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Repair of composites: Effect of laser and different surface treatments

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ABSTRACT

Objectives: This study investigated the repairs of resin composite restorations after using different surface treatments.
Design: Eighty four truncated cones of Filtek Z350 were prepared and thermo-cycled (20,000 cycles). Surfaces were roughened with diamond bur and etched with 37% phosphoric acid. Those cones were divided into 7 groups ($N=12$): 1) Prime&Bond 2.1; 2) aluminum oxide sandblasting+Prime&Bond 2.1; 3) Er:YAG laser treatment+Prime&Bond 2.1; 4) 9.6% hydrofluoric acid for 2 min+silane coupling agent.; 5) silane coupling agent; 6) auto-polymerized acrylic monomer+Prime&Bond 2.1; 7) Adper Scothbond SE. Teflon device was used to fabricate inverted truncated cones of repair composite over the surface-treated. The bonded specimens were stressed to failure under tension. The data were analyzed with one-way ANOVA and Tukey tests.
Results: Mean repair strengths (SD, in MPa) were, Group-2: 18.8a; Group-1: 18.7a; Group-6: 13.4ab; Group-7: 9.5bc; Group-3: 7.5bcd; Group-4: 5.2cd; Group-5: 2.6d.
Conclusions: The use of diamond bur and a conventional adhesive and the use of aluminum oxide sandblasting prior to adhesive provided a simple and cost-effective solutions to composite repair. Er:YAG laser, silane alone, 9.6% hydrofluoric acid plus silane or a self-etching adhesive results in inferior composite repair strengths.
Clinical relevance: Diamond bur roughening alone or in combination with aluminum oxide sandblasting is equally effective in preparing a roughened surface for resin composite repair using Prime&Bond 2.1 as the adhesive.

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1. Introduction

Failure of dental restorations is a major concern in dental practice. Up to half of all resin composite restorations fail within 10 years [1,2], and replacing them consumes 60% of the average practice time [3]. Repairing resin composite restorations is a conservative procedure when material failure occurs [4]. As there is no need for complete removal of the defective restoration, tooth preparation is minimized, reducing treatment time and cost for the patient as well as the risks associated with weakening of remaining tooth structures. Despite the lack of definitive studies due to the expense of randomized clinical trials [5,6], the best evidence available to date appears to favor repair over replacement of resin composite restorations [7].

Repair of aged methacrylate resin-based composites with fresh composites remains a challenge due to the depletion of free radicals in the aged composite after the initial period of polymerization [8,9]. Controversy exists in the literature [10–14] regarding the most optimal repair procedures for improving the bond between the repair resin composite and the existing resin composite restoration. Different procedures have been reported, included the use of bur roughening of the aged composite surface, air abrasion, hydrogen peroxide etching, the use of surface activation methacrylate resin monomers, dentin adhesives, silane coupling agents, tribochemical silica coating as well as combinations of those procedures [15,16]. Some studies have evaluated the use of erbium:YAG (Er:YAG) for surface treatment of indirect composite [17] and repair composite resin to a feldspathic ceramic surface [18]. However, the use of Er:YAG laser for repair of

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resin composite restoration is poorly researched. Ozel et al. [19] found that laser and bur-treated had similar results when used the repair composite resins. Laser irradiation can increase the porosity and surface roughness of the aged resin composites, thereby augmenting their repair strength to fresh composites [17,19].

Therefore, little is known of the influence of the use of ER:YAG laser to optimize repair direct composite restorations, and it was necessary to observe their performance compared with other methods to optimize repair of direct composite restorations. The objective of the present study was to investigate the composite-to-composite repair strength after the use of different composite surface treatment techniques or combination of such techniques to repair aged resin composites. The null hypothesis tested was that there is no difference among the different composite surface treatment techniques on the tensile repair strengths of a resin composite material.

2. Material and methods

A two-piece Teflon device was used to prepare truncated cones of resin composite (Filtek Z350, 3M ESPE, St. Paul, MN, USA). Each truncated cone measured 4 mm in height, with the bottom being 4 mm in diameter and the top being 2 mm in diameter. The resin composite (shade A3) was inserted in the Teflon device in two 2-mm thick increments. Each composite increment was polymerized for 20 s with a light curing unit (XL 3000, 3M ESPE) at an output intensity of 500 mW/cm^2.

Eighty-four truncated resin composite cones were prepared and stored in distilled water at 37 °C for 7 days. The truncated cones were thermal-cycled for 20,000 cycles at a temperature ranging between 5 °C and 55 °C (± 2 °C), with a dwell time of 30 s, followed by storage in distilled water at 37 °C for another 7 days. A diamond bur (#3070; KG Sorensen, Rio de Janeiro, Brazil) operating from a high-speed hand piece was used to create a standardized roughened surface on top of each aged truncated cone. The standardized roughened surfaces were prepared by the same operator, who gently passed the tips 10 times across the surface, under copious air–water spray. Next, the surfaces were etched with 37% phosphoric acid (Scotchbond Etchant, 3M Dental Products, St. Paul, MN, USA) for 15 s, washed with air–water spray for 30 s and dried with air spray for 10 s.

The aged truncated cones (substrates) were divided into 7 groups (N=12) according to the surface treatment performed (Table 1):

Group I (control) – a thin layer of an etch-and-rinse adhesive, Prime&Bond 2.1 (Dentsply De Trey, Konstanz, Germany), was applied to the roughened composite surface followed by gentle air-drying and light polymerization according to the manufacturer's instructions.

Group II – the roughened composite surface was sandblasted with 50 μm aluminum oxide particles (Micro-etcher ERC, Danville Engineering, California, USA) for 10 s prior to the application of Prime&Bond 2.1 in the manner described in Group I.

Group III – the roughened composite surface was irradiated with an Er:YAG (erbium-doped yttrium aluminum garnet) laser (Key Laser 3, KaVo, Biberach, Germany) using a wavelength of 2940 nm, a mean power of 0.24 W, a pulse frequency of 4 Hz, a pulse duration of 100 μs and a pulse energy of 60 mJ in the scanning mode for 70 s under cooling with distilled water (water spray: 0.16 ml/s). The laser handpiece held by hand and roughened surfaces were prepared by the same operator. Irradiation was performed with the laser tip perpendicular to the composite surface at a standardized distance of 10 mm. Application of Prime&Bond 2.1 followed the same protocol described in Group I.

Group IV – the roughened composite surface was treated with 9.6% hydrofluoric acid (Dentsply DeTrey) for 2 min, followed by water rinsing for 1 min and air-drying [14]. A silane coupling agent (Dentsply DeTrey) was applied for 20 s and gently air-dried.

Group V – a silane coupling agent (Dentsply DeTrey) was applied for 20 s and gently air-dried.

Group VI – a self-polymerizing acrylic monomer (Jet, Clássico, São Paulo, Brazil) was applied over the roughened composite surface using a microbrush for 20 s and gently air-dried. This was followed by the application of Prime&Bond 2.1 in the manner described in Group I.

Group VII – a thin layer of a self-etching adhesive (Adper Scotchbond SE, 3M ESPE) was applied to the roughened composite surface for 20 s. The adhesive was air-dried for 5 s and then light-cured according to the manufacturer's recommendations.

A Teflon device was used to fabricate an inverted truncated cone of repair composite over the surface-treated top of each original aged truncated cone, using incremental applications of Filtek Z350, with each layer polymerized separately for 20 s. The final specimen consisted of two inverted truncated cones of resin composites united by their circular top surfaces where the repair was made [20,21] (Fig. 1). The bonded truncated cone assemblies were stored in distilled water at 37 °C for 7 days, thermo-cycled for 20,000 cycles at a temperature ranging between 5 °C and 55 °C (± 2 °C) with a dwell time of 30 s, and stored in distilled water at 37 °C for an additional 7 days prior to mechanical testing.

It was made previously a metallic model for the adaptation of the specimens in the test machine for accomplishment of the tests. The specimens were stress to failure under tension using a universal testing machine (Emic DL 2000, São José dos Pinhais, PR, Brazil) with a load cell of 50 kg f at 0.5 mm/min.

After the tensile test, the specimens were analyzed with a 20 × stereomicroscope (Stemi 2000-Karl Zeiss, Germany). Fractures were classified as: cohesive in the substrate, adhesive at the interface or cohesive in the adherend.

Repair bond strengths (in MPa) derived from the 7 groups were first examined to evaluate the normality (Shapiro–Wilk test) and homoscedasticity (modified Levene test) of the acquired data. As those assumptions did not appear to have been violated, the data was further analyzed using one-way ANOVA and Tukey multiple

Table 1
Experimental groups and their surface treatments.

Group	Physical treatment		Chemical treatment	
I	Surface roughening with a diamond bur	–	–	Prime&Bond 2.1
II		Aluminum oxide	–	Prime&Bond 2.1
III		Laser	–	Prime&Bond 2.1
IV		–	Hydrofluoric acid	Silane
V		–	–	Silane
VI		–	Monomer	Prime&Bond 2.1
VII		–	–	Adper Scotchbond SE

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