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BRENDA GISELLE SÁNCHEZ LEYTON

EFFECT OF A FLOWABLE BASE ON THE FRACTURE STRENGTH OF EXTENDED CLASS I RESTORATIONS WITH BULK-FILL AND CONVENTIONAL RESIN COMPOSITES

Curitiba
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Dissertação apresentada ao Programa de Pós-Graduação em Odontologia da Pontifícia Universidade Católica do Paraná, como parte dos requisitos para obtenção do título de Mestre em Odontologia, Área de Concentração em Clínica Odontológica Integrada - Dentística

Orientador: Profª. Drª. Evelise Machado de Souza

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SUMÁRIO

ARTIGO EM INGLÊS...1
Title page...1
Abstract...2
Introduction...3
Material and Methods...5
Results...9
Discussion...12
Conclusion...14
References...15
ANEXOS...19
Parecer de comitê de ética...19
Termo de transferência de material biológico...23
Analise estatística...24
Normas para publicação – Operative Dentistry...29

ARTIGO EM INGLÊS

Title page

Effect of a flowable base on the fracture strength of extended class I restorations with bulk-fill and conventional resin composites

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Abstract

Objective: The aim of this study was to evaluate the fracture strength of bulk-fill restorations compared to conventional composite resins with and without intermediate bases in teeth with extensive cusp-weakening Class I preparations. Materials and methods: Sixty sound extracted human third molars were prepared with extended Class I cavities and restored with different techniques resulting in the following groups: FS-F, flowable bulk-fill resin composite (Filtek bulk-fill flow, 3M) as a base and a 1mm-thick conventional nanofilled composite layer (Filtek Supreme Ultra, 3M); FB, restored with bulk-fill resin composite (Filtek Bulk-Fill, 3M); FS, restored incrementally with conventional nanofilled composite (Filtek Supreme Ultra, 3M); GR-F, flowable bulk-fill resin composite (X-tra base, VOCO) as a base and a 1mm-thick conventional composite layer (GrandioSO, VOCO); AF, restored with bulk-fill resin composite (Admira Fusion X-tra, VOCO); GR, restored incrementally with conventional resin composite (GrandioSO, VOCO). Sound extracted teeth (n=10) were used as a control group (CTL). All teeth were subjected to thermocycling (20,000 cycles, 5°C and 55°C) and mechanical loading (500,000 cycles, 50N load 2.5 Hz frequency). The specimens were subjected to a compressive axial load in a universal testing machine at 1 mm/min. Data was submitted to statistical analysis at a significance level of 5%. Results: The mean (standard deviation) fracture strength in N were: CTL: 1,871.88 (339.48); FS-F: 1,428.23 (326.10); FB: 1,494.85 (386.81); FS: 1,183.33 (334.99); GR-F: 1,615.70 (188.82); AF: 1,138.38 (286.94) and GR: 1,340.66 (97.50). Groups CTL and GR-F demonstrated significantly higher mean fracture strength when compared to FS, AF and GR ($p<0.05$). The most common type of failure among the groups was restoration and enamel/dentin fracture (Type IV). Conclusions: Restorations with a nanofilled bulk-fill composite or with a conventional resin composite associated with a flowable bulk-fill base reestablished the fracture strength of weakened teeth to that of sound teeth.

Clinical Relevance: The use of a conventional composite in extended class I preparations should be associated with a flowable bulk-fill composite base or restored with a nanofilled bulk-fill composite.

Keywords: Bulk-Fill, Composite, Class I Restoration, Fracture strength.

Introduction

For many decades, resin-based composites have been widely used in restorative dentistry, this material is considered to be the first choice for esthetic posterior restorations.[1,2] More than 500 million direct dental restorations are placed each year all over the world, which makes direct restorations the most prevalent medical intervention in the human body. In about 55% of the cases, resin composites or compomers are used.[3]

Posterior direct composite restorations have their limitations. The annual failure rate varies around 2.2%.[4] The polymerization of resin composite produces internal tensions that may lead to loss of adhesion between teeth and restoration, cuspal deflection and formation of enamel crack, being all of these, primary factors in potential failure.[5]

In order to reduce polymerization shrinkage stress, it has been prescribed the use of the incremental technique when using direct composite, as it results in lower shrinkage stress due to reduced cavity configuration factor, as well as improved light penetration, allowing a higher degree of conversion of the material.[6] Nevertheless, this technique takes more time and can elevate the risk of saliva contamination between the increments, which may lead to less strength and premature failures.[7] In this matter, the chance to fill the dental cavity with one single increment seems to have countless benefits. For instance, the less working time and the reduction of the so-called window of opportunity for technical mistakes, such as incorporations of voids and contamination among increments.[8]

Therefore, it has been developed new restorative material that can be used in one increment of 4 to 5 mm, known as bulk-fill resin composites.[9] This new type of composite reduces the working time, although it presents some limitations in mechanical properties when compared to conventional composites.[10]

Bulk-fill resin composite is available in two kinds of viscosity: flowable and high-viscosity. The latter can be applied in a single increment without the need for coverage as it contains high inorganic filler content and therefore can be used in areas with a higher incidence of masticatory load.[2] Flowable bulk-fill resin composite is a low viscosity composite and therefore has a lower inorganic filler content and is used as liner or base, capped with a conventional composite resin.[11] Studies have shown that flowable bulk-fill composite resins have lower hardness, modulus of elasticity, cusp deformation, and shrinkage stress.[12-14] All of these mechanical characteristics make flowable bulk-fill composite resins act as a stress absorbing layer generated by the high modulus of elasticity of conventional composite resin.[15]

The restorative material named ORMOCER®, developed in the ‘90s, originally derived from the term "organically modified ceramic", is characterized by a hybrid molecular structure that combines organic and inorganic components in the matrix at nanoscopic scale.[16] ORMOCER®s consists of an organic portion, an inorganic portion and polysiloxanes in proportions that can affect the mechanical, thermal and optical qualities of the material: the organic polymers influence the polarity and optical behavior, the inorganic constituents are responsible of chemical stability and the polysiloxanes influence the elasticity and interface properties.[17]

Traditionally, the choice between direct and indirect composite restorations for posterior teeth is based on the size of the cavity to be restored. Small and medium cavities are usually restored with direct composite resin restorations. Conversely, in large cavities, where the width of the isthmus reaches or exceeds two-thirds of the intercuspal distance, indirect restorations are better indicated.[18-20] However, this decision must be based on an individual clinical assessment, taking into consideration patient requests, cost-benefit, and other risk factors such as high caries risk or bruxism.[21,22] Furthermore, earlier systematic reviews and meta-analysis have concluded that there is no significant difference in terms of clinical longevity between direct and indirect technique for posterior restorations.[23-25]

Restoration of extensively destroyed tooth aims to reestablish both function and aesthetics. Earlier studies have shown that fracture strength is inversely proportional to the loss of dental tissue due to either caries lesion or cavity preparations.[26-28] One study showed that class II preparations for direct restorations removed an average of 11.40% of the tooth structure, based on one-half, one-third, or one-quarter boccolingual widths in both maxillary and mandibular molars. On the other hand, preparations for indirect restorations removed on average of 16.79% of tooth structure.[29] Moreover, it has been demonstrated that direct composite preparations have higher resistance to occlusal load fracture than indirect preparations.[30]

Previous studies investigating fracture strength of restorations with bulk-fill resins use Class II preparations, usually MOD type. However, studies with extensive Class I preparations with cusp-weakening are scarce.[31]

Therefore, the aim of this study is to evaluate the fracture strength of bulk-fill restorations compared to conventional composite resins with and without intermediate bases in teeth with extensive cusp-weakening Class I preparations.

The null hypothesis to be tested is that there will be no difference in fracture strength of teeth restored with different composite resins.

Material and Methods

Seventy sound extracted human third molars were randomly assigned to seven groups (n=10) from teeth obtained from the institution's Tooth Bank after approval by the Ethics Committee (No. 2.824.728). Soft tissues and possible calculus were removed using periodontal curettes and the teeth were stored in 0.5% chloramine at 4ºC for a maximum of 3 months. The criteria for tooth selection involved the absence of caries or fractures and similar crown size.

3.1. Restorative Procedures:

The teeth were randomly divided into 7 groups with 10 teeth each. Ten teeth were used as a control group (CTL) and the other sixty teeth were prepared with Class I cavities. In the first step a cavity of 4 mm depth perpendicular to the occlusal surface was ground using cylindrical diamond burs (#3146, KG Sorensen, Cotia, SP, Brazil) with water spray, the buccolingual width was ¾ of the intercuspal distance. A pear-shaped diamond bur (#3168, KG Sorensen, Cotia, SP, Brazil) was placed with its shaft perpendicular to the cavity floor at the cavity margin and a circular undercut was prepared. The burs were replaced every five preparations and were used under high-speed and constant irrigation.

Table 1. *Distribution of experimental groups (n=10).*

Group	***Adhesive System***	***Base***	***Restoration***	***Manufacturer***
CTL	-	-	-	-
FS	Single Bond Universal	-	Filtek Supreme Ultra	3M/ESPE (St. Paul, MN, USA)
FB		-	Filtek Bulk Fill	
FS-F		Filtek Bulk Fill Flow	Filtek Supreme Ultra	
GR	Futurabond U	-	GrandioSO	VOCO (Cuxhaven, Alemanha)
AF		-	Admira Fusion X-tra	
GR-F		X-tra Base	GrandioSO	

The adhesive system chosen for each group was the universal type corresponding to the composites' manufacturers. In all teeth, the adhesive procedure was performed using the selective enamel conditioning technique, in which the enamel was conditioned with 37% phosphoric acid for 30 seconds, followed by rinsing for 15 seconds and drying for 5 seconds and finally active application of adhesive in enamel and dentin for 20 seconds, and light-curing for 10 seconds.

Table 1 shows the codes and distribution of study groups with their materials and Table 2 contains the compositions of the materials that were used in the study.

In the FS-F and GR-F groups, the restorations were made by inserting the bulk-fill flow resin in a single increment of 3 mm, followed by light curing for 20 seconds. A 1mm thick layer of conventional composite resin was placed using the incremental technique and light-cured for 20 seconds by increment with the same light-curing unit.

In the FB and AF groups, the body bulk-fill resins were inserted in a single increment and light-cured for 40 seconds. In the FS and GR groups, restorations were made with conventional composite resins using the incremental technique, with at least 5 polymerized oblique increments for 20 seconds each with the same light-curing unit.

Table 2. *Manufacturer-Specific Information of the materials used in the study.*

Commercial Brand	*Type*	*Resin matrix*	*Filler*	*% of filler weight volume*
Filtek Bulk-Fill Flow (3M ESPE)	Bulk-fill flowable composite	Bis-GMA, UDMA, Bis-EMA, Procrylat	Zirconia/sílica, Ytterbium trifluoride	64.5% / 42.5%
Filtek Bulk-Fill (3M ESPE)	Bulk-fill composite	AUDMA, AFM dimethacrylate, UDMA, Dodecane dimethacrylate	Zirconia/sílica nanofillers, nanocluster Ytterbium trifluoride	76,5% / 58,4%
Filtek Supreme Ultra (3M ESPE)	Nanofilled composite	Bis-GMA, UDMA, TEGDMA, PEGDMA, Bis-EMA	Zirconia/sílica nanofillers, nanocluster Ytterbium trifluoride	72.5% / 55.6%
X-tra Base (VOCO)	Bulk-fill flowable composite	Bis-GMA, Bis-EMA, UDMA	Barium glass, Ytteribium trifluoride, fumed silica	75% / 58%
Admira Fusion X-tra (VOCO)	Bulk-fill composite	ORMOCER®	Glass ceramic and silicone dioxide	84% / n.i.
GrandioSO (VOCO)	Nanohybrid composite	Bis-GMA, Bis-EMA, TEGDMA	Glass ceramic and silicone dioxide	89% / 73%
Single Bond Universal (3M ESPE)	Universal adhesive system	MDP phosphate monomer, dimethacrylate resins, HEMA, polyalkenoic acid copolymer, filler, ethanol, water, initiators, silane		-
Futurabond U (VOCO)	Universal adhesive system	HEMA, Bis-GMA, HEDMA, acidic adhesive monomer, UDMA, catalyst, silica nanoparticles, ethanol		-

Abbreviations: BisGMA—bisphenol-A-diglycidyl-dimethacrylate; UDMA—urethane dimethacrylate; BisEMA—ethoxylated bisphenol A dimethacrylate; DDDMA—1,12-dodecane dimethycrylate; TEGDMA—triethyleneglycol dimethacrylate; HEMA—2-hydroxyethyl methacrylate; PEGDMA—polyethylene glycol dimethacrylate; AUDMA—aromatic urethane dimethacrylate ; ORMOCER®— inorganic-organic hybrid polymers.

3.2. Periodontal Ligament Simulation

For the simulation of the periodontal ligament, the roots were covered with wax heated to 90ºC, by an immersion wax heater (ImerCera, Curitiba, PR, Brazil). Each specimen was embedded in self-curing acrylic resin within polyvinyl chloride tubes (25 mm diameter and 35 mm height).

The teeth were positioned in the center of the base of each tube leaving the root portion inside and the crown outside. The tubes were kept in an inverted position and a self-curing acrylic resin was poured in to fill the tube. The exothermic reaction of the resin polymerization allowed the teeth to be displaced so that the wax surrounding the root was easily removed with a gauze. After that, each tooth was repositioned in the formed acrylic slot. After cooling and final polymerization of the self-curing acrylic resin, the teeth were removed and a light polyvinyl siloxane (PRESIDENT light body, Coltène/Whaledent AG, Altstätten, Switzerland) was dispensed inside the slot, and the teeth were positioned inside. Excess material was removed with a scalpel blade.

3.3. Aging and mechanical load tests

After a 24-hour storage in distilled water at 37°C, the specimens from all groups were subjected to 20,000 cycles thermal cycles (OMC 300, Odeme, Lucerna, SC, Brazil) of 5°C and 55°C in distilled water with a dwell time of 15 seconds.

The specimens were also subjected to 500,000 cycles of mechanical loading (Biocycle, Biopidi, São Carlos, SP, Brazil) with a 50N load at a 2.5-Hz frequency. The load was applied by a metal ball axially to the center of the occlusal surface and the specimens were immerged in distilled water at 37ºC throughout the experiment. The test was considered complete until reaching the maximum number of cycles or until the specimen fracture.

3.4. Fracture strength test

The fracture strength test was performed in a universal testing machine (DL 2000, EMIC, São José dos Pinhais, PR, Brazil). The specimens were subjected to a compression force applied perpendicular to the occlusal surface by a steel cylinder with a 6-mm diameter round tip (axial loading) with a crosshead speed of 1 mm/min. The maximum force to generate fracture was recorded in N (Newtons).

3.5. Failure mode analysis

Fractured specimens were analyzed for failure mode using a stereomicroscope at 40 X magnification (SteREO Discovery V12, Zeiss, Germany). The mode of failure was classified as: (I) Cohesive failure in the restoration; (II) Cohesive failure in the tooth; (III) Failure of the restoration and enamel; (IV) Failure of the restoration and enamel/dentin; (V) Failure of the restoration and enamel/dentin below the cemento-enamel junction (CEJ); (VI) Axial failure of the restoration and tooth structure.[32]

3.6. Scanning Electron Microscopy

Two representative samples from each group were selected for analysis under scanning electron microscopy (SEM), as shown in Figures 2-7. The fractured specimens were cleaned in an ultrasonic bath with distilled water for 15 minutes and kept in a vacuum desiccator with silica for seven days. They were then coated with Au-Pd alloy and examined under SEM. (Vega 3, Tescan Orsay Holding, Brno, Czech Republic).

3.7. Statistical analysis

Normality distribution of the data was analyzed by Shapiro-Wilk and homogeneity of variance with Lèvene test. One-way ANOVA and Games-Howell test were performed to detect significant differences between the groups. A significance level of 5% was used for all the tests. The data were analyzed in SPSS 24.0 (IBM Software, New York, NY, USA).

Results

The mean fracture strength values for each group are shown in Table 1. Groups CTL and GR-F demonstrated significantly higher mean fracture strength when compared to FS, AF and GR ($p<0.05$). Groups FS-F and FB were not statistically different from all the other groups ($p>0.05$).

Among the groups restored with conventional composites, FS and FS-F showed no statistically significant differences ($p>0.05$). Conversely, GR-F showed higher mean fracture strength compared to that of GR ($p<0.05$).

Teeth restored with a single increment of bulk-fill composite (groups AF and FB) were not statistically different from groups restored with the incremental technique ($p>0.05$). When bulk-fill composites were compared with conventional composites associated to flowable base, the results were distinct. Group FB did not show significant difference from group FS-F ($p>0.05$), but contrarily, group AF showed significantly lower fracture strength compared to group GR-F ($p<0.05$).

Table 3. *Mean fracture strength (N) and standard deviation of the evaluated groups.*

Group	*Restoration Technique*	*n*	*Fracture Strength Mean*	*Minimum*	*Maximum*	*Sig.*
CTL	Control	10	1,871.88	1456.49	2568.51	A
FS	Conventional composite on incremental technique	10	1,183.33	1002.97	1935.86	B
FB	Single increment of bulk-fill composite	10	1,494.85	1116.92	2259.36	AB
FS-F	Conventional composite associated with flowable base	10	1,428.23	836.68	1665.58	AB
GR	Conventional composite on incremental technique	10	1,340.66	1356.25	1867.06	B
AF	Single increment of bulk-fill composite	10	1,138.38	732.97	1736.23	B
GR-F	Conventional composite associated with flowable base	10	1,615.70	1198.90	1454.43	A

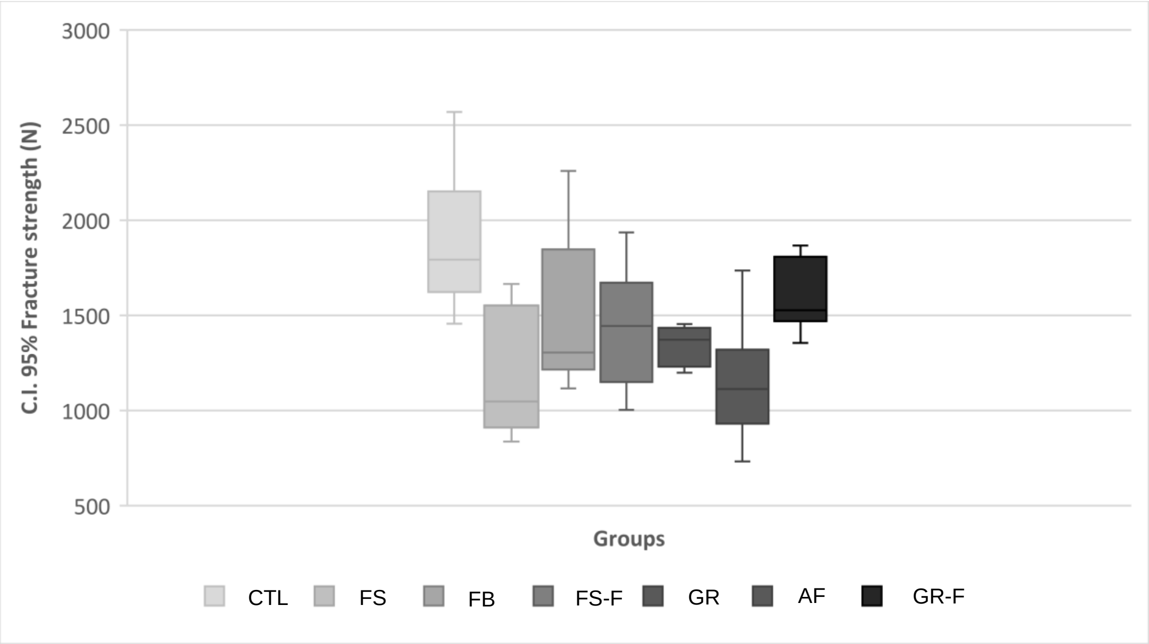

Figure 1. *95% Confidence Interval for Mean*

The frequency distribution of the failure modes for each group expressed as the total number of specimens in the group are shown in Figure 1. The most common type of failure among the groups was type IV: failure of the restoration and enamel/dentin. It was noticed that the groups restored with nanohybrid and ORMOCER® composites achieved a more heterogeneous type of fracture.

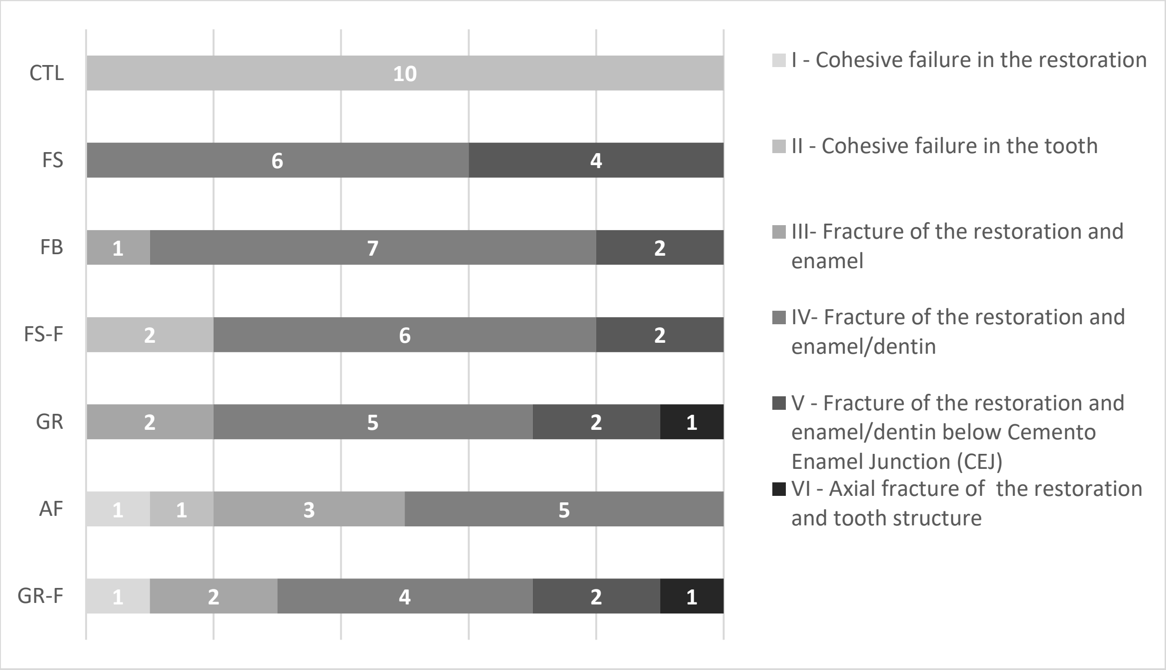

Figure 2. *Frequency distribution of the failure modes.*

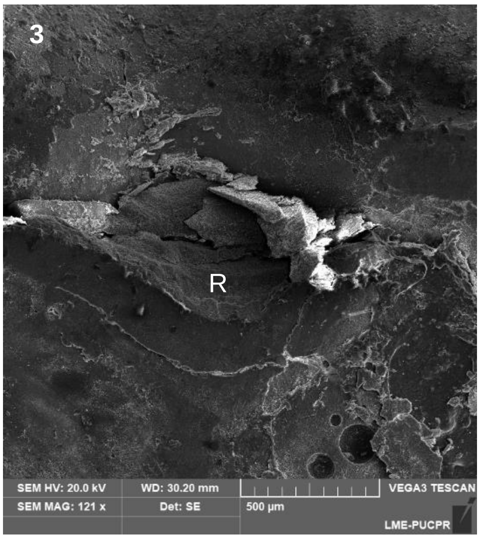

Figure 3. *Specimen from group GR-F showing cohesive failure in the restoration (R).*

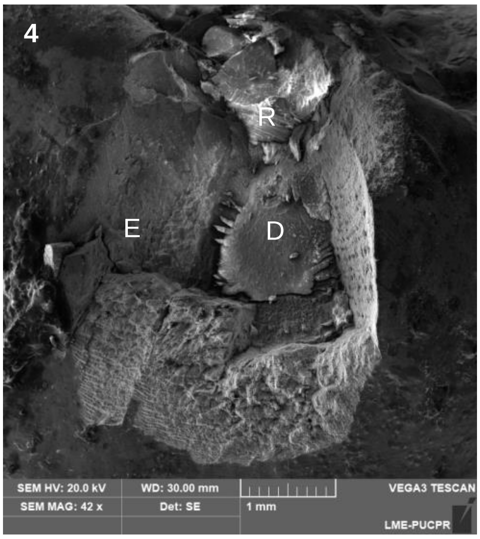

Figure 4. *Specimen from group FS-F showing cohesive failure in the tooth with exposure of enamel (E) and dentin (D).*

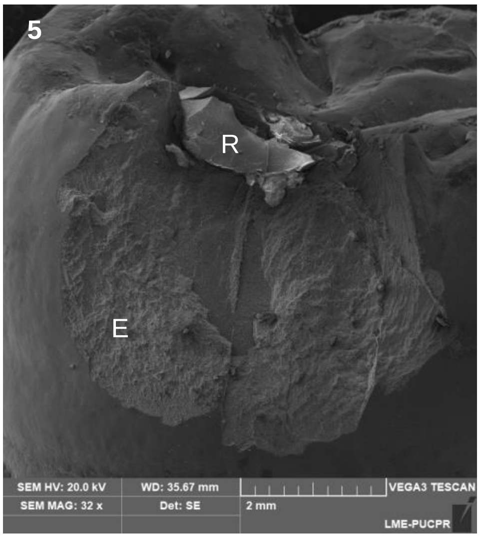

Figure 5. *Specimen from group GR-F showing failure of the restoration (R) and enamel (E).*

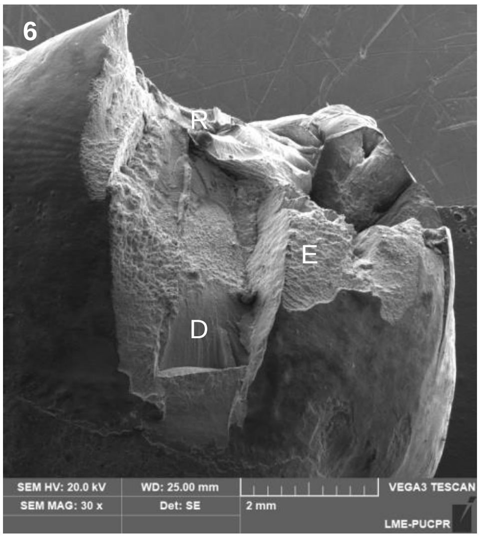

Figure 6. *Specimen from group FS-F showing failure of the restoration (R) and enamel (E) / dentin (D).*

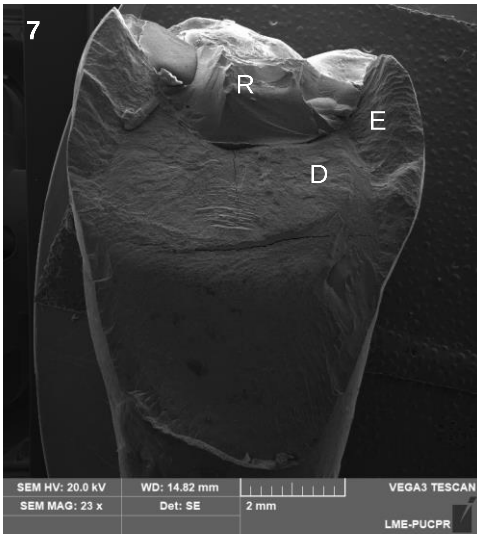

Figure 7. *Specimen from group GR showing failure of the restoration (R) and enamel (E) / dentin (D) below the cemento-enamel junction (CEJ).*

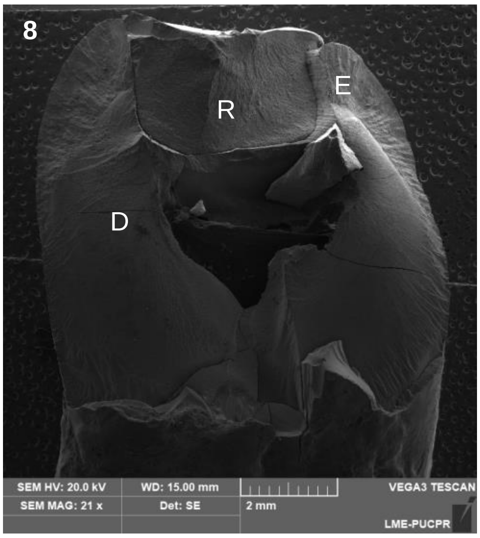

Figure 8. *Specimen from group GR showing axial failure of the restoration (R) and tooth structure with exposure of enamel (E) and dentin (D).*

Discussion

In this study, bulk-fill composite resins and conventional composite resins with and without intermediate flowable bases were compared to evaluate the fracture strength of restored teeth with extensive cusp-weakening Class I preparations. The null hypothesis was rejected since there were found differences in fracture strength of teeth restored with different restorative protocols.

In the present study, restorations made with both nanofilled composites, bulk-fill and conventional, with or without a flowable base resulted in similar fracture strength. Other studies demonstrated similar fracture strength when the same nanofilled bulk-fill composite was placed in a single increment compared with restorations placed with the layering technique.[1,33-35] One of these studies also showed that this composite achieved higher fracture strength values, regardless of covering with a conventional composite or using extended light-curing.[35]

Typically, composites with higher filler loading have been associated with higher mechanical properties.[36,37] In the present study, despite the different composition and filler content of the bulk-fill composites, the fracture strength of both groups restored with bulk-fill was similar. Thus, other aspects, such as size, shape, and type of filler particles must be responsible for the mechanical behavior of composite resins. In the case of the nanofilled composites, this could be related to the presence of the zirconia/silica filler particles and nanoclusters.[38-40] Spheroidal fillers present in the nanofilled composite resin have been associated with reduced stress concentration compared with the sharp edges of irregular-shaped filler particles.[41] A recent study demonstrated that silica nanoclusters have better stress distribution during a compression test, probably due to their doughnut-shape morphology.[42]

In our results, the nanohybrid conventional composite associated with the flowable bulk-fill composite as an intermediate base exhibited higher fracture strength in comparison with the ORMOCER® and the conventional composite without a base. A recent study showed that flowable bulk-fill composite developed significantly lower linear shrinkage than a conventional composite,[43] as well as higher flexural strength and Weibull modulus than bulk-fill composites.[44] Likewise, it was shown that the use of this flowable bulk-fill composite as a base significantly reduced cuspal deflection in standardized Class II cavities when compared to nanohybrid conventional composite restorations using an oblique incremental filling technique.[45]

In this study, the ORMOCER® composite resulted in the lowest fracture strength mean among all the materials tested, although not different from the nanofilled composites and the nanohybrid conventional composite using the incremental technique. In a recent study evaluating cuspal deflection of teeth restored with different resin composites, ORMOCER®s obtained the lowest volumetric cuspal deflection compared to other bulk-fill composites.[46] Additionally, ORMOCER®-based bulk-fill composites showed a reduced polymerization shrinkage when compared with other high and low-viscosity bulk-fill composites and hybrid composites, which was attributed to its resin matrix consisting of inorganic–organic copolymers instead of classic monomers and its reduced amount of organic resin compared with dimethacrylate-based composites.[43,47]

Fracture analysis in this study indicated that the group restored with nanocomposite, with the incremental technique, obtained a higher frequency of failures with root fractures. Nanohybrid composite with and without flowable base exhibited some catastrophic failures, with axial fracture of teeth. When a fracture occurs, it is always desirable to deal with a reparable fracture rather than an unfavorable condition. Fractures involving the root are usually difficult to restore and surgical procedures may be needed, prolonging the treatment and making it more complex.[48]

Due to the presence of an organic matrix, the mechanical properties and clinical longevity of resin-based composite materials subjected to aging can decrease.[49] Based on the literature reviewed, there is no clear statement of a standardized aging protocol, with varied a number of cycles, frequency and load being applied to the specimens. Thus, the choice between thermocycling,[35,50] mechanical load cycling,[1] both, or none,[31,33,34,51] is rather arbitrary. The present study used both protocols, thermocycling and mechanical load cycling, with 20,000 and 500,000 cycles, respectively. It has been previously reported that 10,000 cycles of thermocycling correspond to a service year,[52] and that 2×10^6 cycles correspond to approximately 4 years of normal occlusal and masticatory activity.[53]

Although *in vitro* studies provide information about the general characteristics of the materials, their interpretations should consider aspects regarding the intraoral environment. Hence, further *in vivo* studies are required for bulk-filled composites to replace the gold standard incremental placement technique in case of weakened cusp preparations.

Conclusion

Considering the limitations of this study, it was possible to conclude that:

- Restorations made with a nanofilled bulk-fill composite or with a conventional resin composite associated with a flowable bulk-fill base reestablished the fracture strength of weakened teeth to that of sound teeth;

- The nanohybrid composite used in this study improved its behavior by the presence of a flowable base;
- Both bulk-fill composites demonstrated similar fracture resistance to that of conventional composites using the incremental technique.

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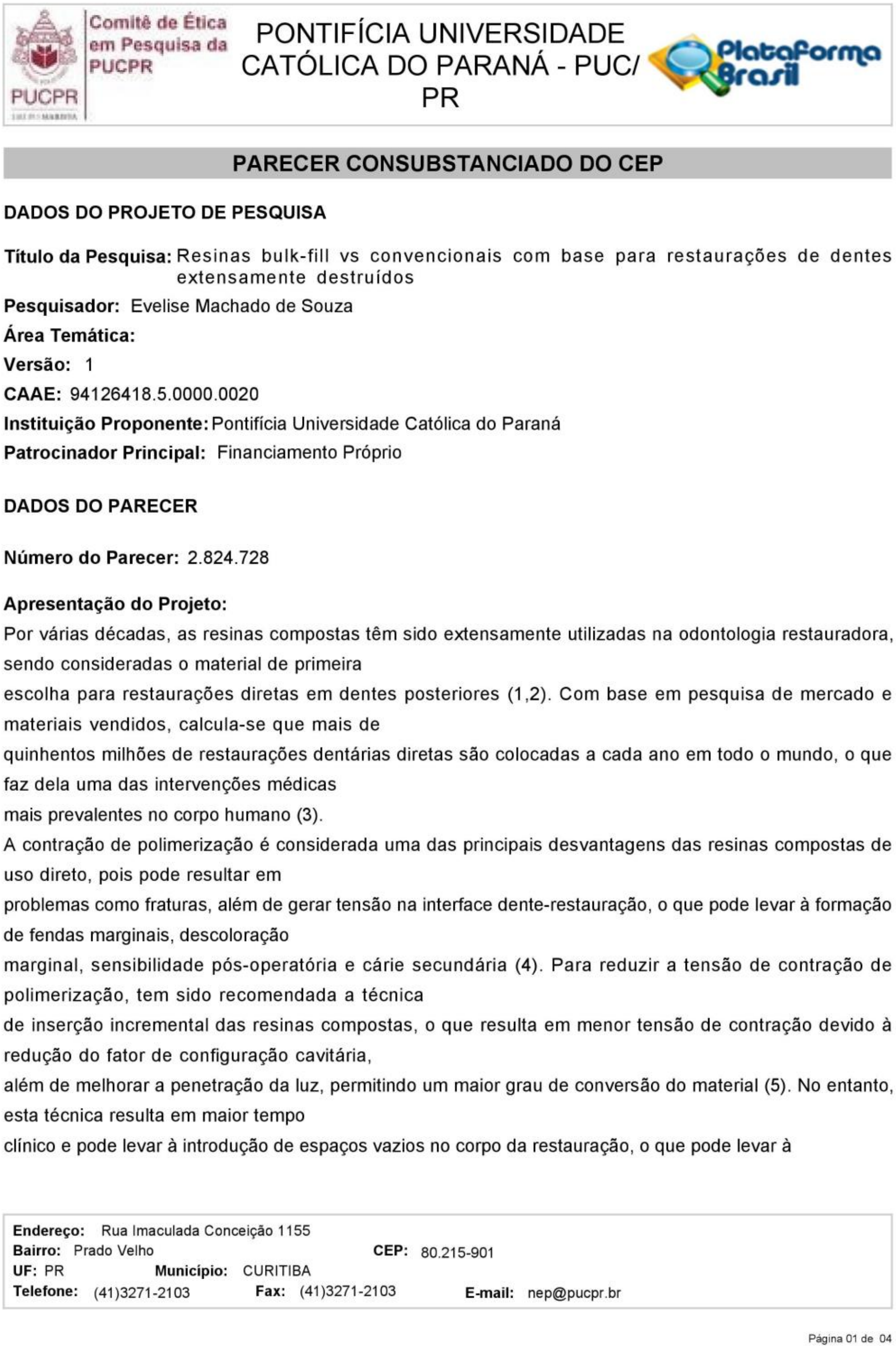
ANEXOS

Parecer de comitê de ética



Comitê de Ética em Pesquisa da PUCPR

PUCPR

PONTIFÍCIA UNIVERSIDADE CATÓLICA DO PARANÁ - PUC/PR

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Resinas bulk-fill vs convencionais com base para restaurações de dentes extensamente destruídos

Pesquisador: Evelise Machado de Souza

Área Temática:

Versão: 1

CAAE: 94126418.5.0000.0020

Instituição Proponente: Pontifícia Universidade Católica do Paraná

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 2.824.728

Apresentação do Projeto:

Por várias décadas, as resinas compostas têm sido extensamente utilizadas na odontologia restauradora, sendo consideradas o material de primeira escolha para restaurações diretas em dentes posteriores (1,2). Com base em pesquisa de mercado e materiais vendidos, calcula-se que mais de quinhentos milhões de restaurações dentárias diretas são colocadas a cada ano em todo o mundo, o que faz dela uma das intervenções médicas mais prevalentes no corpo humano (3).

A contração de polimerização é considerada uma das principais desvantagens das resinas compostas de uso direto, pois pode resultar em problemas como fraturas, além de gerar tensão na interface dente-restauração, o que pode levar à formação de fendas marginais, descoloração marginal, sensibilidade pós-operatória e cárie secundária (4). Para reduzir a tensão de contração de polimerização, tem sido recomendada a técnica de inserção incremental das resinas compostas, o que resulta em menor tensão de contração devido à redução do fator de configuração cavitária, além de melhorar a penetração da luz, permitindo um maior grau de conversão do material (5). No entanto, esta técnica resulta em maior tempo clínico e pode levar à introdução de espaços vazios no corpo da restauração, o que pode levar à

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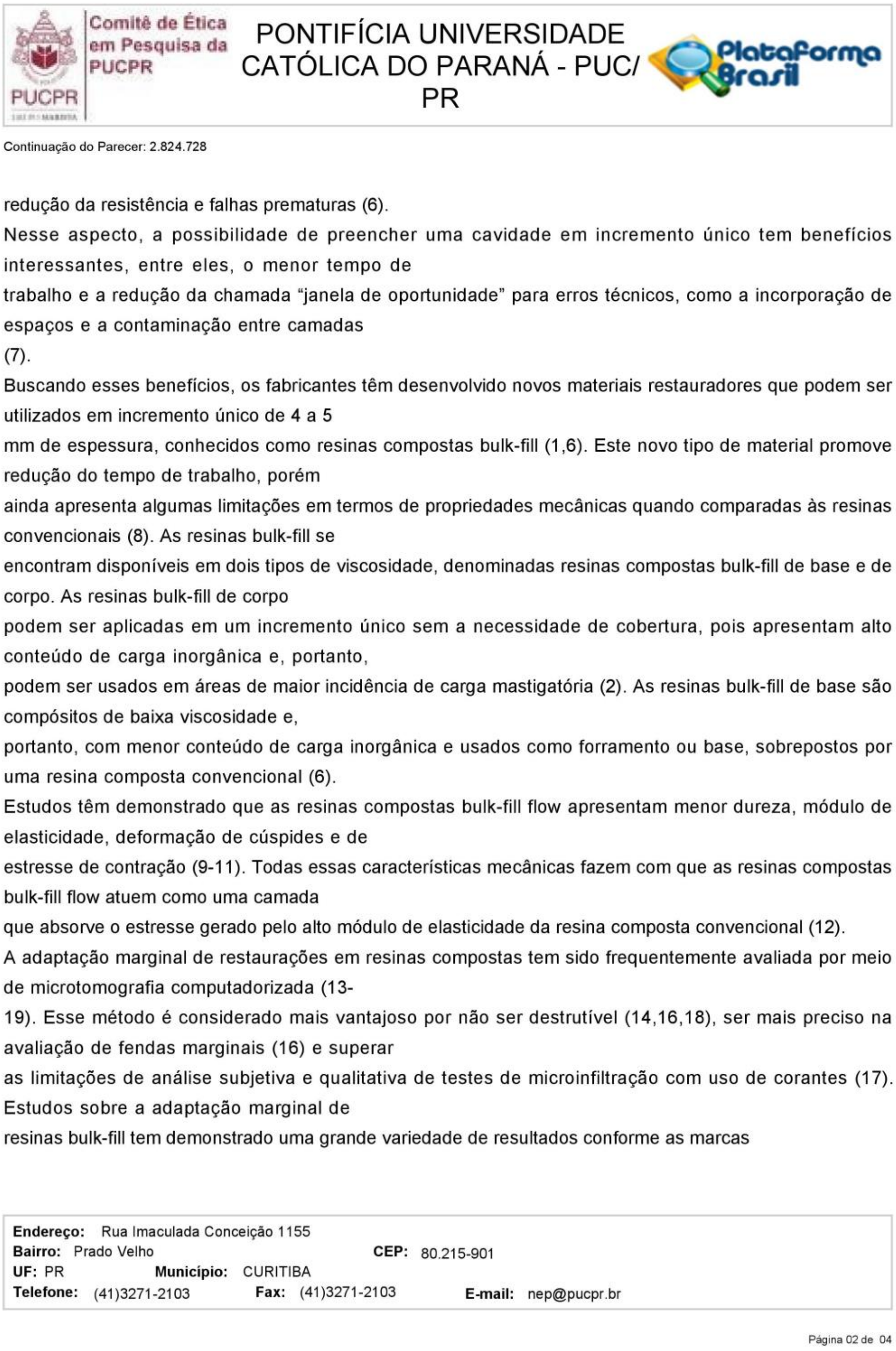
Página 01 de 04



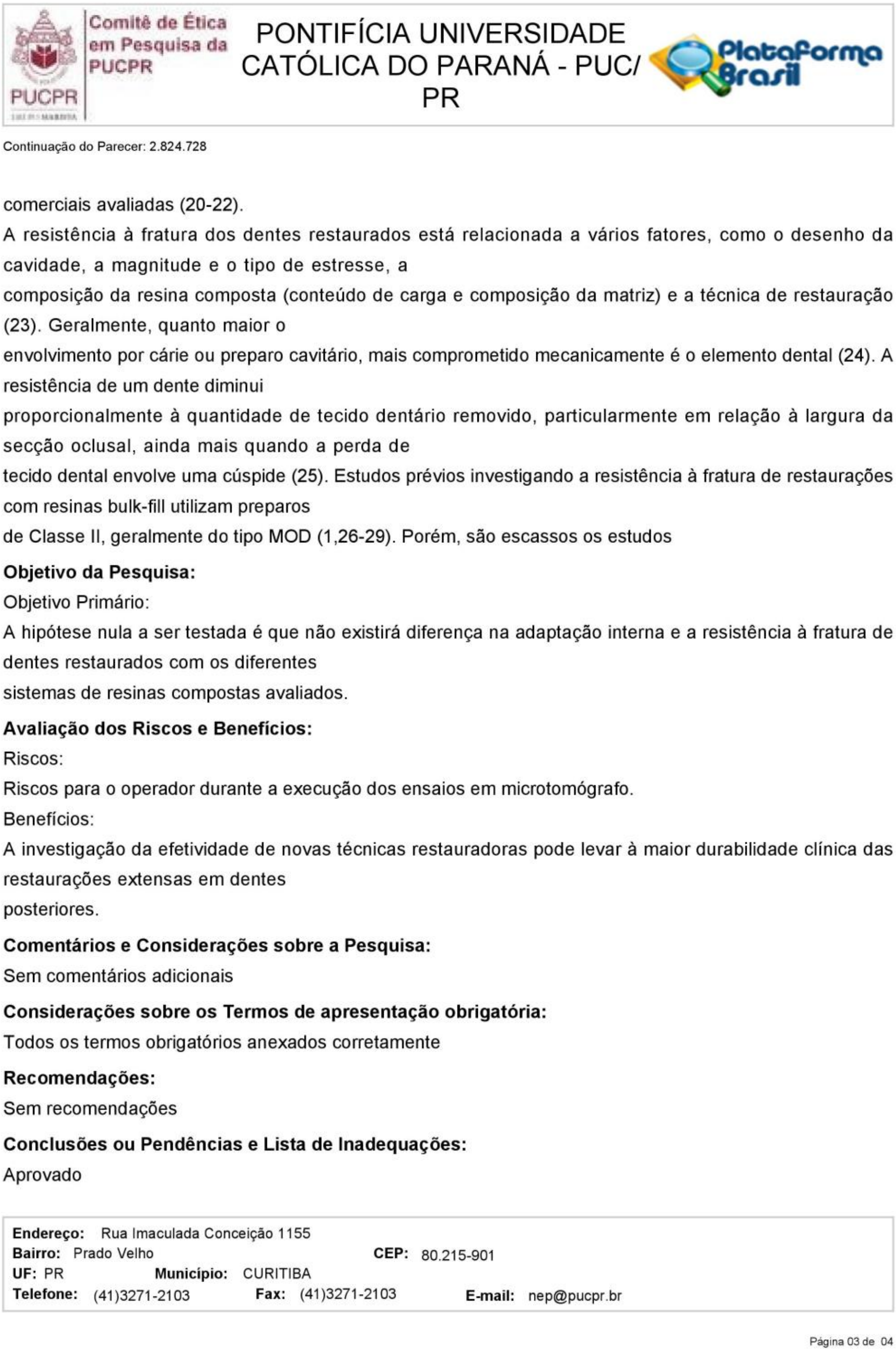
redução da resistência e falhas prematuras (6).

Nesse aspecto, a possibilidade de preencher uma cavidade em incremento único tem benefícios interessantes, entre eles, o menor tempo de trabalho e a redução da chamada "janela de oportunidade" para erros técnicos, como a incorporação de espaços e a contaminação entre camadas (7).

Buscando esses benefícios, os fabricantes têm desenvolvido novos materiais restauradores que podem ser utilizados em incremento único de 4 a 5 mm de espessura, conhecidos como resinas compostas bulk-fill (1,6). Este novo tipo de material promove redução do tempo de trabalho, porém ainda apresenta algumas limitações em termos de propriedades mecânicas quando comparadas às resinas convencionais (8). As resinas bulk-fill se encontram disponíveis em dois tipos de viscosidade, denominadas resinas compostas bulk-fill de base e de corpo. As resinas bulk-fill de corpo podem ser aplicadas em um incremento único sem a necessidade de cobertura, pois apresentam alto conteúdo de carga inorgânica e, portanto, podem ser usados em áreas de maior incidência de carga mastigatória (2). As resinas bulk-fill de base são compósitos de baixa viscosidade e, portanto, com menor conteúdo de carga inorgânica e usados como forramento ou base, sobrepostos por uma resina composta convencional (6).

Estudos têm demonstrado que as resinas compostas bulk-fill flow apresentam menor dureza, módulo de elasticidade, deformação de cúspides e de estresse de contração (9-11). Todas essas características mecânicas fazem com que as resinas compostas bulk-fill flow atuem como uma camada que absorve o estresse gerado pelo alto módulo de elasticidade da resina composta convencional (12).

A adaptação marginal de restaurações em resinas compostas tem sido frequentemente avaliada por meio de microtomografia computadorizada (13-19). Esse método é considerado mais vantajoso por não ser destrutível (14,16,18), ser mais preciso na avaliação de fendas marginais (16) e superar as limitações de análise subjetiva e qualitativa de testes de microinfiltração com uso de corantes (17). Estudos sobre a adaptação marginal de resinas bulk-fill tem demonstrado uma grande variedade de resultados conforme as marcas



comerciais avaliadas (20-22).
A resistência à fratura dos dentes restaurados está relacionada a vários fatores, como o desenho da cavidade, a magnitude e o tipo de estresse, a
composição da resina composta (conteúdo de carga e composição da matriz) e a técnica de restauração (23). Geralmente, quanto maior o
envolvimento por cárie ou preparo cavitário, mais comprometido mecanicamente é o elemento dental (24). A resistência de um dente diminui
proporcionalmente à quantidade de tecido dentário removido, particularmente em relação à largura da secção oclusal, ainda mais quando a perda de
tecido dental envolve uma cúspide (25). Estudos prévios investigando a resistência à fratura de restaurações com resinas bulk-fill utilizam preparos
de Classe II, geralmente do tipo MOD (1,26-29). Porém, são escassos os estudos

Objetivo da Pesquisa:

Objetivo Primário:
A hipótese nula a ser testada é que não existirá diferença na adaptação interna e a resistência à fratura de dentes restaurados com os diferentes
sistemas de resinas compostas avaliados.

Avaliação dos Riscos e Benefícios:

Riscos:
Riscos para o operador durante a execução dos ensaios em microtomógrafo.
Benefícios:
A investigação da efetividade de novas técnicas restauradoras pode levar à maior durabilidade clínica das restaurações extensas em dentes
posteriores.

Comentários e Considerações sobre a Pesquisa:

Sem comentários adicionais

Considerações sobre os Termos de apresentação obrigatória:

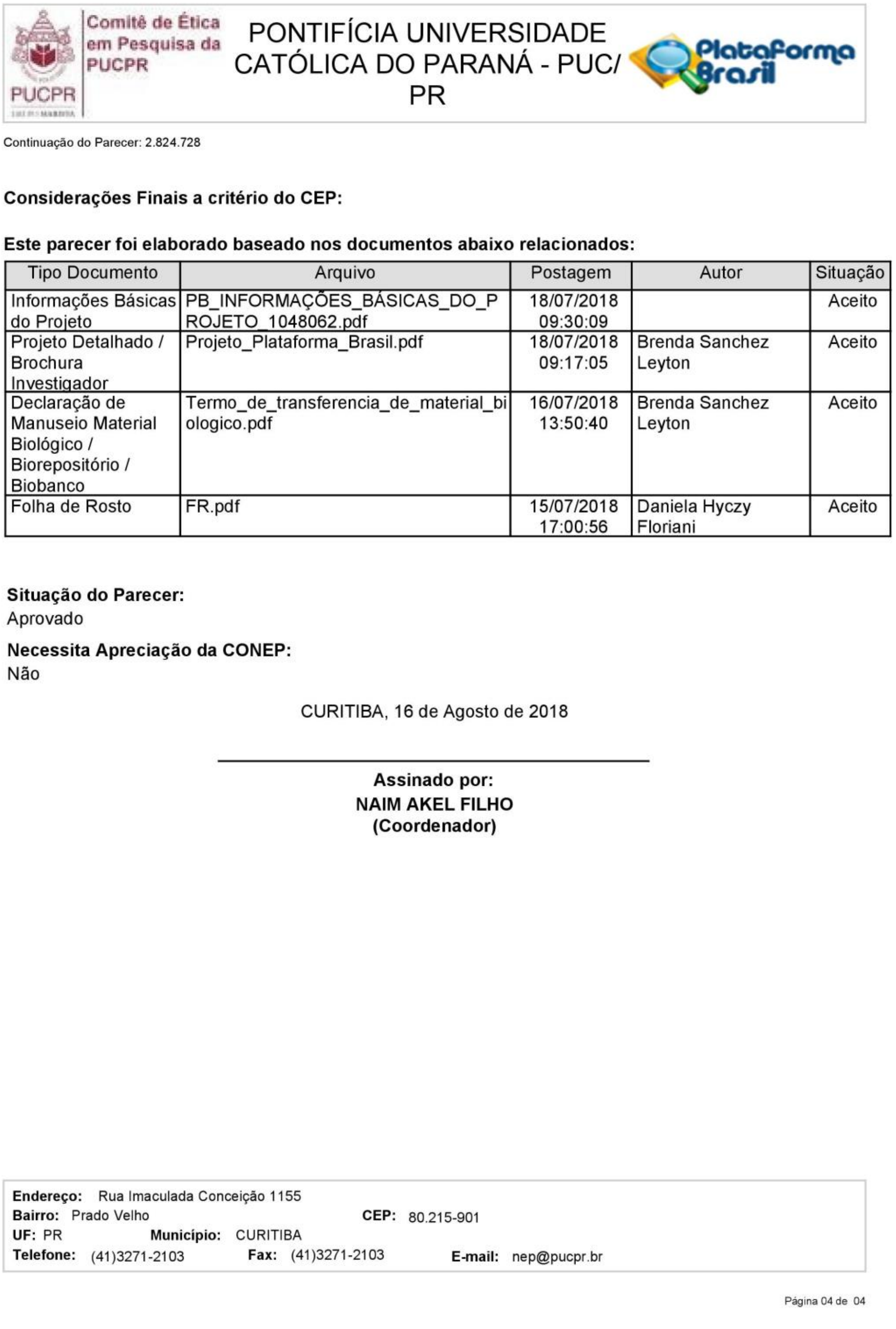
Todos os termos obrigatórios anexados corretamente

Recomendações:

Sem recomendações

Conclusões ou Pendências e Lista de Inadequações:

Aprovado



Continuação do Parecer: 2.824.728

Considerações Finais a critério do CEP:

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1048062.pdf	18/07/2018 09:30:09		Aceito
Projeto Detalhado / Brochura Investigador	Projeto_Plataforma_Brasil.pdf	18/07/2018 09:17:05	Brenda Sanchez Leyton	Aceito
Declaração de Manuseio Material Biológico / Biorepositório / Biobanco	Termo_de_transferencia_de_material_biologico.pdf	16/07/2018 13:50:40	Brenda Sanchez Leyton	Aceito
Folha de Rosto	FR.pdf	15/07/2018 17:00:56	Daniela Hyczy Floriani	Aceito

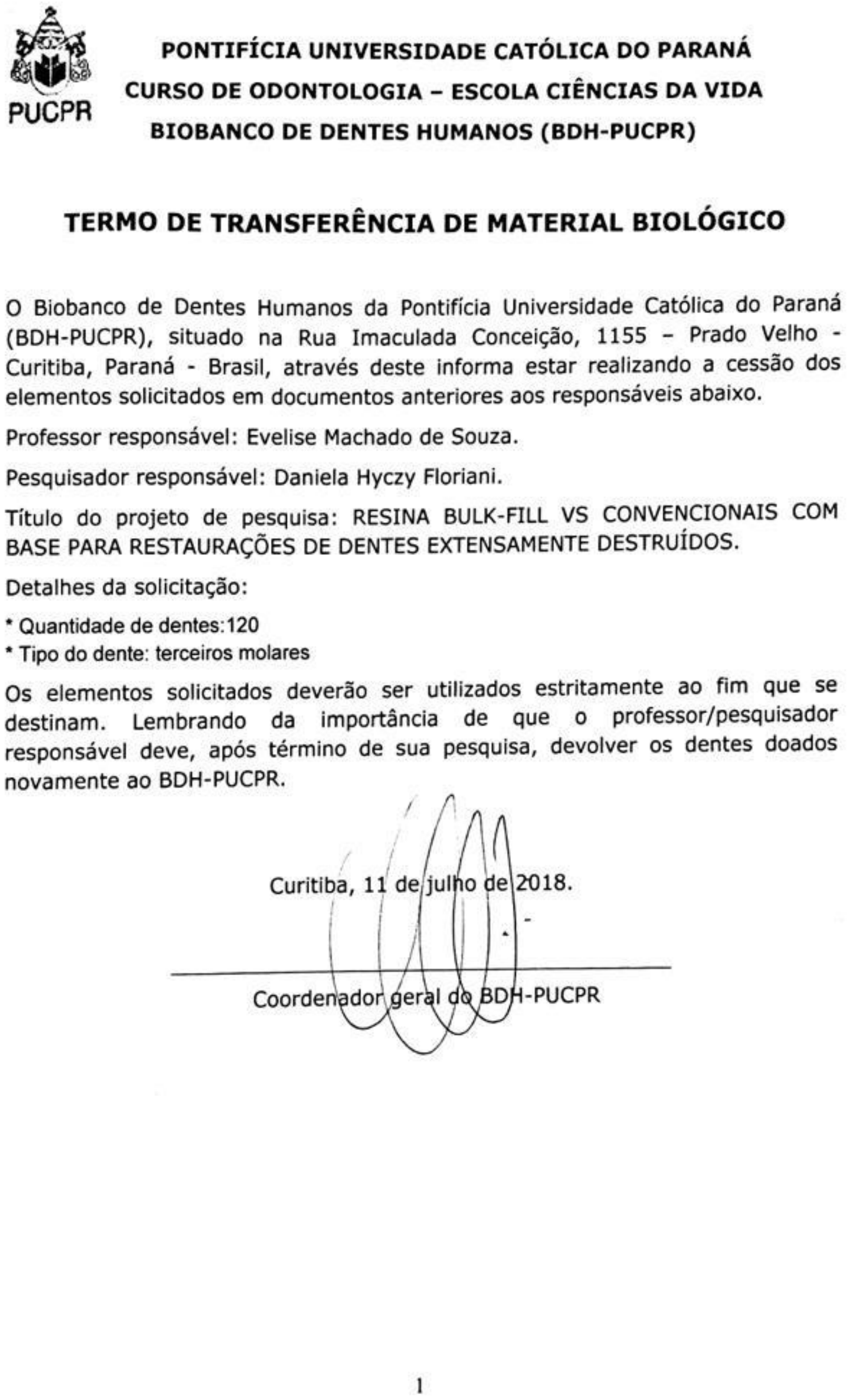
Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

CURITIBA, 16 de Agosto de 2018

Assinado por:
NAIM AKEL FILHO
(Coordenador)

Termo de transferência de material biológico



PONTIFÍCIA UNIVERSIDADE CATÓLICA DO PARANÁ
CURSO DE ODONTOLOGIA – ESCOLA CIÊNCIAS DA VIDA
BIOBANCO DE DENTES HUMANOS (BDH-PUCPR)

PUCPR

TERMO DE TRANSFERÊNCIA DE MATERIAL BIOLÓGICO

O Biobanco de Dentes Humanos da Pontifícia Universidade Católica do Paraná (BDH-PUCPR), situado na Rua Imaculada Conceição, 1155 – Prado Velho - Curitiba, Paraná - Brasil, através deste informa estar realizando a cessão dos elementos solicitados em documentos anteriores aos responsáveis abaixo.

Professor responsável: Evelise Machado de Souza.

Pesquisador responsável: Daniela Hyczy Floriani.

Título do projeto de pesquisa: RESINA BULK-FILL VS CONVENCIONAIS COM BASE PARA RESTAURAÇÕES DE DENTES EXTENSAMENTE DESTRUÍDOS.

Detalhes da solicitação:

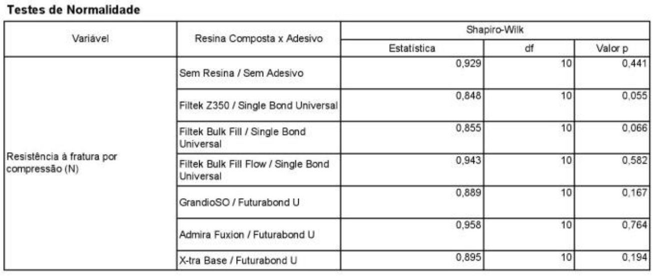
* Quantidade de dentes:120
* Tipo do dente: terceiros molares

Os elementos solicitados deverão ser utilizados estritamente ao fim que se destinam. Lembrando da importância de que o professor/pesquisador responsável deve, após término de sua pesquisa, devolver os dentes doados novamente ao BDH-PUCPR.

Curitiba, 11 de julho de 2018.

Coordenador geral do BDH-PUCPR

Analise estatística



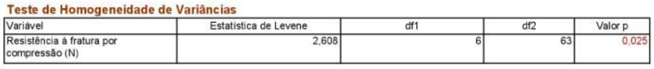
Testes de Normalidade

Variável	Resina Composta x Adesivo	Shapiro-Wilk		
		Estatística	df	Valor p
Resistência à fratura por compressão (N)	Sem Resina / Sem Adesivo	0,929	10	0,441
	Filtek Z350 / Single Bond Universal	0,848	10	0,055
	Filtek Bulk Fill / Single Bond Universal	0,855	10	0,066
	Filtek Bulk Fill Flow / Single Bond Universal	0,943	10	0,582
	GrandioSO / Futurabond U	0,889	10	0,167
	Admira Fuxion / Futurabond U	0,958	10	0,764
	X-tra Base / Futurabond U	0,895	10	0,194

Descritivos

Resistência à fratura por compressão (N)

Resina	N	Média	Desvio Padrão	Erro Padrão	Intervalo de confiança de 95% para média		Mínimo	Máximo
					Limite inferior	Limite superior		
Sem resina	10	1871,88	339,48	107,35	1629,03	2114,73	1456,49	2568,51
Filtek Z350	10	1183,33	334,99	105,93	943,69	1422,97	836,68	1665,58
Filtek Bulk Fill	10	1494,85	386,81	122,32	1218,14	1771,55	1116,92	2259,36
Filtek Bulk Fill Flow	10	1428,23	326,10	103,12	1194,95	1661,50	1002,97	1935,86
GrandioSO	10	1340,66	97,50	30,83	1270,91	1410,40	1198,90	1454,43
Admira Fuxion	10	1138,38	286,94	90,74	933,12	1343,64	732,97	1736,23
X-tra Base	10	1615,70	188,82	59,71	1480,63	1750,77	1356,25	1867,06

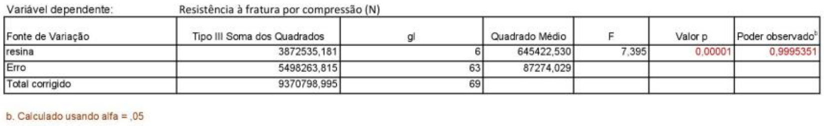


Teste de Homogeneidade de Variâncias

Variável	Estatística de Levene	df1	df2	Valor p
Resistência à fratura por compressão (N)	2,608	6	63	0,025

Análise Univariada de Variância

Resina Composta	Rótulo de valor	N
1	Sem resina	10
2	Filtek Z350	10
3	Filtek Bulk Fill	10
4	Filtek Bulk Fill Flow	10
5	GrandioSO	10
6	Admira Fuxion	10
7	X-tra Base	10



Variável dependente: Resistência à fratura por compressão (N)

Fonte de Variação	Tipo III Soma dos Quadrados	gl	Quadrado Médio	F	Valor p	Poder observado[b]
resina	3872535,181	6	645422,530	7,395	0,00001	0,9995351
Erro	5498263,815	63	87274,029			
Total corrigido	9370798,995	69				

b. Calculado usando alfa = ,05

Comparações múltiplas

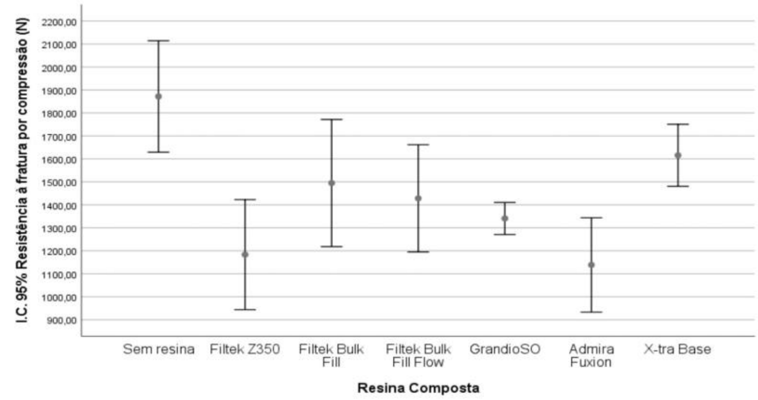
Variável dependente: Resistência à fratura por compressão (N)

Games-Howell

(I) Resina Composta	(J) Resina Composta	Diferença média (I-J)	Erro Padrão	Valor p	Intervalo de Confiança 95%	
					Limite inferior	Limite superior
Sem resina	Filtek Z350	688,5490*	150,82006	0,0037	190,1686	1186,9294
	Filtek Bulk Fill	377,0350	162,74691	0,2894	-161,7856	915,8556
	Filtek Bulk Fill Flow	443,6530	148,85696	0,0932	-48,3215	935,6275
	GrandioSO	531,2240*	111,69218	0,0085	130,3274	932,1206
	Admira Fuxion	733,5010*	140,56331	0,0010	267,5435	1199,4585
	X-tra Base	256,1810	122,84116	0,4098	-162,9088	675,2708
Filtek Z350	Sem resina	-688,5490*	150,82006	0,0037	-1186,9294	-190,1686
	Filtek Bulk Fill	-311,5140	161,81490	0,4906	-847,4675	224,4395
	Filtek Bulk Fill Flow	-244,8960	147,83741	0,6506	-733,4510	243,6590
	GrandioSO	-157,3250	110,32973	0,7784	-553,0381	238,3881
	Admira Fuxion	44,9520	139,48315	0,9999	-417,2050	507,1090
	X-tra Base	-432,3680*	121,60369	0,0383	-846,7543	-17,9817
Filtek Bulk Fill	Sem resina	-377,0350	162,74691	0,2894	-915,8556	161,7856
	Filtek Z350	311,5140	161,81490	0,4906	-224,4395	847,4675
	Filtek Bulk Fill Flow	66,6180	159,98678	0,9995	-463,7784	597,0144
	GrandioSO	154,1890	126,14482	0,8707	-301,5722	609,9502

	Admira Fuxion	356,4660	152,30042	0,2822	-151,6753	864,6073
	X-tra Base	-120,8540	136,11511	0,9683	-590,6129	348,9049
Filtek Bulk Fill Flow	Sem resina	-443,6530	148,85696	0,0932	-935,6275	48,3215
	Filtek Z350	244,8960	147,83741	0,6506	-243,6590	733,4510
	Filtek Bulk Fill	-66,6180	159,98678	0,9995	-597,0144	463,7784
	GrandioSO	87,5710	107,63064	0,9782	-297,8673	473,0093
	Admira Fuxion	289,8480	137,35813	0,3883	-164,8815	744,5775
	X-tra Base	-187,4720	119,16024	0,6999	-592,5857	217,6417
GrandioSO	Sem resina	-531,2240*	111,69218	0,0085	-932,1206	-130,3274
	Filtek Z350	157,3250	110,32973	0,7784	-238,3881	553,0381
	Filtek Bulk Fill	-154,1890	126,14482	0,8707	-609,9502	301,5722
	Filtek Bulk Fill Flow	-87,5710	107,63064	0,9782	-473,0093	297,8673
	Admira Fuxion	202,2770	95,83320	0,4080	-138,1535	542,7075
	X-tra Base	-275,0430*	67,20052	0,0155	-505,8167	-44,2693
Admira Fuxion	Sem resina	-733,5010*	140,56331	0,0010	-1199,4585	-267,5435
	Filtek Z350	-44,9520	139,48315	0,9999	-507,1090	417,2050
	Filtek Bulk Fill	-356,4660	152,30042	0,2822	-864,6073	151,6753
	Filtek Bulk Fill Flow	-289,8480	137,35813	0,3883	-744,5775	164,8815
	GrandioSO	-202,2770	95,83320	0,4080	-542,7075	138,1535
	X-tra Base	-477,3200*	108,62233	0,0069	-842,7553	-111,8847
X-tra Base	Sem resina	-256,1810	122,84116	0,4098	-675,2708	162,9088
	Filtek Z350	432,3680*	121,60369	0,0383	17,9817	846,7543
	Filtek Bulk Fill	120,8540	136,11511	0,9683	-348,9049	590,6129
	Filtek Bulk Fill Flow	187,4720	119,16024	0,6999	-217,6417	592,5857
	GrandioSO	275,0430*	67,20052	0,0155	44,2693	505,8167
	Admira Fuxion	477,3200*	108,62233	0,0069	111,8847	842,7553

*. A diferença média é significativa no nível ,05.



Descritivos

Resistência à fratura por compressão (N)

Adesivo	N	Média	Desvio Padrão	Erro Padrão	Intervalo de confiança de 95% para média		Mínimo	Máximo
					Limite inferior	Limite superior		
Sem adesivo	10	1.871,88	339,48	107,35	1.629,03	2.114,73	1.456,49	2.568,51
Single Bond Universal	30	1.368,80	364,44	66,54	1.232,72	1.504,89	836,68	2.259,36
Futurabond U	30	1.364,91	281,34	51,37	1.259,86	1.469,97	732,97	1.867,06

Teste de Homogeneidade de Variâncias

Variável	Estatística de Levene	df1	df2	Valor p
Resistência à fratura por compressão (N)	1,404	2	67	0,2527

Análise Univariada de Variância

Adesivo	Rótulo de valor	N
1	Sem adesivo	10
2	Single Bond Universal	30
3	Futurabond U	30

Variável dependente: Resistência à fratura por compressão (N)

Fonte de Variação	Tipo III Soma dos Quadrados	gl	Quadrado Médio	F	Valor p	Poder observado[b]
adesivo	2186361,847	2	1093180,924	10,195	0,00014	0,98295
Erro	7184437,148	67	107230,405			
Total corrigido	9370798,995	69				

b. Calculado usando alfa = ,05

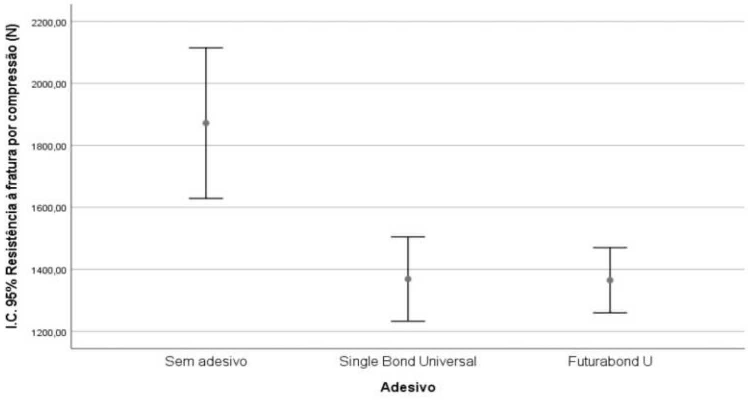
Comparações múltiplas

Variável dependente: Resistência à fratura por compressão (N)

Tukey HSD

(I) Adesivo	(J) Adesivo	Diferença média (I-J)	Erro Erro	Valor p	Intervalo de Confiança 95%	
					Limite inferior	Limite superior
Sem adesivo	Single Bond Universal	503,07900*	119,57168	0,000	216,4798	789,6782
	Futurabond U	506,96867*	119,57168	0,000	220,3695	793,5678
Single Bond Universal	Sem adesivo	-503,07900*	119,57168	0,000	-789,6782	-216,4798
	Futurabond U	3,88967	84,54995	0,999	-198,7665	206,5459
Futurabond U	Sem adesivo	-506,96867*	119,57168	0,000	-793,5678	-220,3695
	Single Bond Universal	-3,88967	84,54995	0,999	-206,5459	198,7665

*. A diferença média é significativa no nível 0.05.



Descritivos

Resistência à fratura por compressão (N)

Resina x Adesivo	N	Média	Desvio Padrão	Erro Padrão	Intervalo de confiança de 95% para média		Mínimo	Máximo
					Limite inferior	Limite superior		
Sem Resina / Sem Adesivo	10	1.871,88	339,48	107,35	1.629,03	2.114,73	1.456,49	2.568,51
Filtek Z350 / Single Bond Universal	10	1.183,33	334,99	105,93	943,69	1.422,97	836,68	1.665,58
Filtek Bulk Fill / Single Bond Universal	10	1.494,85	386,81	122,32	1.218,14	1.771,55	1.116,92	2.259,36
Filtek Bulk Fill Flow / Single Bond Universal	10	1.428,23	326,10	103,12	1.194,95	1.661,50	1.002,97	1.935,86
GrandioSO / Futurabond U	10	1.340,66	97,50	30,83	1.270,91	1.410,40	1.198,90	1.454,43
Admira Fuxion / Futurabond U	10	1.138,38	286,94	90,74	933,12	1.343,64	732,97	1.736,23
X-tra Base / Futurabond U	10	1.615,70	188,82	59,71	1.480,63	1.750,77	1.356,25	1.867,06

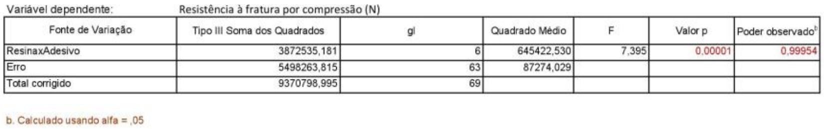
Teste de Homogeneidade de Variâncias

Variável	Estatística de Levene	df1	df2	Valor p
Resistência à fratura por compressão (N)	2,608	6	63	0,0254

Análise Univariada de Variância

Resina Composta x Adesivo	Rótulo de valor	N

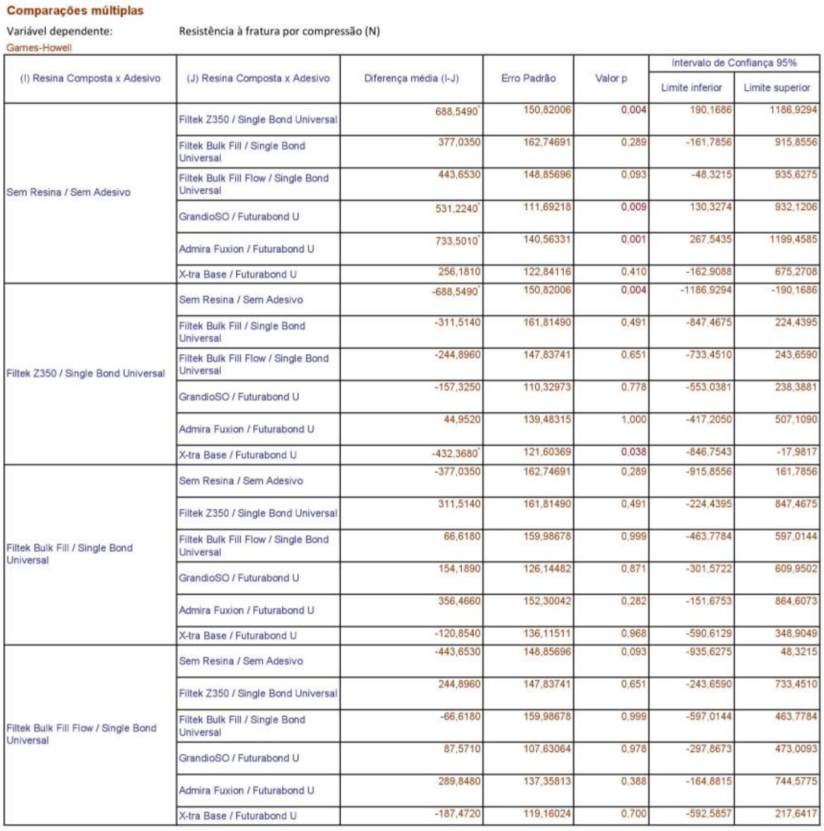
1	Sem Resina / Sem Adesivo	10
2	Filtek Z350 / Single Bond Universal	10
3	Filtek Bulk Fill / Single Bond Universal	10
4	Filtek Bulk Fill Flow / Single Bond Universal	10
5	GrandioSO / Futurabond U	10
6	Admira Fuxion / Futurabond U	10
7	X-tra Base / Futurabond U	10



Variável dependente: Resistência à fratura por compressão (N)

Fonte de Variação	Tipo III Soma dos Quadrados	gl	Quadrado Médio	F	Valor p	Poder observado[b]
ResinaxAdesivo	3872535,181	6	645422,530	7,395	0,00001	0,99954
Erro	5498263,815	63	87274,029			
Total corrigido	9370798,995	69				

b. Calculado usando alfa = ,05



Comparações múltiplas

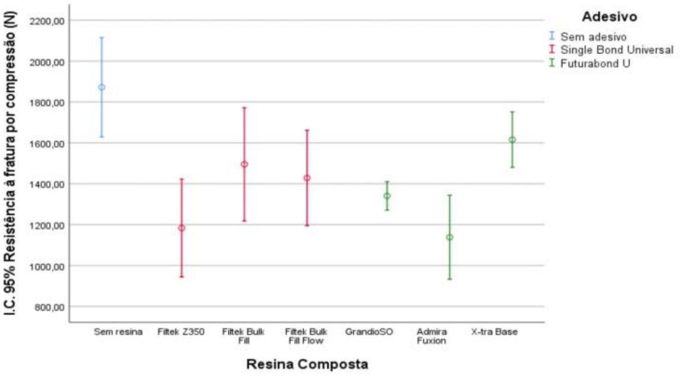
Variável dependente: Resistência à fratura por compressão (N)

Games-Howell

(I) Resina Composta x Adesivo	(J) Resina Composta x Adesivo	Diferença média (I-J)	Erro Padrão	Valor p	Intervalo de Confiança 95%	
					Limite inferior	Limite superior
Sem Resina / Sem Adesivo	Filtek Z350 / Single Bond Universal	688,5490*	150,82006	0,004	190,1686	1186,9294
	Filtek Bulk Fill / Single Bond Universal	377,0350	162,74691	0,289	-161,7856	915,8556
	Filtek Bulk Fill Flow / Single Bond Universal	443,6530	148,85696	0,093	-48,3215	935,6275
	GrandioSO / Futurabond U	531,2240*	111,69218	0,009	130,3274	932,1206
	Admira Fuxion / Futurabond U	733,5010*	140,56331	0,001	267,5435	1199,4585
	X-tra Base / Futurabond U	256,1810	122,84116	0,410	-162,9088	675,2708
Filtek Z350 / Single Bond Universal	Sem Resina / Sem Adesivo	-688,5490*	150,82006	0,004	-1186,9294	-190,1686
	Filtek Bulk Fill / Single Bond Universal	-311,5140	161,81490	0,491	-847,4675	224,4395
	Filtek Bulk Fill Flow / Single Bond Universal	-244,8960	147,83741	0,651	-733,4510	243,6590
	GrandioSO / Futurabond U	-157,3250	110,32973	0,778	-553,0381	238,3881
	Admira Fuxion / Futurabond U	44,9520	139,48315	1,000	-417,2050	507,1090
	X-tra Base / Futurabond U	-432,3680*	121,60369	0,038	-846,7543	-17,9817
Filtek Bulk Fill / Single Bond Universal	Sem Resina / Sem Adesivo	-377,0350	162,74691	0,289	-915,8556	161,7856
	Filtek Z350 / Single Bond Universal	311,5140	161,81490	0,491	-224,4395	847,4675
	Filtek Bulk Fill Flow / Single Bond Universal	66,6180	159,98678	0,999	-463,7784	597,0144
	GrandioSO / Futurabond U	154,1890	126,14482	0,871	-301,5722	609,9502
	Admira Fuxion / Futurabond U	356,4660	152,30042	0,282	-151,6753	864,6073
	X-tra Base / Futurabond U	-120,8540	136,11511	0,968	-590,6129	348,9049
Filtek Bulk Fill Flow / Single Bond Universal	Sem Resina / Sem Adesivo	-443,6530	148,85696	0,093	-935,6275	48,3215
	Filtek Z350 / Single Bond Universal	244,8960	147,83741	0,651	-243,6590	733,4510
	Filtek Bulk Fill / Single Bond Universal	-66,6180	159,98678	0,999	-597,0144	463,7784
	GrandioSO / Futurabond U	87,5710	107,63064	0,978	-297,8673	473,0093
	Admira Fuxion / Futurabond U	289,8480	137,35813	0,388	-164,8815	744,5775
	X-tra Base / Futurabond U	-187,4720	119,16024	0,700	-592,5857	217,6417

GrandioSO / Futurabond U	Sem Resina / Sem Adesivo	-531,2240*	111,69218	0,009	-932,1206	-130,3274
	Filtek Z350 / Single Bond Universal	157,3250	110,32973	0,778	-238,3881	553,0381
	Filtek Bulk Fill / Single Bond Universal	-154,1890	126,14482	0,871	-609,9502	301,5722
	Filtek Bulk Fill Flow / Single Bond Universal	-87,5710	107,63064	0,978	-473,0093	297,8673
	Admira Fuxion / Futurabond U	202,2770	95,83320	0,408	-138,1535	542,7075
	X-tra Base / Futurabond U	-275,0430*	67,20052	0,016	-505,8167	-44,2693
Admira Fuxion / Futurabond U	Sem Resina / Sem Adesivo	-733,5010*	140,56331	0,001	-1199,4585	-267,5435
	Filtek Z350 / Single Bond Universal	-44,9520	139,48315	1,000	-507,1090	417,2050
	Filtek Bulk Fill / Single Bond Universal	-356,4660	152,30042	0,282	-864,6073	151,6753
	Filtek Bulk Fill Flow / Single Bond Universal	-289,8480	137,35813	0,388	-744,5775	164,8815
	GrandioSO / Futurabond U	-202,2770	95,83320	0,408	-542,7075	138,1535
	X-tra Base / Futurabond U	-477,3200*	108,62233	0,007	-842,7553	-111,8847
X-tra Base / Futurabond U	Sem Resina / Sem Adesivo	-256,1810	122,84116	0,410	-675,2708	162,9088
	Filtek Z350 / Single Bond Universal	432,3680*	121,60369	0,038	17,9817	846,7543
	Filtek Bulk Fill / Single Bond Universal	120,8540	136,11511	0,968	-348,9049	590,6129
	Filtek Bulk Fill Flow / Single Bond Universal	187,4720	119,16024	0,700	-217,6417	592,5857
	GrandioSO / Futurabond U	275,0430*	67,20052	0,016	44,2693	505,8167
	Admira Fuxion / Futurabond U	477,3200*	108,62233	0,007	111,8847	842,7553

*. A diferença média é significativa no nível ,05.



Normas para publicação – Operative Dentistry

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