10.5005/jp-journals-10015-1353

ORIGINAL RESEARCH

Bond Strength of Reline Resins to Aged-simulated Denture Base Acrylic Resin

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ABSTRACT

Objectives: The aim of this study was to evaluate the bond strength of different direct reliners to acrylic resin for denture base.

Materials and methods: Double-cone specimens were made: HA—heat-cured acrylic resin—(n = 20); U—Ufi Gel Hard C—(n = 10); K: Kooliner—(n = 10); R—Rebase II Fast—(n = 10) and RH—Rebase II Fast + Resin Hardener—(n = 10). Ten HA samples were immediately submitted to cohesive test. The remaining HA samples and others were submitted to thermal aging (HAaged, 1000 cycles, 5–55ºC), followed by tensile test. For tensile strength, 50 single cone-shaped samples were made of heat-cured acrylic resin and aged (HAaged, 1000 cycles, 5–55ºC). After surface treatment, relining resin cones were build up using silicon molds, and stressed to failure. Values of cohesive and tensile strength were submitted to one-way ANOVA and Tukey's test (α = 5%).

Results: Bond strength were: HA/HAaged: 21.17 (±4.89)a, U/HAaged: 11.56 (±1.98)b, R/HAaged: 9.69 (±2.37)b, RH/HAaged: 9.38 (±1.78)bc and K/HAaged: 5.98 (±1.90)c. The cohesive strength were: KCoe: 22.29(±4.06)a; RCoe: 23.99 (±3.29)a; RHCoe: 24.84 (±3.88)a; UCoe: 25.62 (±3.03)a; HAaged: 36.06 (±8.65)b and HA:42.29 (±7.68)b. Groups followed by the same letters do not show differences.

Conclusion: Bond strength of acrylic resin to acrylic denture base material is higher than the reliners and Ufi Gel Hard C showed the higher bond strength.

Keywords: Base, Bond strength, Denture, Reline materials.

How to cite this article: Zanatta RF, Batista GR, Crastechini É, Bresciani E, Borges AB, Torres CRG. Bond Strength of Reline Resins to Aged-simulated Denture Base Acrylic Resin. World J Dent 2016;7(1):1-5.

Source of support: Nil

Conflict of interest: None

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INTRODUCTION

Changes of support oral tissues due bone reabsorption require the improvement in adaptation of complete or partial dentures by relining then to the supporting tissues.[3] The use of relining techniques for complete dentures is a routine clinical practice. A reliable bond between denture base and the reliner is required for the denture to function properly.[13,17] Several materials are marketed and their clinical performance relies greatly on the adhesive bond strength of these materials to acrylic resin used as denture bases.[10,22] Thus, the importance of knowing their adhesive performance is crucial for achieving success.

Dentures constructed of two different materials can only be successful if a satisfactory bond between these two materials exists.[3,4] Properties, such as tensile and shear bond strength has been shown to be dependent on chemical composition of both reline materials and denture base polymers.[13] The weak bonding properties of reline materials might lead to poor adaptation by detachment of reline and the former material and consequently lead to microorganisms' contamination and difficult denture hygiene.[13,22] If delamination of reline materials occurs, the adaptation to oral soft mucosa will be affected.

Several studies reported the influence of different pretreatment of denture base materials prior to reline procedures, and conflicting results are discussed.[3,11-15,17,22] The ideal scenario would be an effective penetration of reline monomers into the materials used in denture base, promoting a polymer network.[4,22] Polymers used in denture base are usually composed by methyl methacrylate and present high crosslinking properties due its great molecular weight, which negatively interferes with the repairing procedures. For this reason, manufacturers indicate the roughening of the denture base surface in order to improve the bonding of reline materials.[4]

Denture relining eliminates the need for making new dentures for the patient when changes are minimal and the existing denture is in a relatively good condition. Also, chairside reline materials allow dentist to reline removable prostheses directly in mouth, eliminating both the need for a laboratorial step and the need to

leave the patient without the prosthesis for some days. However, the efficiency of the adhesion between this relining materials and the acrylic resin of dentures are questioned. So, the aim of the present study was to assess the tensile bond strength of several commercial brands of reline materials to age-induced thermoactivated acrylic resin, and to compare the obtained values to the cohesive strength of the materials.

MATERIALS AND METHODS

Measurement of Cohesive Strength

The cohesive strength of the acrylic resin and different relining materials was evaluated using 60 double cone-shaped specimens, which were prepared using a silicon mold. The cones were made using one of the four different materials: Heat-cured acrylic resin (Clássico, São Paulo, Brazil) (n = 20); Ufi Gel Hard C (Voco, Cuxhaven, Germany) (n = 10); Kooliner (GC America Inc, Alsip, IL, USA) (n = 10) and Rebase II Fast (Tokuyama Dental Corp., Tokyo, Japan) (n = 20). For the Rebase material, half of the samples were submitted to the optional hardener treatment recommended by the manufacturer. The hardener was used to improve material hardness and polishing, and was used mixing the powder in 200 ml of water, and then immersing the samples in it for 3 minutes. The information about the materials tested is presented on Table 1. The materials were mixed according to the manufacturer's instructions and heated or self-cured. All samples were kept immersed in deionized water at 37°C for 7 days to allow the chemical cure to be completed.

After this time, for the heat-cured acrylic resin (Clássico), half of the specimens (n = 10) were immediately submitted to tensile test in order to evaluate the cohesive strength of a new material. The other half (n = 10) of this group and the other relining groups were submitted to thermal cycling to simulate the aging that occurs inside the oral cavity. It was performed 1000 thermal cycles, with the temperatures changing from 5ºC to 55ºC, using a cycling machine (ER37000, Erios, São Paulo, Brazil). After that, all samples were submitted to tensile test using a universal testing machine (DL—200MF, EMIC, São José dos Pinhais, PR, Brazil), at a crosshead speed of 1 mm/min and load cell of 10 kgf (Fig. 1).

Bond Strength Measurement

Forty simple cone-shaped samples were prepared with heat-cured acrylic resin (Clássico) and immersed in deionized water at 37°C for 7 days. After that they were submitted to artificial aging using thermal cycling, in order to simulate an old denture over which the new reline material would be applied. The top part of each cone was gently abraded with a cylindrical diamond bur (PM 700, KG Sorensen, Cotia, São Paulo, Brazil) in a low speed handpiece and the surface was chemically treated according to the recommendations of each manufacturer (Table 1). The acrylic-aged simple cone was positioned in a silicone matrix, and a second cone was build up over the first using the same relining materials tested for cohesive strength (Table 1). The samples were immersed in deionized water at 37°C for 7 days and submitted to tensile test (Fig. 2).

STATISTICAL ANALYSIS

The data of cohesive strength for the different materials and the results of bond strength for the relining materials were analyzed independently using one-way analysis of variance (ANOVA) and Tukey's test. The data of bond strength was compared with the cohesive strength of aged acrylic resin (control) using Dunnett's test. A significance level of 5% was adopted.

Table 1: Name, Composition, recommended surface treatment and application form of all materials tested

Material (Manufacturer)	*Composition/Surface treatment*
Acrylic Resin (Clássico, Brazil)	Composition: Powder—monomer of methyl methacrylate. Liquid: Polymer of methyl methacrylate
	Surface treatment: Roughen areas to be relined with a proper bur
Ufi Gel Hard C (Voco, Cuxhaven, Germany)	Composition: Powder—PEMA. Liquid: BPO (catalyst), 1,6-HDMA and acetone (adhesive).
	Surface treatment: Roughen areas to be relined with a proper bur and application of specific adhesive
Kooliner (GC America Inc, Alsip, IL, USA)	Composition: Powder—PEMA. Liquid: IBMA
	Surface treatment: Roughen areas to be relined with a proper bur
Rebase II Fast* (Tokuyama Dental Corp., Tokyo, Japan)	Composition: Powder—PEMA. Liquid: MAOP, 1,6-HDMA, AAEM and 1,9-nonanediol dimethacrylate
	Surface treatment: Roughen areas to be relined with a proper bur and application of specific adhesive

* The Hardener can be used to improve material hardness and polishing. In this case the Hardener powder is mixture in 200 ml of water and the denture immersed in it for 3 minutes; PEMA: Poly (ethyl methacrylate); BPO: Benzoyl peroxide; 1,6-HDMA: 1,6-hexanediol dimethacrylate; IBMA: Isobutyl methacrylate; MAOP: Beta-methacryloyl oxyethyl propionate; AAEM: 2-acetoacetoxy (ethyl) methacrylate

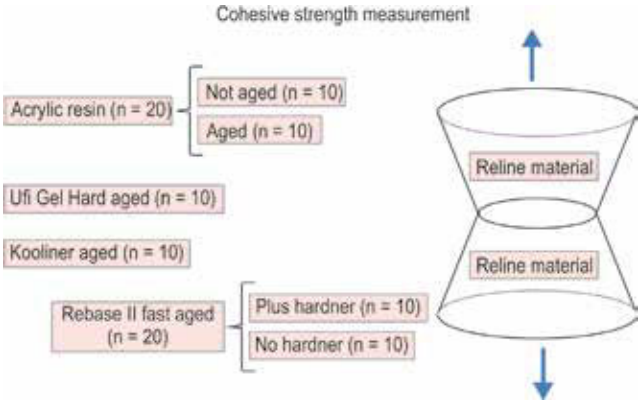


Fig. 1: Group division and a schematic drawing of the cones used to in the tensile test

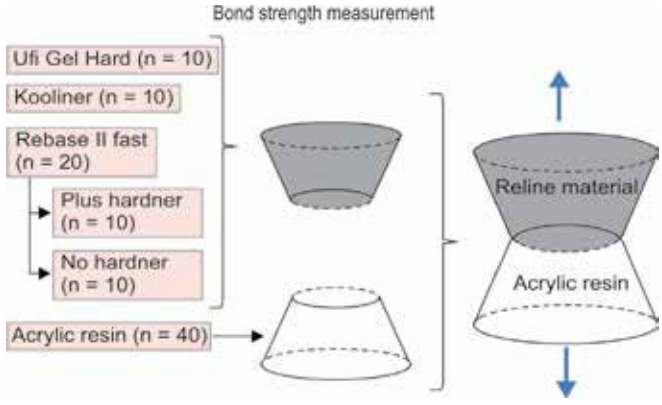


Fig. 2: Groups' division and the schematic drawing for the tensile test

RESULTS

The results of one-way ANOVA for cohesive groups showed statistically significant differences (p = 0.00, F = 2.06, df = 5). The means of cohesive strength and the results of Tukey´s test can be seen at Table 2. The results at Table 2 showed that the cohesive strength of acrylic resin was greater than the other materials. Although the thermal cycling reduced the cohesive strength of acrylic resin, this reduction was not statistically significant. The cohesive strengths of the relining materials were not statistically different.

The results of one-way ANOVA for bond strength of relining material to aged acrylic showed statistically significant differences ($p < 0.0001$, F = 40.96, df = 4). The means of bond strength and the results of Tukey's test can be seen at Table 3.

Table 2: Means and standard deviation of cohesive strength for all materials

Groups	*Mean (MPa)*	*SD*	*Homogeneous sets**
Kooliner	22.29	4.06	a
Rebase II	23.99	3.29	a
Rebase II + hardner	24.84	3.88	a
Ufi Gel Hard C	25.62	3.03	a
Acrylic cycled	36.06	8.65	b
Acrylic noncycled	42.29	7.68	b

*Groups followed by the same letter do no present significant differences

Table 3: Means and standard deviation of bond strength for relining materials bonded to acrylic resin

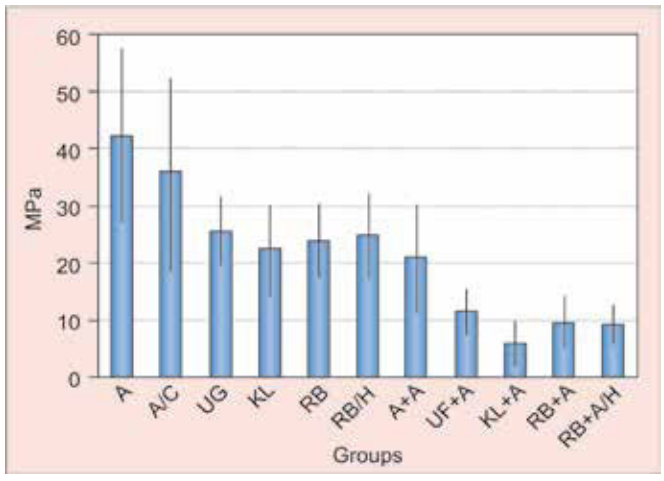
Groups	*Mean (Mpa)*	*SD*	*Homogeneous sets**
Acrylic cycled + A	21.17	4.89	a
Ufi Gel Hard C + A	11.56	1.98	b
Rebase II + A	9.69	2.37	b
Rebase II + A/H	9.38	1.78	bc
Kooliner + A	5.98	1.90	c

*Groups followed by the same letter do not present significant differences; A: acrylic resin

The results showed that the bond strength of aged acrylic to acrylic relining was higher than to the other relining materials. The Kooliner reline showed smaller bond strength in relation to the other materials tested. Dunnett's test showed that all relining material had significantly smaller bond strength to aged acrylic that the cohesive strength of aged acrylic ($p < 0.0001$). The comparison between the tensile strength means for cohesive and bonded groups can be seen in the Graph 1.

DISCUSSION

Bond strengths of autopolymerizing resin to denture-base resin are influenced by resin composition, surface treatment and thermal cycling.[13,14,19] Regarding composition, the hard denture relining materials tested



Graph 1: Cohesive and tensile bond strength means for all groups tested (A—cohesive strength of acrylic resin; A/C—cohesive strength of acrylic resin cycled; UG—cohesive strength of Ufi Gel Hard C; KL—cohesive strength of Kooliner; RB—cohesive strength of Rebase II; RB/H—cohesive strength of Rebase II with hardener; A + A—tensile bond strength of acrylic resin with acrylic resin; UF + A—tensile bond strength of Ufi Gel Hard C with acrylic resin; KL + A—tensile bond strength of Kooliner with acrylic resin; RB + A—tensile bond strength of Rebase II with acrylic resin; RB + A/H—tensile bond strength of Rebase II plus hardener with acrylic resin)

contains in its formulation (Table 1) a variety of methacrylate monomers instead of the simple methyl methacrylate found in the acrylic resin.

Bonding between reline materials and denture resin base (acrylic resin) is established at the interface where the two materials intermix.[13,19] Studies showed that the comparison between conventional polymers based on methyl methacrylate and highly cross-linked reline resins is usually not effective due to low penetration of the monomers with relatively greater molecular weight into the denture base.[4] That might be caused by the inefficiency of some surface treatments. Manufacturers usually recommend mechanical roughening of the surface of the denture base or the application of proper and specific bonding agents before relining.[22]

The reline resins Ufi Gel Hard and Rebase II Fast have proper and specific bonding agents supplied by the manufacturers. These bonding agents usually contain solvents and/or monomers,[18] responsible to dissolve the surface of the denture base and promote penetration of the reline acrylic resin into the denture base resin, resulting in the formation of a mixed layer of reline acrylic resin and denture base resin.[18] Although compared with the control group (acrylic resin with acrylic resin) both of these materials had a worse behavior, they presented similar bond strength results when associated with aged acrylic resin.

On the other hand, Kooliner has in its composition IBMA (Isobutyl methacrylate) without a cross-linking agent (specific adhesive).[5] This substance is the responsible to soften the denture base, but due its large size, does not penetrate the denture base properly. That might be the cause of the worse behavior of Kooliner presented in this study, corroborating with previous ones.[1,13,21]

Thermocycling was used as an accelerated aging test to evaluate the influence of time over the materials, and the results after thermocycling might be more significant when considering the situation of a removable denture in the oral cavity.[23] Also, the constantly ingestion of hot and cold liquids and food lead to variations inside the mouth.[7,21] The heat stress may increase water sorption because of an extension of the distance between the polymer chains, reducing mechanical properties of the materials, and the wet environment may cause degradation of the denture polymers.[2,21]

In this study, thermocycling did not seem to influence the acrylic resin group, as both groups (with and without thermocycling) present similar results. That might have happened due the low number of cycles performed (1000). It is estimated that a person performs 10000 thermal cycles in a year;[9] however, there is no consensus about the amount of cycles and the time that it represents in years and studies using less cycles than 10000 is easily found.[6,8,20] A more important observation found in these studies is that the bond strength of the reline materials thermocycled is usually lower, being this a useful tool to simulate the behavior of materials inside oral cavity.

According to the current literature, there is no general agreement about a test method to be used for evaluating the bond strength of hard relining materials.[13,16] Both cohesive strength between same materials and bond strength between acrylic resin and the reline materials where perform using tensile test which applies a simple tensile load to the interface reline denture. This test is used by many investigators and is considered to be better than shear tests load, due to the efforts that the polymer interface is subjected clinically.[16,17]

Regarding all limitations of the study, although all reline materials tested presented similar cohesive strength, they were all lower than acrylic resin with and without thermocycling. Also, all materials had a worse performance in bond strength than acrylic resin bonded to aged-acrylic resin. So, it might be highlighted that the reline materials tested are still inferior to acrylic resin. Studies must be conducted in order to achieve better bonding agents with better ability to establish an interface between denture resin bases and reline material, where the two materials can properly intermix.

CONCLUSION

It was concluded that the cohesive strength of acrylic resin is higher than the relining material. The bond strength of a relining with acrylic resin to acrylic denture base material is higher than the other relining material. The bond strength of Ufi Gel Hard C and Rebase is higher than Kooliner.

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