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Research / Araştırma Makalesi

Comparison of the Effect of Adhesive Protocols and Light Curing Units on the Repair Bond Strength of Bulk Fill Composite Resins

Adeziv Protokollerinin ve Işıkla Sertleştirme Ünitelerinin Bulk Fill Kompozit Rezinlerin Tamir Bağlanma Dayanımı Üzerindeki Etkisinin Karşılaştırılması

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ABSTRACT

Background: The aim of this study was to compare the shear bond strengths (SBS) of a microhybrid composite resin (CR) after repair with 3 different bulk fill CR using 2nd and 3rd generation light-emitting diode (LED) light devices and a universal adhesive applied with different protocols.

Methods: 120 acrylic blocks, each with an open surface and a depth of 2 mm and a diameter of 6 mm, were filled with a microhybrid CR (Filtek Z250) and cured with an LED for 20 seconds. The samples were roughened for 5 seconds with a diamond fissure bur under water cooling and then subjected to 5,000 thermal cycles. A universal adhesive was applied to the prepared samples using two different protocols (total etch and self-etch), and samples were then filled with bulk fill CRs. Each bulk fill CR group was polymerized with 2nd and 3rd generation LED to form subgroups (n=10). The SBS values were recorded in MPa using a universal testing device.

Results: The highest SBS values were obtained for the X-tra Fil group in total etch mode with polymerization using 3rd generation LED, while the lowest SBS values were found for Filtek One Bulk Fill group in self-etch mode with polymerization using the 3rd generation LED. In all groups, total etch mode yielded higher SBS values compared to self-etch mode.

Conclusion: Different adhesive protocols and LCUs were found to affect the SBS values of bulk fill CRs during repair.

Keywords: Adhesive Protocols, Bulk Fill Composite, Composite Repair, LED Units

ÖZ

Amaç: Bu çalışmanın amacı mikrohibrit bir kompozit rezinin (KR), 2. ve 3. nesil LED ışık cihazlarının ve farklı protokollerle uygulanan universal bir adeziv kullanarak 3 farklı bulk fill KR ile tamiri sonrası makaslama bağlanma dayanımlarını karşılaştırmaktır.

Materyal Metod: Bir yüzeyi açık ve derinliği 2 mm, çapı 6 mm olan 120 adet akrilik blok bir mikrohibrit KR olan Filtek Z250 ile dolduruldu ve LED ışık cihazı ile 20 sn ışıklandı. Hazırlanan örnekler su soğutması altında elmas fissür frez ile 5 saniye pürüzlendirildi ve 5.000 termal döngüye tabi tutuldu. Hazırlanan örneklere universal bir adeziv ajan iki farklı protokolle (total etch ve self etch) uygulandı ve gruplara uygun olacak şekilde bulk fill KR' lerle dolduruldu. Alt grupları oluşturmak için ise her bir bulk fill KR grubu 2. ve 3. nesil LED ışık cihazları ile polimerize edildi (n=10). Örnekler universal bir test cihazında SBS testine tabi tutularak değerler MPa cinsinden kaydedildi.

Bulgular: X-tra Fil KR grubunun total etch modunda 3. nesil LED ışık cihazıyla polimerizasyonu sonrası en yüksek, Filtek One Bulk Fill KR grubunun self etch modunda 3. nesil LED ışık cihazıyla polimeriasyonu sonrası ise en düşük SBS değerleri elde edilmiştir. Bütün gruplarda total etch modunda self etch moduna kıyasla daha yüksek SBS değerleri gözlendi.

Sonuç: Farklı adeziv protokoller ve ışık cihazları bulk fill KR' lerin tamirinde SBS değerleri üzerinde etkili bulunmuştur.

Anahtar Kelimeler: Adeziv Protokol, Bulk Fill Kompozitler, Kompozit Tamiri, LED Işık Cihazı

Introduction

Composite resins (CRs) are frequently preferred for dental restorations due to their aesthetic appeal, economic efficiency, quick treatment time, acceptable longevity, and preservation of healthy tooth structure.[1] However, their extensive clinical use also brings various problems and restoration failures such as discoloration, fractures, secondary caries, and contact issues. There are different procedures for treating failed restorations, including complete replacement, adjustment, or repair. Complete replacement can result in significant loss of tooth substance, pulp perforations, and time loss for both the patient and the clinician, as well as being more costly compared to repair.[2] Therefore, repair is often preferred when possible.

Bulk fill composites are produced to eliminate the disadvantages of the incremental technique, such as its long duration and the risk of contamination that may occur between layers.[3] These CRs have higher translucency and modified monomer and filler content compared to conventional composites.[4,5] Due to their advantages, bulk fill CRs are frequently used by clinicians.[6] However, similar to conventional CRs, failures can also occur in restorations made with bulk fill CRs, and repair is an option for these failed restorations as well.

Various light curing units (LCUs) with different characteristics are used in dental practice for the polymerization of resin-based materials. Recent light-emitting diode (LED) with higher intensity, stronger light output, and shorter curing times have been introduced to improve the success factors of restorations.[7] Despite providing quick polymerization, the high intensity and power of these devices pose risks of damage to the pulp and surrounding tissues, and there are concerns regarding the depth of polymerization.[8,9]

The main issue in the repair of composite restorations is to ensure an acceptable bond between the repair material and the old restoration.[10] Aging reduces the number of unreacted double bonds in the existing restoration, negatively affecting the bond with the repair material. Surface treatments such as etching with hydrofluoric or phosphoric acid can increase surface roughness and enhance the bond between the repair material and the existing restoration.[11,12] Universal adhesives, which contain MDP (methacryloyloxydecyl dihydrogen phosphate) monomers and silane, can be used with different techniques (total-etch, selective, and self-etch) to improve the bond strength.[13] For this reason, they can be preferred as adhesive materials in the repair of existing restorations.[14] The options for use suggest the evaluation of which method will strengthen the connection between the existing restoration and the repair material.

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Given the advantages of CR repair, it is a frequently used treatment option. This research aim to evaluate repair bond strength of bulk fill composite resins during repair using different light curing and adhesive protocols. The null hypothesis of the study was that LED light curing units of different generations and different application protocols of universal adhesive do not affect repair bond strength of bulk fill composites.

Material and Methods

Sample Preparation

In this study, three different bulk fill composite materials (Filtek One Bulk Fill, X-tra Fil, Tetric N-Ceram Bulk Fill), two LED light curing units (Woodpecker LED. B, Valo Cordless), and a universal adhesive (Single Bond Universal, 3M ESPE) were used. Technical information about bulk fill composite resins and different generation LED units used is presented in **Table 1**. As a result of the power analysis to calculate the sample size, the power of test was found to be p=.87240 and 10 samples were taken for each group.

Table 1. Materials used in this study

Material	Contents		Manufacturer
Filtek One Bulk Fill	AUDMA, AFM, diurethane-DMA and 1,12-dodecane-DMA, ytterbium trifluoride, zironia/silica		3M ESPE, St. Paul, MN, USA
X-tra Fil	Matrix: dimethacrylate (Bis-GMA, TEGDMA, UDMA) Inorganic filler (Barium aluminum silicate, fumed silica, pigments)		Voco, Cuxhaven, Germany
Tetric N-Ceram Bulk Fill	Matrix: bis-GMA, bis-EMA, UDMA Filler: barium silicate alumino glass, "isofiller" (prepolymer, glass and ytterbium fluoride), ytterbium fluoride and mixed oxides		Ivoclar Vivadent, Schaan, Liechtenstein
Light Curing Units	**Type**	**Intensity**	**Manufacturer**
Valo	LED third generation *(Polywave)*	~1400 mW/cm2 ± 10%	Ultradent products Inc., South Jordan, USA
Woodpecker LED.B	LED second generation (Monowave)	~1200 mW/cm2 ± 10%	Guilin Woodpecker Medical Instrument, Guilin, China

120 acrylic blocks with an open surface and dimensions of 2 mm in depth and 6 mm in diameter were created. The blocks were filled with a microhybrid composite resin (Filtek Z250) and cured with an LED light curing unit (Elipar DeepCure-S, 3M ESPE, St. Paul, MN, USA) for 20 seconds. The samples were roughened for 5 seconds with a diamond fissure bur under water cooling. After all composite samples were rinsed under water, they were kept in distilled water at 37 °C for 24 hours and 5,000 thermal cycles (Thermocyler, Turkey) were applied. The thermal cycling procedure included water baths at 5°C and 55°C (±2°C) and consisted of immersion with a 30-second dwell time-5-second transfer time.

Repair Procedure:

The groups where the total etching mode would be applied were etched with 37% phosphoric acid (Scotchbond Universal Etchant, 3M ESPE) for 30 seconds. After acid treatment, they were rinsed with water spray for 15 seconds and then dried for 10 seconds. The adhesive agent (Single Bond Universal, 3M ESPE) was then applied. The samples were scrubbed with a disposable brush for 15 seconds, and the solvent was removed by air drying for 10 seconds.

In the groups where the adhesive agent was applied in the self-etch mode, the adhesive agent was applied to the surfaces of the samples using a disposable brush, rubbed for 15 seconds, and solvent was removed by air drying for 10 seconds.

After the adhesive application, a cylindrical transparent tube with a height of 4 mm and an inner diameter of 3 mm was placed in the center of the composite resin and filled with bulk filling composite resins suitable for the groups. The groups cured with the LEDB light curing unit (2^{nd} generation LED) were light-cured for 20 seconds, and the groups cured with the Valo Cordless (3^{rd} generation LED) were light-cured for 3 seconds in high power mode. After polymerization, the plastic molds were removed and after repair process, the samples were kept in distilled water at 37ºC for 4 weeks. It was then subjected to shear bond strength (SBS) testing.

SBS Test

Samples were positioned a universal testing machine (Instron Lloyd LRX; Lloyd Instruments Ltd., England). The breaking apparatus was aligned perpendicular to the repair surface of the samples. The samples were then subjected to an SBS test at a head speed of 1 mm/min. The values obtained after the SBS test were recorded in Megapascals (MPa).

Statistical Analysis

Data were analyzed using SPSS 22.0 (Statistical Package for Social Science Version: 22). Since parametric test assumption was performed for data analysis, one-way analysis of variance (ANOVA) was used, and Tukey HSD test was used for pairwise comparisons. P-values equal to or less than 0.05 were considered statistically significant.

Results

The results obtained from our study are shown in **Table 2**. According to our study results, when evaluated in terms of adhesive application protocol, the highest repair bond strength value was observed in total etching mode in all composite groups. Considering the light curing units, the highest bond strength was observed in X-tra Fil group polymerized with Valo light curing unit. The lowest repair bond strength value was observed in Filtek One Bulk Fill group polymerized with Valo light curing unit.

Table 2. SBS test values (MPa)

Composite Resin	LED.B	Valo
Filtek One Bulk Fill (Total etch mode)	$25.01 \pm 3.87^{A, a}$	$23.12 \pm 2.90^{A, a}$
X-tra Fil (Total etch mode)	$26.81 \pm 1.09^{A, a}$	$27.91 \pm 1.82^{B, a}$
Tetric N Ceram Bulk Fill (Total etch mode)	$23.11 \pm 2.99^{A, a}$	$27.65 \pm 1.54^{B, b}$
Filtek One Bulk Fill (Self etch mode)	$20.16 \pm 1.33^{B, a}$	$18.21 \pm 1.67^{C, a}$
X-tra Fil (Self etch mode)	$22.81 \pm 2.09^{B, a}$	$24.98 \pm 2.41^{A, a}$
Tetric N Ceram Bulk Fill (Self etch mode)	$20.65 \pm 1.66^{B, a}$	$22.72 \pm 1.13^{A, a}$

** Different uppercase letters indicate statistical difference vertically, different lowercase letters indicate statistical difference horizontally.*

Discussion

Based on the study data, the null hypothesis that different light sources and adhesive protocols do not affect the repair bond strength of bulk fill composites was rejected.

Repair is a commonly applied protocol for composite resins. Successful repair is achieved through strong bonding, which is influenced by numerous factors. Challenges in this procedure stem from the fact that the surface of the old composite lacks unreacted double bonds necessary for bonding to new composite material. Clinicians often do not know which material was used in the existing restoration. The light sources used in the polymerization of composite resins can affect their optical, physical, and mechanical properties. In this study, the LED light curing units used included a 2^{nd} generation monowave LED light curing unit (LED B) and a 3^{rd} generation polywave LED light curing unit (Valo). Universal adhesives provide versatility in application techniques. Therefore, the aim of this study is to evaluate the bonding strength of 3 different bulk fill composites by applying a universal adhesive in different protocols and using 2 different generations of LED light curing units.

Photoinitiators in composite resins significantly influence polymerization. Studies have shown that improving the quality of polymerization can increase the bond strength of the repair area.[15,16] Shimokawa et al.[17] demonstrated that better polymerization is achieved with a light curing unit that emits light at the appropriate wavelength for the photoinitiator in the composite resin used. Lucey et al.[18] comparing the effect of 2^{nd} and 3^{rd} generation LED on the degree of conversion of different materials, they found that the composite resin containing camphorquinone achieved the best degree of conversion with the 2^{nd} generation LED. Kiliç et al.[19] evaluated the repair bond strength of different composite resins polymerized with QTH, 2^{nd}

generation LED, and 3rd generation LED light curing units, and found higher SBS values with the 2nd generation LED light curing unit for composite resins containing camphorquinone. Tetric EvoCeram Bulk Fill contains Ivocerin®, an alternative photoinitiator most sensitive to violet light around 410 nm. Filtek Bulk Fill Posterior Restorative does not contain additional photoinitiators besides camphorquinone. The Valo light curing unit produces polywave light, while the LED B light curing unit produces monowave light. This could explain why the Tetric EvoCeram Bulk Fill group achieved better polymerization and thus stronger bonding when activated with the Valo light curing unit, while the FBF group bonded more strongly with the LED B light curing unit.

The structural properties of composite resins, such as organic monomer content, inorganic filler volume and size, affect their physical and mechanical properties post-polymerization. Different monomers have different degrees of conversion, with TEGDMA monomer showing low viscosity and high conversion rates.[20] One study observed a synergistic effect on polymerization rate and conversion degree when Bis-GMA was diluted with low-viscosity TEGDMA monomer.[21] Sgarbi et al.[22] indicated that resin composites containing Bis-GMA and TEGDMA as organic matrix components might include larger amounts of TEGDMA as the main contributor to polymerization. Improved polymerization enhances bond strength, which could explain why the highest SBS values were observed in the X-tra Fill group containing both Bis-GMA and TEGDMA monomers.

In our study, using the adhesive agent in total etch mode increased bond strength in all groups compared to self-etch mode. The microporosities and surface irregularities created by phosphoric acid in the total etch mode may have facilitated stronger bonding of the adhesive agent.[23] Wendler et al.[24] evaluated the repair bond strength of a nanohybrid composite material after different surface preparation protocols and found the best bonding in the phosphoric acid-applied group due to the increased surface area for bonding. Removing surface residues with acid increases surface energy and wettability, strengthening adhesion to the repair material. Rathke et al.[23] roughened composite surfaces with different particle sizes (50 µm and 30 µm) and found higher bond strength in groups with more microporosities. Akgül et al.[14] in their study evaluating the repair shear bond strengths of bulk fill composites after different surface treatments, observed higher shear bonding in the total etch groups. Irmak et al.[25] reported higher bond strength in groups with one-step total etch adhesive applications in their study evaluating the repair bond strengths of adhesives on composite resin.

Conclusion

Within the limitations of our study, the adhesive agent, adhesion protocol, and light curing unit used in the repair process are crucial in evaluating the bond between the repair composite resin and the existing restoration. Additionally, the appropriate use of light curing units and increased surface area of the materials used enhance bond strength. Clinicians should consider these parameters when performing composite resin repairs.

Although the materials used with thermal cycling have been aged, the limitation of this study is that the oral environment cannot be fully imitated. Additionally, further in vitro studies can be conducted using different test methods and different types of composite resins.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

Bu makale, sempozyum ya da kongrede sunulan bir tebliğin içeriği geliştirilerek ve kısmen değiştirilerek üretilmemiştir.

Bu çalışma, yüksek lisans ya da doktora tezi esas alınarak hazırlanmamıştır.

Bu çalışmanın hazırlanma sürecinde bilimsel ve etik ilkelere uyulduğu ve yararlanılan tüm çalışmaların kaynakçada belirtildiği beyan olunur.

This article is not the version of a presentation.

This article has not been prepared on the basis of a master's/doctoral thesis.

It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

Yapıldı – ithenticate

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Çıkar Çatışması / Conflict of Interest

Yazarlar çıkar çatışması bildirmemiştir. | The authors have no conflict of interest to declare.

Yazar Katkıları / Author Contributions

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