior of the restorative material under the stress of functional and parafunctional biting forces.

Several methods are widely employed in dental research to determine the fracture resistance of a material: flexural three-point bending[7,8,9], double torsion mode[11,12], indentation test[13] and compact tension test[12].

However, the large beam specimens (25 x 2 x 2 mm) as stipulated in ISO 4049 (ISO 1992) are difficult to prepare without flaws, especially with *compule* packaging. Several overlapping irradiations from the radiation exit window of the curing device are required. This leads to specimens that are not homogeneous since localized areas exposed to twice the curing time are inevitable. A flexural test involving the use of smaller and more clinically realistic specimens is therefore desirable. There is a strong correlation between flexural test stipulated in ISO 4049 and the mini-flexural test (12x2x2 mm). Thus, the mini-flexural test has the advantage of ease of specimen fabrication and is more clinically realistic and recommended for the testing of flexural properties[9].

The test fixture is designed to allow increasing load in the center of the specimen bar. In this study a bar of restorative material was made in a 10 mm x 1 mm x 1 mm mold. The bar is supported at two points with the application of load at the central point, generating a three point loading.

The specimens were stored in distilled water, because Braem et al.[14] (1995) found different values of flexural fatigue of dental materials under wet and dry conditions, and it is impossible to extrapolate the results for one material even within the same group of materials.

The findings of current research are in agreement with past research[7,8]. Hybrid composite resin is found to have higher flexural strength values than resin-modified glass ionomer and compomers. Attin et al.[7] (1996) observed that the modulus of elasticity of hybrid composite resin and resin-modified glass ionomer were higher than that of compomers. El-Kalla & Garcia-Godoy[8] (1997) verified that the flexural and compressive strengths and microhardnesses of the three compomers tested (Compoglass. Dyract e Hytac) were higher than Vitremer but lower than Z100, but the surface roughness of the three compomers and the composite was not significantly different.

In stress-bearing situations a high flexural strength is necessary to withstand biting forces without fractures. A high modulus or stiffness is also required for the restoration to maintain its shape under load. Braem et al.[14] (1995) verified that neither the elastic property nor strength are accurate predictors for the fatigue behavior of dental restorations. The glass ionomers showed lower fatigue resistance than the composites. These results may offer an explanation for cracks observed in glass ionomers in the clinic.

In this study the effect of 35% hydrogen peroxide on surface of composite resin, resin-modified glass ionomer and compomer was analyzed. The results also indicate that the bleaching treatment can promote significant alterations in the flexural resistances of these dental materials.

Dental bleaching requires the product to penetrate the enamel and dentin reacting with the complex dark chains. Hydrogen peroxide and its free radicals with low molecular weight can denature the protein, promoting greatest ion movement through the tissues[15]. This penetration occurs mainly through the enamel organic matrix, and could act on the organic matrix of the restorative materials.

Hydrogen peroxide produces free radicals that react with the dark complex chains of pigments, transforming them into simple chains, changing the optical structure of the molecule, making it whiter, and forming carbon dioxide and water as byproducts[16].

Bleaching agents can promote changes in the structure of restorative materials. Turker & Biskin[17] (2003) found that all of the modified glass ionomer specimens revealed serious cracking areas, whereas microfilled composite specimens showed increased surface porosity and cracks in certain areas when compared to control specimens. Surface spectral analyses results indicated a decrease in the silica content in the microfilled composite groups for bleaching agents.

According to the literature, hydrogen peroxide acts on the organic matrix producing lower flexural strength, as found in this study (Table 3). However, it was verified that the effect of 35% hydrogen peroxide on the organic components of the materials studied (composite resin, resin-modified glass ionomer and compomers) seemed to promote a similar pattern of alteration when analyzing flexural strength (Fig. 2).

Cullen et al.[18] (1993) verified that after exposure for one week to 10% carbamide peroxide and 30% hydrogen peroxide, the diametral tensile strength of highly filled composite resin restorative materials was unaffected. However, microfilled composite resins were significantly affected by 30% hydrogen peroxide after one week, resulting in a reduction in tensile strength. By means of visual inspection of all composite resins exposed to 30% hydrogen peroxide, the authors verified a marked change in color, which appeared to result from a reduction of chroma or increase in value. In our study, 35% hydrogen peroxide was used, which is a more concentrated bleaching agent that would promote greater changes on the surface of restorative materials than less concentrated agents would. Campos et al.[19] (2003) found a decrease in microhardness for a compomer material (Dyract AP) and a resin modified glass ionomer (Vitremer) after treatment with 10% and 15% carbamide peroxide.

In our study, the flexural strength of hybrid restorative materials was found to decrease after treatment with 35% hydrogen peroxide.

CONCLUSION

Within the limits of this study, the null hypothesis that there would be no differences between the flexural strengths of composite resin, compomer and resin-modified glass ionomer was rejected. The composite resin presented the highest flexural strength, followed by compomer and resin-modified glass ionomer. Furthermore, the null hypothesis that there would be no differences in the flexural strengths before and after bleaching treatment was also rejected. The bleaching treatment with 35% hydrogen peroxide promoted lower flexural strength values in all the materials that were studied.

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