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Original research

EFFECT OF DIFFERENT SURFACE TREATMENTS ON THE REPAIR OF AGED BULK-FILL COMPOSITES: AN IN VITRO STUDY

Soner ŞİŞMANOĞLU[1]

ORCID IDs of the authors:
S.Ş. 0000-0002-1272-5581

[1] Department of Restorative Dentistry, Faculty of Dentistry, Altınbaş University, Istanbul, Turkey.

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ABSTRACT

Objectives: The aim of this *in vitro* study was to evaluate the efficiency of different surface treatments on the microtensile bond strength (μTBS) of aged bulk-fill composite.

Materials and Methods: Sixty bulk-fill resin-based composite (RBC) specimens in 5 x 5 x 5 dimensions were prepared. After the aging by thermal cycling for 5000 times between 5 and 55°C, substrate surfaces were abraded with SiC abrasive papers. Specimens were divided into 6 groups according to the surface treatment protocol: no surface treatment (control), control + Single Bond Universal (SBU; 3M ESPE) application, phosphoric acid etching (PA) + SBU, hydrofluoric acid etching (HF) + SBU, aluminum oxide air abrasion (AlO) + SBU, and tribochemical silica coating (TSC) + SBU. Surface roughness values were measured in five different directions using a contact profilometer (n=10). Then, specimens were repaired with a conventional RBC. After the repair, bonded specimens were cut into 1 mm^2 beams and μTBS values were determined until failure at a crosshead speed of 0.5 mm/min. Specimen surfaces after surface treatments were observed by SEM. Data were analyzed using ANOVA and Tukey tests ($p<0.05$).

Results: One-way ANOVA revealed significant difference ($p<0.001$) among the surface treatments. The lowest repair μTBS values were observed for the control group. SBU application alone significantly improved repair μTBS values ($p<0.001$). The highest μTBS values were obtained for the AlO and TSC, and HF followed. The surface roughness ranking for the five surface treatment protocols was as follows: TSC > AlO > HF > PA = Control.

Conclusions: Aged bulk-fill RBCs can be successfully repaired if effective and safe repair protocol is chosen. The highest μTBS values were obtained for the AlO and TSC. The use of universal adhesive alone is promising to facilitate the repair of bulk-fill RBCs.

Keywords: Composite resins, dental restoration repair, dental adhesives, surface properties.

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***Corresponding Author:**
Department of Restorative Dentistry, Faculty of Dentistry, Altınbaş University, Istanbul, Turkey.
Phone: +90 212 709 45 28 **Fax:** +90 212 525 00 75 **Email:** soner.s@hotmail.com

INTRODUCTION

The application of resin-based composite (RBC) restorations in the posterior region increases in parallel with the development of restorative materials. One of the most important problems of RBCs is polymerization shrinkage and its associated stress. Due to the polymerization shrinkage, loss of adhesion may occur at the tooth-restoration interface, which results in nano-leakage causing secondary caries.[1,2] In order to prevent the undesirable effects of polymerization shrinkage, the use of incremental technique is required when applying the RBC to the cavity. According to this technique, maximum of 2-mm thick RBC layers are applied to the cavity.[3] The polymerization of each layer separately with light and the polymerization time varying between 20 to 40 seconds prolong the duration of the restorative procedure. On the other hand, the application of RBCs is a process requiring technical precision and adequate isolation. The adaptation and light-curing of each layer with incremental technique increases the risk of contamination, which may adversely affect restoration success.[4] Thus, the use of RBCs is time-consuming and requires more technical precision, especially in the posterior region. Therefore, the demand for relatively easy-to-use materials, such as amalgam, which can be placed to the cavity as a single bulk increment to overcome the application difficulty, the risk of contamination, the possibility of leaving air gaps between the increments, and the time consumption of the incremental technique[4] led to the development of bulk-fill RBCs. This novel material that exhibits controlled polymerization shrinkage, acceptable degree of conversion and micro hardness[5] when placed in a single bulk increment have been introduced with a wide range of products to the dental market.[6]

Bulk-fill RBCs are a new type of composite produced by the customization of resin monomers, photo-initiators and filler particles. The most important feature of bulk-fill RBCs is that they can be used as bulk with a depth of cure up to 5 mm.[7] Unlike bisphenol A-glycidyl methacrylate (Bis-GMA) based resin composites, higher molecular weight monomers are used to compensate the degree of conversion expected to decrease at the claimed layering depth.[8,9] The approach of reducing the size and increasing the proportion of filler particles in conventional RBCs is modified in bulk-fill RBCs[10,11], and composites with reduced filler ratios are produced.[12] Due to the increased filler particle size, the filler and resin matrix interface is reduced, which results in less scattering and more penetration of the curing light. Moreover, adequate polymerization depth of bulk-fill RBCs in deep cavities is also achieved by increasing their translucency.[10] However there are some concerns on their clinical performance regarding the bond strength.[13]

RBCs have a limited longevity with an average of 2.2% annual failure rate regardless of their extensive use.[14] In a recent meta-analysis, researchers reported that there was no significant difference between bulk-fill RBCs and conventional RBC regarding their clinical performances.[15] Many researchers have suggested that composite restorations should be repaired, and in such cases, the bond strength is within clinically acceptable limits that after the repair.[16–20] Total replacement may result in the removal of sound dental substances and unnecessary expansion of the existing preparation. In deep cavities, a total replacement may lead to unnecessary trauma to the dental pulp. In addition, restoration repair is less time-consuming and cost-effective than total replacement. The most common restorative material in dental practice is conventional composites.[21] In this case, bulk fill composite materials may need to be repaired with conventional composites. As bulk-fill composites are increasingly preferred, there is a need for a procedure for repairing these modified RBCs. Therefore, the aim of this *in vitro* study was to evaluate the efficiency of different surface treatments on the microtensile bond strength (μTBS) of aged bulk-fill RBC repair using a conventional RBC. The null hypotheses were: (1) type of surface treatment protocol would not influence the repair μTBS values and (2) type of surface treatment protocol would not influence the surface roughness values of bulk-fill RBC.

MATERIALS AND METHODS

Specimen preparation

This *in vitro* study was performed in accordance with the Helsinki Declaration. Sixty specimens were prepared for this *in vitro* study in a Teflon®

mold (5 x 5 x 5 mm). The chemical compositions of the materials are given in Table 1.

Table 1. Material, batch number, composition, and application of the universal adhesive

Restorative		Composition	Filler Type
Filtek™ Bulk Fill Restorative (3M ESPE, St. Paul, MN, USA) #N681830		UDMA, Bis-GMA, EBPADMA, Procrylat resin	Filler loading is 42.5% by weight and 64% by volume. Zirconia/silica, ytterbium Trifluoride
Filtek Ultimate Universal Restorative (3M ESPE, St. Paul, MN, USA) #N817010		Bis-GMA, UDMA, TEGDMA, Bis-EMA, PEGDMA.	Filler loading is 78.5% by weight and 63.3% by volume. 20 nm silica particles and 4-11 nm zirconia particles
Adhesive	**pH**	**Composition**	**Application**
Single Bond Universal (3M ESPE, St. Paul, MN, USA) #80516B	2.7	2-HEMA, 10-MDP, dimethacrylate resins, Vitrebond™ copolymer, silane, filler, ethanol, water, initiators.	1. Apply the adhesive to the prepared tooth and rub it in for 20 s. 2. Gently air dry the adhesive for approximately 5 s to evaporate the solvent. 3. Light cure for 10 s.

Abbreviations: 2-HEMA, 2-hydroxyethyl methacrylate; 10-MDP, 10-methacryloyloxydecyl dihydrogen phosphate; Bis-EMA, ethoxylated bisphenol-A dimethacrylate; Bis-GMA, bisphenol A glycidyl methacrylate; EBPADMA, ethoxylated bisphenol A dimethacrylate; PEGDMA, poly(ethylene glycol) dimethacrylate.

The bulk-fill RBC was loaded into the molds as a single increment (5 mm bulk) and covered with a Mylar strip to obtain flat surface. Then, the bulk-fill RBC was light-cured using a light emitting diode (LED) curing unit (Valo Grand; 1000 mW/cm^2; Ultradent, South Jordan, UT, USA) for 20 s, and the light intensity was controlled before each specimen. After the specimen removal from the mold, the specimen was further polymerized for 20 s/all surfaces to ensure adequate polymerization since the objective of the current study was not to measure the depth of cure. All samples were kept in distilled water at 37°C for 24 h, and then polymerized specimens were aged by thermal cycling for 5000 cycles between 5 and 55°C with a dwell time of 30 s and a transfer time of 5 s. The aged bulk-fill RBC surfaces were wet-ground flat with 320-grit abrasive paper[22], and divided into 6 groups according to the surface treatment protocols before repair (n=10).

Group 1: No treatment, control group.

Group 2: Single Bond Universal (SBU; 3M ESPE, St. Paul, MN, USA) adhesive was applied on non-treated bulk-fill RBC surfaces using the self-etch mode according to the manufacturer's recommendations.

Group 3: Bulk-fill RBC surfaces were etched with 37% phosphoric acid (PA, Scotchbond Etchant; 3M ESPE, St. Paul, MN, USA) for 20 s, and rinsed thoroughly.

Group 4: Hydrofluoric acid (HF; 9%, Ultradent) was used for etching the bulk-fill RBC surfaces for 20 s, and rinsed thoroughly.

Group 5: Bulk-fill RBC surfaces were air-abraded using aluminum oxide (AlO) particles (Cobra; 50 µm, Renfert GmbH, Hilzingen, Germany). Air abrasion procedures were performed using a sandblaster (Basic Quattro IS, Renfert GmbH, Hilzingen, Germany) 10 mm above from the RBC surface at 2.5 bar pressure.

Group 6: Tribochemical silica coating (TSC) was performed on the bulk-fill RBC surfaces with silica coated aluminum oxide sand (CoJet Sand; 30 µm, 3M ESPE, Seefeld, Germany) using the sandblaster 10 mm above from the RBC surface at 2.5 bar pressure.

After each surface treatment protocol, the specimens were cleaned in an ultrasonic bath with distilled water for 5 min and air-dried with an air syringe.

Surface Roughness Measurement

A contact profilometer (Surtronic S128, Taylor Hobson Ltd., Leicester, England) with a 5 µm diamond stylus was used for the surface roughness measurements. Five consecutive measurements were taken from different directions, with a 0.25 mm cut-off length. The average surface roughness values (Ra) were then recorded in µm (n=10).

Repair of the Bulk-fill RBC

After the completion of surface roughness measurements, SBU was applied on surface-treated bulk-fill RBC surfaces according to the manufacturer's recommendations and light cured for 10 s. A conventional RBC (Filtek Ultimate Universal A3.5; 3M ESPE, St. Paul, MN, USA) was used as a repair material, and A3.5 shade was chosen to distinguish the bulk-fill RBC from the repair RBC. The bulk-fill RBCs were placed in a Teflon® mold (10 x 5 x 5 mm) treated surface facing upwards for repair protocol. The repair RBC (5 x 5 x 5 mm) was applied in 2-mm thick increments. Each increment was polymerized for 20 s, and specimens were kept in distilled water at 37°C for 24 h following the repair.

Microtensile Bond Strength Testing

Repaired specimens were longitudinally sectioned using a low-speed saw (Isomet; Buechler, Lake Bluff, IL, USA) to obtain 1 mm^2 beams. Beams in the outer parts of repaired specimens were discarded. Consequently, beams were fixed to jigs of a microtensile testing device (MOD Dental, Esetron Smart Robotechnologies, Ankara, Turkey) with cyanoacrylate adhesive. The tensile load was applied until failure at a crosshead speed of 0.5 mm/min, and recorded in MPa. Failure modes were evaluated by a stereomicroscope at 30x magnification. The failure modes categorized as adhesive failure (A), cohesive failure within substrate (C_{sub}), cohesive failure within repair (C_{rep}), or mixed failure (M). Pretest failures were excluded from the statistical analysis of the µTBS values.

Scanning Electron Microscopy Observation

For scanning electron microscope (SEM) observations, two samples were prepared for each of the five surface treatment groups as described before (in total, 10 specimens). The specimens were sputter-coated with gold (Polaron SC7620 sputter coater, ThermoVG Scientific), and were examined under a SEM (JEOL 5500; JEOL Inc., Peabody, MA, USA) at 10 kV accelerating voltage. Observations were performed under x1000 magnification.

Statistical Analysis

The mean values and standard deviations were determined, and analyzed using a one-way ANOVA, to evaluate the effects of surface treatment protocols on the repair µTBS and surface roughness values. Pairwise analyzes were performed using Tukey HSD post-hoc analysis. Data analyzes was performed by SPSS for Windows v22 software (IBM Corp., Armonk, NY, USA), and results were considered as statistically significant for p<0.05.

RESULTS

Microtensile Bond Strength Test

Mean µTBS values and standard deviations are given in Table 2.

Table 2. Mean repair µTBS values and failure mode distribution according to the surface treatments

			Failure Modes (%)			
Treatment	Mean ± SD	n	A	C_{Sub}	C_{Rep}	M
No treatment (Control)	12.1 ± 3.47 ^{a}	31	87.1	0	0	12.9
Control + SBU	25.8 ± 4.36 ^{b}	36	77.8	10	0	22.2
PA + SBU	26.8 ± 3.72 ^{b}	38	58	10.5	0	31.5
HF + SBU	33.3 ± 2.23 ^{c}	36	55.6	11.1	11.1	22.2
AlO + SBU	42.9 ± 3.79 ^{d}	38	26.4	21	21	31.6
TSC + SBU	45.5 ± 3.83 ^{d}	37	24.4	32.4	10.8	32.4

Different superscripts indicate significant differences (p<0.05). A, Adhesive failure; C_{sub}, Cohesive failure within substrate; C_{rep}, Cohesive failure within repair; M, Mixed failure.

One-way ANOVA exhibited significant differences (p<0.001) among five surface treatment protocols regarding the µTBS values (Table 2). The significantly lowest repair µTBS values were achieved by the control group (12.1 ± 3.47 MPa), in which no universal adhesive was applied. On the other hand, universal adhesive application only (Group 2) was significantly increased repair µTBS values ($p<0.001$). The highest μTBS values were obtained for the Group 6 (45.5 ± 3.83 MPa) and the Group 5 (42.9 ± 3.79 MPa; $p<0.05$), which did not show significant difference ($p>0.05$), and HF etching (Group 4; 33.3 ± 2.23 MPa) was followed them. Although the PA etching (Group 3) slightly increased the repair μTBS values compared to the Group 2. There was no significant difference between Group 2 (25.8 ± 4.36 MPa) and Group 3 (26.8 ± 3.72 MPa), and showed lower repair μTBS values than Group 4 ($p<0.05$).

In terms of failure mode, most of the groups exhibited adhesive failure mode (Table 2). Although cohesive failure was not observed in the control group, there was a clear increase in the number of cohesive and mixed failure modes after surface treatment protocols. The highest adhesive failure rate was observed for Group 6 (30% for C_{Sub} and 10% for C_{Rep}) and Group 5 (20% for C_{Sub} and 20% for C_{Rep}).

Surface Roughness Measurement

The surface roughness values according to the surface treatment protocols are shown in Figure 1.

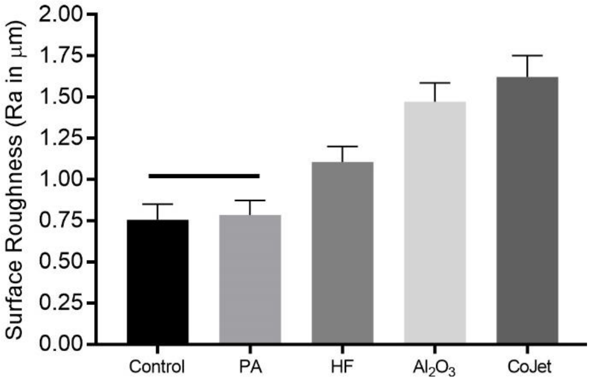

Figure. 1 Surface roughness means and standard deviations according to five different surface treatments. Horizontal line above the columns indicates nonsignificant difference ($p>0.05$)

PA etching (Group 3) of the bulk-fill RBC surfaces did not differ significantly from the control group ($p=0.975$). However, other surface treatments resulted in rougher surfaces than the control group and Group 3 ($p<0.001$). The highest surface roughness values were found in the TSC treatment ($p<0.05$). The ranking of the five surface treatment protocols regarding the surface roughness from highest to lowest were as follows: TSC (1.62 ± 0.13) > AlO (1.47 ± 0.11) > HF (1.11 ± 0.09) > PA (0.78 ± 0.09) = Control (0.76 ± 0.10).

SEM Observation

SEM images of the bulk-fill RBC surfaces according to the surface treatments are presented in Figure 2.

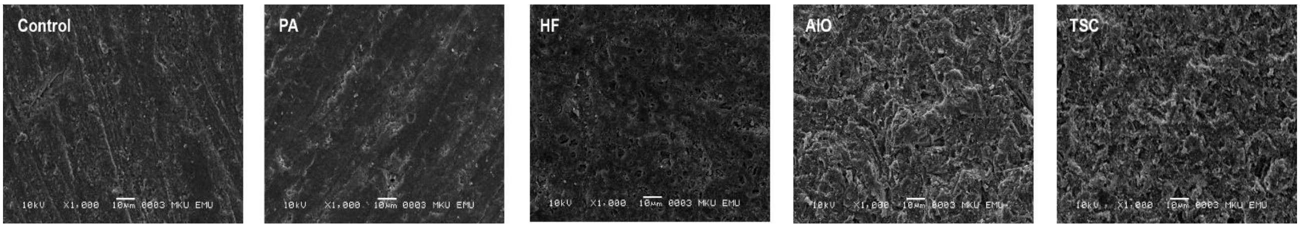

Figure. 2 SEM images of the bulk-fill RBC after five different surface treatment protocols. Control, No treatment group; PA, Phosphoric acid etching; HF, Hydrofluoric acid etching; AlO, Aluminum oxide air abrasion; TSC, Tribochemical silica coating.

The characteristic image of the surface grinding with 320-grit SiC paper can be identified (Figure 2, Control). Distinct deep grooves and smear debris produced by the grinding motion can be noticed. SEM image (Figure 2, PA) showed that the smear on the bulk-fill RBC surface was slightly removed after PA etching. HF etching effectively removes smear debris on the bulk-fill RBC surface and exposes filler particles (Figure 2, HF). The increase in surface roughness and prominent ridges after AlO air abrasion and TSC treatments were observed in SEM images (Figure 2, AlO and TSC).

DISCUSSION

The RBC restorations have been reported to have a successful clinical performance with a failure rate ranging between 1.6%[23] to 2.2%[14] per year. The repaired RBC restorations is shown to have an annual failure rate of 5.7% during 4 years of clinical use.[24] In a recent meta-analysis, Veloso *et al.*[15] reported that there was no significant difference in clinical performance between bulk-fill and conventional RBCs. The clinical adequacy of the bond strength between the old and new materials is crucial for durability of the repair. Therefore, in this *in vitro* study, the effect of different surface treatments on the repair of bulk-fill RBCs was evaluated. The results of the present study showed that the lowest repair μTBS values were found in the no treatment (control) group. Surface treatments effectively improved bond strength values in agreement with the previous studies.[16–20,25,26] Thus, the first hypothesis – that type of surface treatment protocol would not influence the repair μTBS values – was rejected, as there was a significant difference between the repair μTBS values between the surface treatment protocols. The second hypothesis – that type of surface treatment protocol would not influence the surface roughness values – was also rejected, because some surface treatments significantly differed from each other in terms of surface roughness values.

The bonding of the RBC increments to each other is achieved by covalent chemical bonds between the unreacted monomers of the first polymerized increment and the newly added one.[27] The oxygen inhibited layer, which is partially polymerized and has a low viscosity also favors to bonding.[28] Therefore, the conditions that affect the unreacted layer will affect the bond strength. However, RBCs are unstable after polymerization and continue to interact with the oral environment.[29] This interaction causes water diffusion through polymers, causing hydrolytic degradation, which results in leakage of unreacted monomers from the repairable surface.[30] It has been reported that aging process affects repair bond strength values, and an aging protocol should be performed before *in vitro* repair of RBCs to better mimic clinical conditions.[18]

Various methods such as thermal cycling, boiling, water storage, acid challenges are preferred for aging.[20] However, there is still no consensus on the best aging protocol. Thermal cycling properly simulates *in vivo* conditions.[31] This process also induces stress to a restoration due to aging, and thermal challenges.[32] Based on the ISO TR 11450 standard, 500 cycles must be performed for thermal cycling.[33] However, De Munck *et al.*[33] reported that a thermal cycling of 10000 times is similar to approximately 1-year fatigue in the oral environment. Therefore, thermal cycling, which is preferred in other studies[25,34] was used for aging in this study.

In the present study, universal adhesive application alone doubled the repair μTBS values in comparison to control group, even resulting in a cohesive failure pattern (Table 2). The increase in repair μTBS values after the application of adhesive resin is most likely due to the inability of the repair RBC to penetrate into the substrate microstructure as a result of its high viscosity.[35,36] In addition, as mentioned above, it is inevitable to experience a reduction in bonding potential due to the reduction of unreacted monomers of the substrate surface as a result of aging.[36,37] The application of adhesive resin enhances the mechanical interlocking by infiltration to the irregular surface structure obtained after surface treatments[34,38], as well as chemical bonding to the organic matrix and exposed filler particles.[16,17,19,25] In a study comparing the efficacy of repair with or without adhesive resin application, the application of adhesive resin was reported to increase repair bond strength values[39], in consistent with the present study.

On the other hand, the universal adhesive used (Single Bond Universal) in the present study contains 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP), polyalkenoic acid copolymer, and prehydrolyzed silane in its chemical formulation (Table 1). The 10-MDP monomer is known to improve bonding to metals, hydroxyapatite and filler particles of RBCs.[40,41] Fonseca *et al.*[42] reported that phosphate esters increase the hydrolytic stability more effectively than silane coupling agents by directly bonding to the surface hydroxyl groups of zirconia. Considering zirconia filler presence in the composition of both substrate and repair RBCs (Table 1), 10-MDP may be one of the reasons for the increase in repair μTBS values. Bond strengths are reported to be similar to the original monolithic composite when SBU is used for repair of the aged RBC substrates.[43] In another study, researchers were concluded that Silane containing universal adhesive alone is suggested as a promising material for the simplification of the repair procedure.[16]

PA etching is the most commonly used repair protocol in clinical practice for the preparation of both the surrounding dental hard tissues and the substrate surface to be repaired.[20] Although it has been reported that the PA etching treatment in composite-composite repair increases the total surface area of the substrate,[35] studies have shown that PA etching does not enhance the repair bond strength values.[20,25] Ayar *et al.*[20] reported that the effect of PA etching is thought to be limited only by removal of debris present on the substrate surface after mechanical surface treatments. In the present study, PA etching did not cause a significant improvement in both surface roughness and repair μTBS values. SEM images show no change in surface topography after PA etching, only debris on the substrate surface is removed (Figure 2, Control and PA). This finding is similar to other studies in the literature.[19,20,25] On the other hand, HF etching of bulk-fill RBC surfaces yielded better repair μTBS values compared to PA did, in parallel with a previous study.[20] However, the use of HF etching intraorally might be very dangerous and protective measures should be taken.[44]

Air abrasion is one of the surface treatments successfully applied to the surface of various dental materials such as direct and indirect RBCs, ceramics and metal alloys.[26] This treatment not only cleans the substrate, it also increases the surface tension and surface area by roughening the substrate surface, thereby improving the interaction between the substrate and the repair material.[42] This interaction has been reported to be more successful, especially when silica coated aluminum oxide particles (CoJet sand) are used.[26] When sandblasting performed with CoJet sand, silica particles tribochemically forms a silicate ceramic layer according to the manufacturer. This layer has surface irregularities that provide mechanical anchoring to repair RBCs, and the silica coating provides a chemical anchoring through the interaction of the silica coating with the monomers of the repair RBCs.[26]

Atalay *et al.*[25] reported that the highest repair μTBS values were obtained by air-abrasion with aluminum oxide particles. In the present *in vitro* study, no significant difference was observed for surface roughness or repair μTBS values between AlO and TSC treatments. This result is in an agreement with the previous studies.[19,45] In SEM images, it was observed that the both treatments produce similarly rough surfaces (Figure 2, AlO and TSC). When both surface roughness and repair μTBS findings are evaluated, it might be considered that the improvement in repair μTBS values due to the air abrasion protocols was based on micromechanical retention achieved by roughening of the substrate surface. Furthermore, it was observed that the roughness patterns differ according to surface treatment protocol (Figure 2). In a previous study, it was indicated that bond strength might also depend on the roughness pattern.[46] In this study, 320-grit SiC abrasive paper was used to provide coarse diamond bur abrasion in a standardized way.[22] Evaluation of the control SEM image revealed that 320-grit SiC paper abrasion consists of parallel grooves representing on the characteristic of the grinding motion. The same parallel grooves were also evident in the SEM image of PA etched substrate surface. After HF etching, it was clearly observed that the substrate surface is more irregular and the filler particles are exposed. After air abrasion treatments, there are peaks of different heights and dimensions. It could be suggested that this type of roughness pattern obtained after air abrasion treatments may be more favorable for micromechanical retention than the parallel grooves.

The repaired restorations are exposed to chemical and mechanical degradation in the oral environment.[18] This degradation may adversely affect the success of the repair. The main limitation of the present study is that no additional aging protocol is applied after the repair. Further studies using different repair materials with post repair aging protocol should be conducted to improve the repair prognosis and raise awareness of the repair treatment among clinicians.

CONCLUSIONS

Within the limitations of the present *in vitro* study, the following conclusions can be drawn. According to the profilometry findings, TSC and AlO treatments produced more rough surfaces compared to the other surface treatments.

Furthermore, etching with PA did not provide significant roughness compared to the control group. The highest repair µTBS values were obtained by air abrasion treatments, but no significant difference was observed between AlO and TSC. On the other hand, silane-containing universal adhesive application alone doubled the repair µTBS values compared to the control group. The use of this material is promising to facilitate the repair of bulk-fill RBCs.

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CONFLICT OF INTEREST STATEMENT

None.

Farklı Yüzey İşlemlerinin Yaşlandırılmış Bulk-Fill Kompozitlerin Tamirine Olan Etkisi: In Vitro Çalışma

ÖZ

Amaç: *Bu in vitro çalışmanın amacı, farklı yüzey işlemlerinin, yaşlandırılmış bulk-fill kompozit reçine kompozit tamirinin mikrogerilme bağlanma dayanımı üzerindeki etkilerini değerlendirmektir.* ***Gereç ve Yöntemler:*** *Hazırlanan bulk-fill kompozit bloklar (n=60, 5 x 5 x 5 mm), 5 ile 55°C arasında 5000 defa yaşlandırma döngüsü sonrasında, uygulanacak yüzey işlemi protokolüne göre 6 gruba ayrılmıştır: yüzey işlemi yok (kontrol), üniversal adeziv uygulaması (SBU; 3M ESPE), fosforik asit (PA) + SBU, hidroflorik asit (HF) + SBU, alüminyum oksit kumlama (AlO) + SBU ve tribokimyasal silika kaplama (TSC) + SBU. Yüzey pürüzlülük değerleri beş farklı yönde ölçüm yapılarak kontakt profilometre ile belirlenmiştir (n=10). Tamir işleminden sonra, örneklerden 1 mm^2'lik çubuklar elde edilmiş ve mikrogerilme bağlanma değerleri kopma olana kadar 0,5 mm/dak hızda kaydedilmiştir. Yüzey işlemlerinden sonra numune yüzeyleri SEM ile gözlenmiştir. Veriler, tek yönlü ANOVA ve Tukey testleri kullanılarak analiz edilmiştir (p<0,05).* ***Bulgular:*** *Tek yönlü ANOVA analizi sonucunda yüzey işlemleri arasında önemli farklılıklar tespit edilmiştir (p<0,001). En düşük tamir bağlanma dayanımı değerleri, kontrol grubunda gözlenmiştir. Tek başına üniversal adeziv uygulaması tamir bağlanma dayanımı değerlerinde anlamlı bir artış sağlamıştır (p<0,001). En yüksek bağlanma dayanımı değerleri AlO ve TSC işlemleri için elde edilmiştir (p>0,05) ve HF onları takip etmektedir. Beş farklı yüzey işleminin oluşturduğu yüzey pürüzlülükleri; TSC>AlO>HF>PA=Kontrol şeklindedir.* ***Sonuçlar:*** *Etkili ve güvenli bir onarım protokolü seçildiğinde, bulk-fill kompozitlerin başarılı bir şekilde onarılabilmektedir. En yüksek mikrogerilme bağlanma dayanımı değerleri AlO ve CoJet işlemleri sonucunda elde edilmiştir. Üniversal adezivler, bulk-fill kompozit tamiri süreçlerini kolaylaştırmak adına umut vericidir.* ***Anahtar Kelimeler:*** *Bileşik rezinler, dental restorasyon onarımı, dental adezivler, yüzey özellikleri.*

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