Influence of Light-Curing Glaze and Chlorhexidine Gluconate in the Acrylic Resin Properties: An *in situ* Study

Keywords

Hardness
Surface Property
Acrylic Resin
Temporary Dental Restorations

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Received: 18.01.2021
Accepted: 02.07.2022

doi: 10.1922/EJPRD_2281Commar07

ABSTRACT

This in-situ study aimed to evaluate the chromatic stability, microhardness, and surface-free energy of chemically activated acrylic resin (CAAR) samples. Eighty CAAR samples were made and each volunteer (n = 20) received two palatal plates with two sides of groups (without and with glaze application). The samples were exposed to two conditions: the control condition (sucrose 30%) and the test condition (sucrose 30% and 0.12% chlorhexidine). The volunteers used the first palatal device (control condition) for seven days and the second palatal device (test condition) for another seven days, with a seven-day break between them. Then, the ΔE_{00}, microhardness, and surface-free energy tests were performed. Analysis of Variance and the Tukey test were used ($\alpha = 0.05$). The control group with glaze showed higher ΔE_{00} compared to the group without the glaze. The test group with glaze had less ΔE_{00} than their respective controls. In both periods, when the glaze was applied, higher microhardness values were found for all groups. Groups with glaze showed lower roughness and higher surface-free energy than groups without the glaze. The values obtained in this study were satisfactory, showing the clinical efficacy of glaze and the use of 0.12% CH for maintaining the physical and mechanical properties of CAAR.

INTRODUCTION

Interim restorations are used during the initial period of dental preparation until the cementation of the final prosthesis and play a significant role in preserving dental and periodontal health, enabling the adaptation of the gingival contour, in addition to rehabilitating the function and offering an aesthetic gain.[1,2] These prostheses can be manufactured by different materials, and several commercial brands are available in the dental market.[3] Polymethylmethacrylate (PMMA) -based material, such as the chemically activated acrylic resin (CAAR), is widely used for making interim restorations, mostly for the fabrication of single and multiple crowns.[3]

These interim restorations may be needed for a longer time, being exposed to the adverse conditions of the oral cavity.[4] These conditions may promote properties changes in the materials used.[4] The use of external substances, such as drinks, food, and mouthwashes, can negatively affect the color of these restorations.[5-8] Chlorhexidine-based (CH) rinses can cause staining of the surface of the CAAR restorations.[6,7] This product is widely indicated in dentistry, due to its excellent antimicrobial properties, although its use for longer periods should be restricted only by professional indication.[9-11]

The chromatic alteration of CAAR material can also result from the low polymeric conversion of the self-curing resins, resulting in a higher release of residual monomers.[12,13] These monomers can interact with the pigments of the polymeric matrix and cause its yellowing.[12,13] Furthermore, the surface microhardness of this material must be suitable, maintaining the surface integrity of the polymer over the period.[8,14-16] Another important factor is the surface roughness of the material. A rough surface can facilitate the adhesion of microbial biofilm due to the increase in the contact surface caused by cracks and microcracks, compromising the health of gingival tissues.[17,18] The integrity of the material is also related to its surface-free energy and its hydrophilicity. More hydrophilic surfaces have higher surface energy and retain more hydrophilic microorganisms.[12,19,20] Also, they present higher absorption of polar liquids, such as water, a fact that could change the properties of CAAR.[12,19,20]

Based on the above, it is essential to maintain the properties of the interim restorations, looking for the patient's health and the longevity of the rehabilitation.[16,21,22] To achieve these goals, careful polishing must be performed before installing the interim restorations. Surface sealing agents, such as photoactivated glaze, are an excellent polishing option.[23,24] They reduce micro-cracks, improve surface smoothness and, thus, hinder the retention of coloring substances and the undesirable formation of microbial biofilm.[23,24] Glaze application may not influence bacterial adhesion to polymeric surfaces.[25,26]

This study aimed to evaluate the influence of a light-curing glaze on the physical properties of a CAAR after immersion in a 0.12% chlorhexidine mouthwash. The null hypothesis tested was that the physical properties of the analyzed resin would not be altered either after the application of light-curing glaze or after immersion in a 0.12% chlorhexidine mouthwash.

MATERIALS AND METHODS

This study selected 20 participants between 18 and 25 years old. This study was approved by the Ethics Committee under opinion number 71186117.0.0000.5420. They were given a copy signed by the responsible researcher (DMS). The inclusion criteria were the absence of systemic and oral diseases, absence of the use of dental prostheses and/or orthodontic appliances, not using drugs that would alter the salivary flow, good oral hygiene and general health.[19,20]

Eighty samples (10 mm in diameter × 2 mm in thickness) from CAAR (Dencor, Artigos Odontológicas Clássico LTDA, São Paulo, Brazil) were fabricated using a metallic matrix with 10 circular spaces inside, supported by a glass slide. The interior of all matrix spaces was lubricated with petroleum jelly (Vaseline, Unilever) and the CAAR was manipulated according to the manufacturer's recommendations.[4] In the plastic phase, the resin was inserted into the matrix spaces and another glass slide was placed on top of the matrix to allow the excess material to flow until the end of the self-curing process.[4] After that, all samples were polished with #400 and #800 metallographic sandpaper (Buehler, Illinois, USA) in a semiautomatic polishing machine (Ecomet 300PRO; Buehler, Illinois, USA), under constant water irrigation and speed of 300 rpm. The thickness of the samples was checked with a digital caliper (500-171-20B, Tokyo, Japan).[4]

The samples were divided into two groups: CAAR without glaze application (n = 40) and CAAR with glaze application (n = 40). For the glaze application, a thin and uniform layer of light-curing glaze (Megadenta; Radeberg, Germany) was applied with an applicator (KG Brush; KG Sorensen; Brazil) on both sides of the samples, waited for 20 s and light-cured for 180 s.

Forty palatal devices (2 for each volunteer) were made with acrylic resin (Jet, Classic Ind. And Com., São Paulo, Brazil) with two niches (10 × 2.0 mm) in the palatal area. Samples from both groups were inserted in a palatal device. A sticky wax (Kota, São Paulo, Brazil) and a plastic net (1 mm away from the samples) were used to prevent samples' displacement.[27] The samples were exposed to two conditions: the control condition (sucrose 30%) and the test condition (sucrose 30% and 0.12% chlorhexidine). The volunteers used the first palatal device (control condition) for seven days and the second palatal device (test condition) for another seven days, with a seven-day break between them.

For the control condition, the volunteers dripped one drop of sucrose solution at 30% (Manipullis, Araçatuba, São Paulo, Brazil) on each sample, six times a day.[28] After this, the volunteers waited 5 minutes before repositioning the device in the oral cavity,[28] without rinsing or removing the excess. After a seven-day break, the volunteers resumed the process using the second device, to perform the test condition. For this condition, the same protocol for the application of sucrose at 30% was performed equally for the control condition. However, in the interval between the third and sixth applications, these samples also received one drop of 0.12% chlorhexidine (Manipullis, Araçatuba, São Paulo, Brazil) without dye and alcohol. So, the volunteers dripped a drop of the 0.12% chlorhexidine solution on the sample surface twice a day.[29,30] Subsequently, they waited 5 minutes to introduce the device into the oral cavity, without rinsing or removing the excess. The volunteers were instructed to remove their devices during meals[31,32] and to clean the oral cavity *(Figure 1)* 3 times a day with specific toothpaste (Colgate Maximum Cavity Protection, Colgate, São Paulo, Brazil).[32,33]

A spectrophotometer (Shimadzu Corp., Kyoto, Japan) was used to obtain the color coordinates (L*, a*, b*) of each sample and evaluated using the CIEDE2000 (ΔE_{00}) formula,[17] according to the Commission Internationale de I´Eclairage - CIE (International Commission on Illumination).[17,33] Color difference by the ΔE_{00} was calculated as

$$(\Delta E_{00}) = [(\Delta L'/K_L S_L)^2 + (\Delta C'/K_C S_C)^2 + (\Delta H'/K_H S_H)^2 + R_T(\Delta C'/K_C S_C)(\Delta H'/K_H S_H)]^{1/2}.17$$

$\Delta L'$, $\Delta C'$, and $\Delta H'$ represent the differences in lightness, chroma, and hue between 2 compared specimens. S_L represents the lightness, S_C represents the chroma, and S_H represents the hue components. K_L, K_C, and K_H represent the parametric factors to be regulated according to diverse viewing parameters. In this study, K_L, K_C, and K_H were set to 1.

For the surface microhardness (Knoop), a microdurometer (HMV-2T, Shimadzu Corp., Kyoto, Japan) was used. Three penetrations with a load of 25 g for 10 s were made into the surface of each sample, with 500 µm of the distance between each one.[34] The surface roughness was verified with a portable profilometer (Mitutoyo SJ-400; Mitutoyo Corp., Tokyo, Japan), using the cut-off of 500 µm for 12 s to obtain the Ra values (average of roughness).[4] The surface-free energy was analyzed using a goniometer (Kruss, Hamburg, Germany), through the contact angle present on the surface, according to the Owens–Wendt–Rabel–Kaelble (OWRK) technique.[35] All analyzes were performed initially and after the seven-day *in situ* period.

The values obtained in all tests were subjected to the two-way (ΔE_{00}) and three-way (microhardness, roughness, surface-free energy) Analysis of Variance (ANOVA). The Tukey test was used as a post-hoc (α = .05) (SPSS version 20.0—Statistical Package for the Social Sciences; IBM Corp., New York).

RESULTS

For ΔE_{00}, the factors Group (P = 0.007) and Condition (P = 0.026) affected in the results, however the interaction between them was not affected (P = 0.314). Figure 2 shows the comparison of ΔE_{00} of all groups and conditions. In the

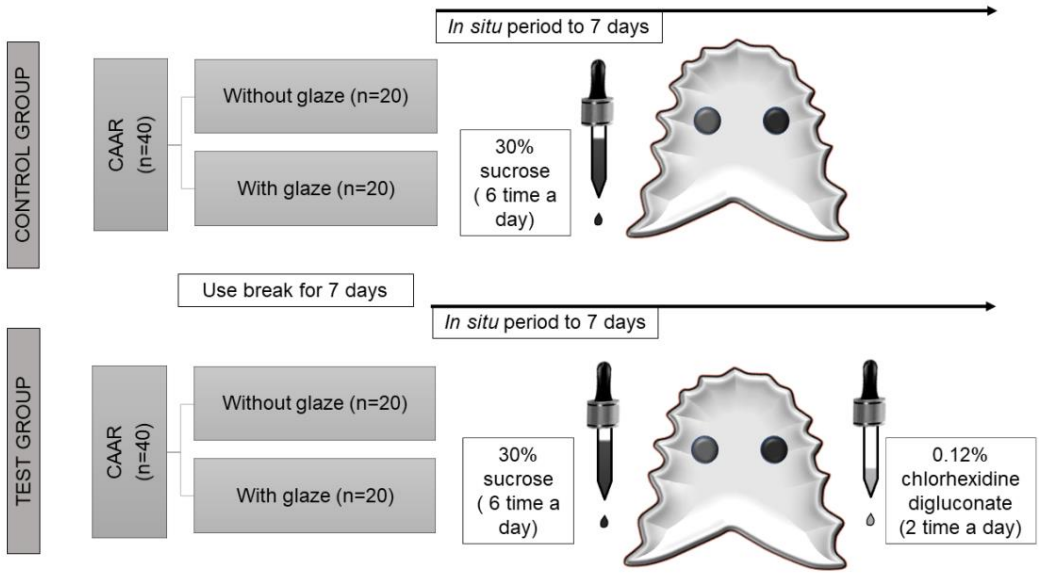

Figure 1: Study design.

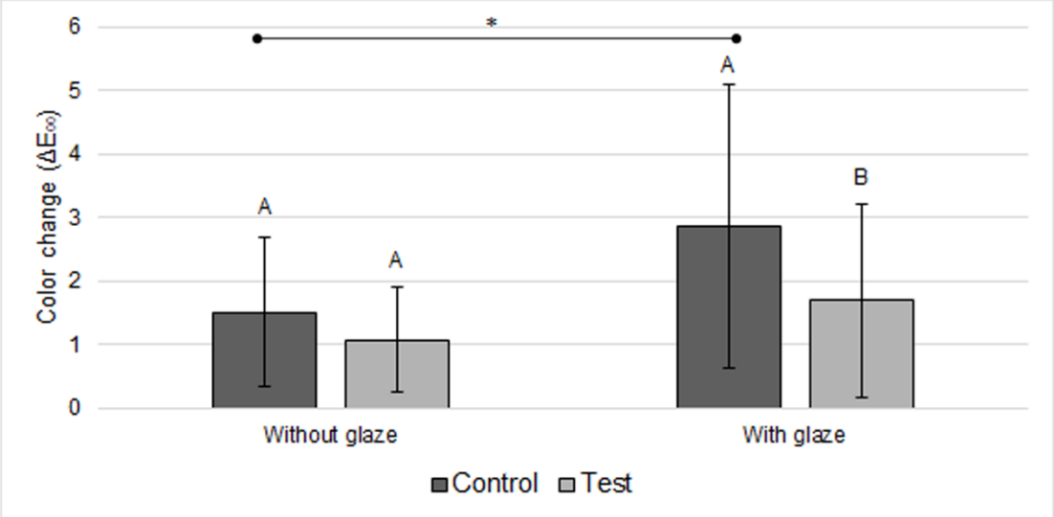

Figure 2: Means ± SD for ΔE_{00} data. Same uppercase letters between the same glaze group indicate statistical significance, according to the resin type (control/test). (*) indicates statistical significance between the same type of resin, according to the glaze (without/with).

control condition, the group with glaze had values statistically higher than the group without glaze. In the test condition, no statistical difference was found between both groups. In the comparison between both groups about the conditions, the group with glaze showed higher values than without glaze only in the control condition.

The microhardness values were influenced by the interaction of the factors Time × Glaze × Test (P = 0.001). All groups presented a statistically significant decrease in microhardness over time, except for the test without the glaze. In both periods, when the glaze was applied, higher values were found for all groups. Only in the final period, the microhardness of the group with glaze in the test condition was statistically higher than in the control condition *(Figure 3*).

The interaction of the factors Time × Glaze (P = 0.016) influenced the roughness results. Figure 4 shows the roughness values for all groups. When the glaze was not applied, the values of all groups increased statistically over time. Groups with glaze showed roughness values statistically lower than groups without glaze, in both periods. The condition did not influence in the roughness values for all groups.

The surface-free energy was influenced by the interaction of the factors Time × Glaze × Test (P <0.001). Figure 5 shows that a statistically decrease in surface-free energy values over time for all groups, except for the group without glaze in the control condition. Groups with glaze showed statistically higher surface-free energy values than groups without glaze. The test condition had surface-free energy values statistically higher than their respective controls.

DISCUSSION

The null hypothesis, that the physical properties of the analyzed resin would not be altered either after the application of light-curing glaze or after immersion in a 0.12% chlorhexidine mouthwash, was rejected since the glaze application and the chlorhexidine treatment influenced the CAAR's physical properties evaluated.

The present study showed that the color alteration was statistically higher in the control condition when the glaze was applied, above the clinically acceptable threshold (ΔE_{00}> 2.2).[17] The absorption of water present in saliva[5] and the material's own degradation by toxins from bacterial biofilm[15] may have influenced the glaze properties. Extrinsic factors such as acidic drinks, dyes, and some mouthwashes, can interfere with the color of polymeric materials such as CAAR.[4,5] One intrinsic factor of CAAR pigmentation is the presence of the initiating benzomeric peroxide monomer and the activating agent dimethyl p-toluidine, which act together and promote its yellowing over time.[12] The low conversion rate of self-curing resins is another factor which can interfere with the release of residual monomers, which can interact with resin pigments and interfere with their color.[13]

In addition, the interaction of the compounds presented in the glaze matrix and the residual monomers present on the surface of the CAAR samples may be an explanation of the higher ΔE_{00} value in the control condition when the glaze was applied. This can cause the degradation of the glaze, leading to the color change over time.[4] Another important result is

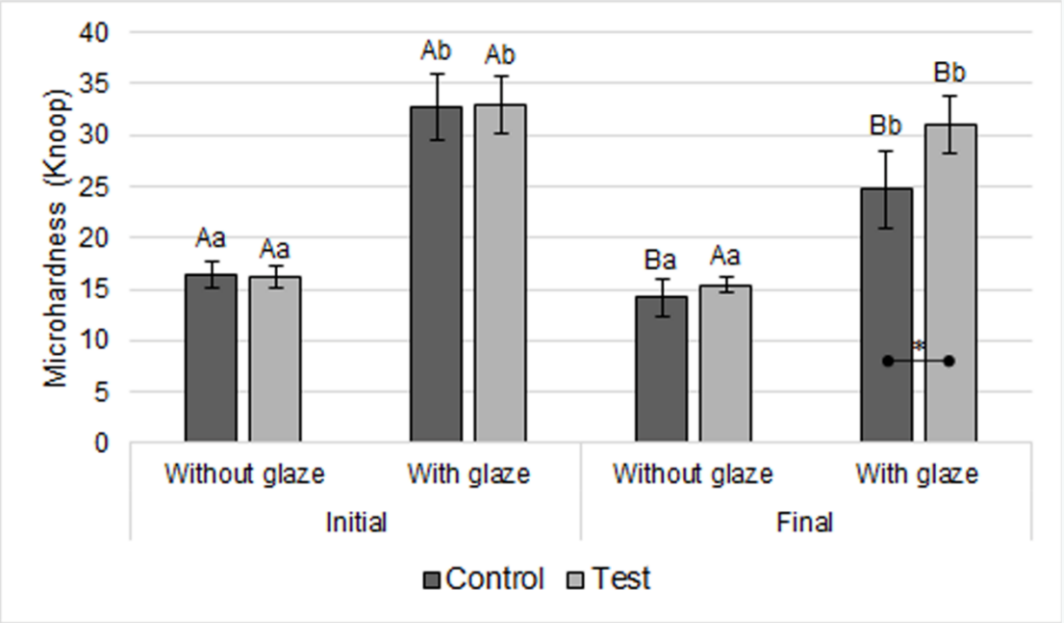

Figure 3: Means ± SD for microhardness data. Means followed by the same uppercase letter do not differ between the same glaze and resin group, according to period. Means followed by the same lowercase letter do not differ between the same resin group in the same period, according to glaze. (*) shows statistical significance between the same glaze and period group, according to resin type.

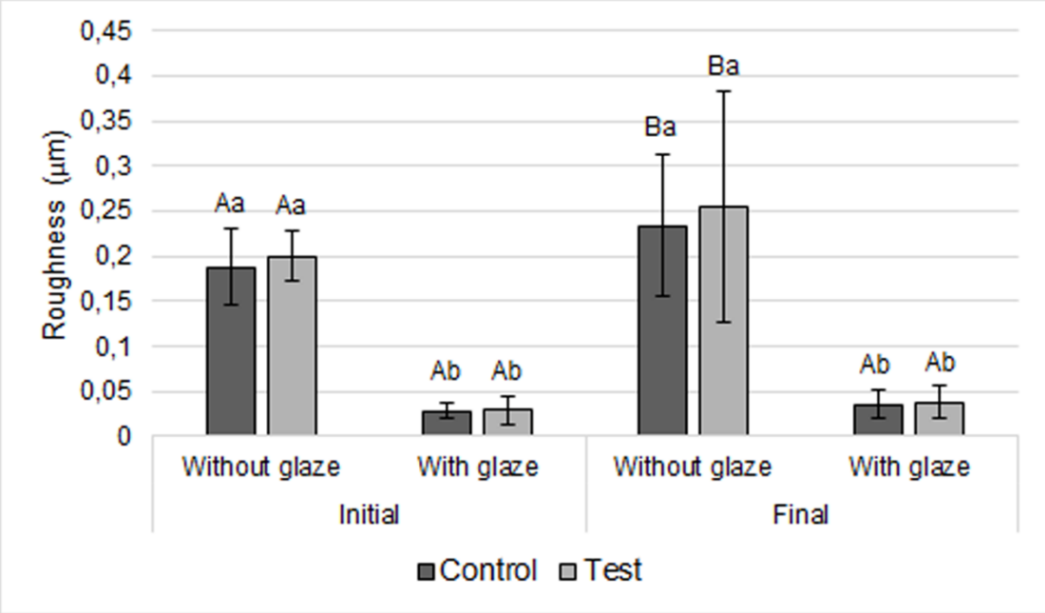

Figure 4: Means ± SD for roughness data. Means followed by the same uppercase letter do not differ between the same glaze and resin group, according to period. Means followed by the same lowercase letter do not differ between the same resin group in the same period, according to glaze. (*) shows statistical significance between the same glaze and period group, according to resin type.

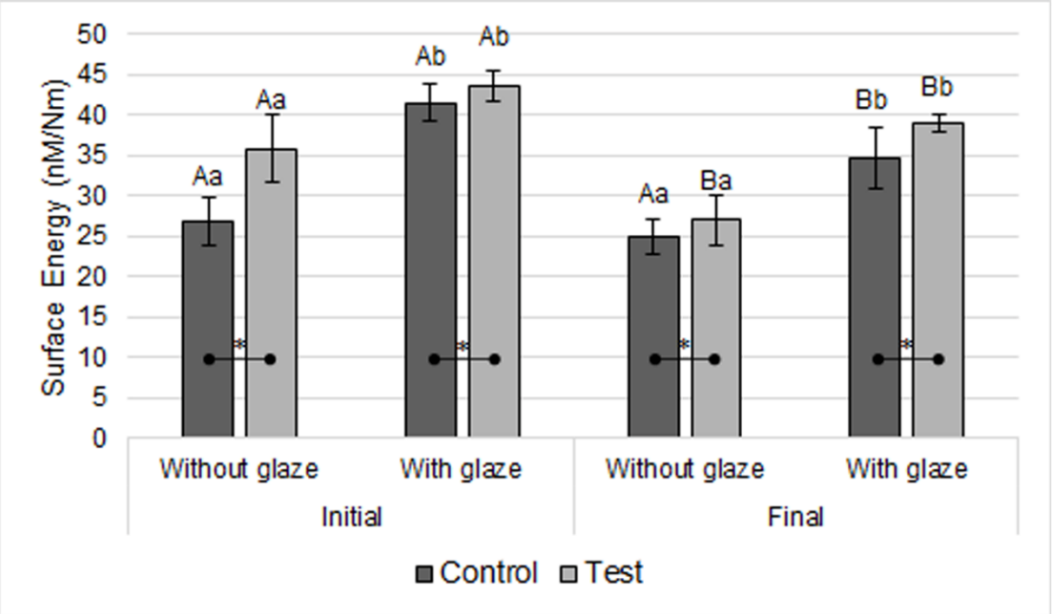

Figure 5: Means ± SD for surface-free energy data. Means followed by the same uppercase letter do not differ between the same glaze and resin group, according to period. Means followed by the same lowercase letter do not differ between the same resin group in the same period, according to glaze. (*) shows statistical significance between the same glaze and period group, according to resin type.

that the group with glaze treated with 0.12% CH maintained its chromatic alteration at acceptable clinical levels. This may be related to the antibiofilm capacity present in CH, which possibly resulted in less accumulation of biofilm and, thus, less surface degradation caused by its toxins.[4,15]

The microhardness was higher in the glaze groups, which may have occurred due to the glaze presents higher microhardness than the surface of CAAR, modifying the resin surface and improving it.[4,29] This fact may be also associated with the action of sealing irregularities and microcracks present on the surface of the CAAR. The glaze had a protective

role and decreased the absorption of water and the accumulation of undesirable and harmful substances to the resin.[22-24] In addition, the treatment with 0.12% CH seemed to had a protective role on the surfaces of the samples with and without glaze, since this treatment probably prevented surface degradation.[9,10,15]

Roughness was another property optimized with the use of glaze, with higher smoothness on the surface of these samples, compared to groups without glaze. In addition, the roughness increased over time in groups without glaze. It is known that the absorption of water and other extrinsic substances, such as acidic drinks and some mouthwashes with alcohol, can alter and deteriorate the polymeric matrix and make the surface rougher with more pores, microcracks and irregularities.[5,6] Thus, the application of the glaze filled the microdefects and microcracks, leaving the surface more homogeneous and smoother.

The use of 0.12% CH, due to its cationic character, can form salts with anions such as phosphate, sulfate or chloride, which can deposit on the surface of the polymeric matrix or undergo dissolution, making the surface more porous and irregular.[11] However, in this study, CH did not statistically influence the CAAR roughness, as seen in a previous study,[14] in which the acrylic resin samples after undergoing disinfection cycles with CH, did not show significant differences neither in the roughness nor on the surface hardness.

The surface-free energy is related to the material's ability to repel or attract water, so the higher the value, the more hydrophilic the material will be.[30] In this study, higher values were found when glaze was applied. Bürgers *et al*.[19] reported that the glaze alone has higher surface energy than the surface of the CAAR. However, there was a decrease in surface energy in the groups with glaze over time, probably due to the conditions of the oral environment.[5,6] Also, the groups treated with 0.12% CH had higher surface-free energy, this may be due to the binding of CH molecules to phosphate ions present on the resin surface.[36,37]

It is important to note that the self-curing resins present a large release of residual monomers, which can result in structural defects, pore enlargement over time, and alterations in the properties.[13,20] Therefore, the use of materials that improve the properties of self-curing resin is important to maintain the quality of interim materials and also making rehabilitation success more predictable. The literature presents few studies *in situ* that evaluate the interaction of CH, as well as the use of glaze, in polymeric materials such as CAAR. Future research with new methodologies and possibly with a higher number of volunteers may corroborate the increase in scientific content and the improvement of restorative materials.

CONCLUSION

Based on the results of this *in situ* study, it is possible to conclude the clinical efficiency of the application of glaze and the use of 0.12% CH in maintaining the physical and mechanical properties of CAAR.

ACKNOWLEDGMENTS

The authors thank FAPESP (Foundation for Support to Research of the State of Sao Paulo) (2017/11803-8) for funding this research.

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