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LUÍSA DE ALMEIDA VIEIRA MARINS

EFEITO DA ESCOVAÇÃO NA RUGOSIDADE DE SUPERFÍCIE E DESGASTE DO MATERIAL CIMENTANTE NA ÁREA DE UNIÃO ENTRE O ESMALTE E A CERÂMICA VÍTREA CAD/CAM

EFFECT OF TOOTHBRUSHING ON THE ROUGHNESS SURFACE AND WEAR OF CEMENTING MATERIAL AT THE BONDED ENAMEL-CAD/CAM GLASS CERAMIC INTERFACE

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Trabalho de Conclusão de Curso apresentado à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para obtenção do título de Cirurgiã-Dentista.

Undergraduate final work presented to the Piracicaba Dental School of the University of Campinas in partial fulfillment of the requirements for the degree of Dental Surgeon

Orientador: Prof. Dr. Marcelo Giannini

Coorientador: Doutorando Vitaliano Gomes de Araújo Neto

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RESUMO

Este estudo avaliou o efeito da escovação na linha de cimentação entre esmalte e cerâmica vítrea, utilizando diferentes materiais para cimentação. Para confecção das amostras, foram utilizados 30 blocos de esmalte e 30 de cerâmica, que foram unidos com 3 tipos de agentes cimentantes: 1- cimento resinoso RelyX Ultimate (REXU), 2- cimento autoadesivo RelyX Unicem 2 (REU2) e 3- cimentação com compósito restaurador Z100 aquecido (60°C). A linha de cimentação das amostras foram escovadas e a superfície dos 3 materiais avaliadas quanto à rugosidade (RG, em µm), perfil de rugosidade (PR, em µm) e perda de volume (PV, em $µm^3$) (antes ou "baseline", após 20 e 60 mil ciclos de escovação). Os dados foram avaliados pela Análise Linear Generalizada (dois fatores: "material" e "ciclo de escovação") e teste Bonferroni ($α=0,05$). REXU e Z100 exibiram menor RG que REU2, exceto após 60 mil ciclos de escovação quando apenas Z100 diferiu de REU2. A progressão da escovação aumentou a RG e PR para todos materiais. REU2 também apresentou maior PR que REXU e Z100, quando analisados em relação ao esmalte. A PV com relação ao esmalte e à cerâmica foi menor para o Z100 com 20 mil ciclos. Para 60 mil ciclos, REXU apresentou a menor PV em relação à cerâmica e o REU2 a maior PV em relação ao esmalte e cerâmica. No geral, REXU e Z100 apresentaram os melhores resultados com relação às avaliações realizadas e o REU2 os maiores valores RG, PR e PV com o aumento da escovação.

Palavras-chave: cimento resinoso, resina composta, esmalte dentário, cerâmica odontológica, escovação, restauração indireta.

ABSTRACT

This study evaluated the effect of toothbrushing on enamel-cementing material-ceramic bonded interfaces, using different cementing materials. Thirty enamel and thirty ceramic blocks were bonded with three types of cementing materials to produce the samples that were bonded with 3 cementing materials: 1- resin cement RelyX Ultimate (REXU), 2- self-adhesive resin cement RelyX Unicem 2 (REU2) and 3- heated Z100 restorative composite (60°C). Bonded interfaces of the samples were toothbrushed and the surfaces of the 3 cementing materials were evaluated for roughness (RG, in µm), roughness profile (RP, in µm) and volume loss (VL, in μm^3) (before or baseline and after 20,000 and 60,000 toothbrushing cycles). Data were evaluated by Generalized Linear Analysis (two factors: “material” and “toothbrushing cycle”) and Bonferroni test (α=0.05). REXU and Z100 exhibited lower RUS than that presented by REU2, except after 60,000 toothbrushing cycles when only Z100 differed from REU2. The increase in toothbrushing cycles increased the RG and RP for all materials. REU2 also showed higher RP than those sowed by REXU and Z100, when analyzed regarding the enamel. The VL of Z100 was the lowest with 20,000 toothbrushing cycles, regarding the enamel and ceramic. For 60,000 cycles, REXU showed the lowest VL regarding the ceramic and REU2 the highest VLO regarding the enamel and ceramic. In general, REXU and Z100 showed the best results regarding the evaluations performed and the REU2 exhibited the greatest RG, RP and VL.

Keywords: resin cement, resin composite, dental enamel, dental ceramic, toothbrushing, indirect restorations.

LISTA DE ABREVIATURAS E SIGLAS

RG	-	Rugosidade de superfície
PR	-	Perfil de rugosidade
PV	-	Perda de volume

SUMÁRIO

1. INTRODUÇÃO

O desenvolvimento dos materiais dentários com a evolução digital proporcionou um fluxo de trabalho mais prático para dentistas e técnicos. O sistema CAD/CAM (*computer-aided design / computer-aided manufacturing*) na Odontologia é um exemplo dessa evolução, que tem simplificado a forma de confecção das próteses e, consequentemente, diminuído o tempo de trabalho no processo de preparação da peça protética, proporcionando automatização do processo que era manual e mais complexo. Com foi possível obter maior qualidade e padronização na fabricação das próteses, além de reduzir os custo e tempo de produção. (Furtado de Mendonca et al., 2019).

Com o advento dos materiais totalmente cerâmicos, houve a necessidade de desenvolver materiais cimentantes alternativos ao fosfato de zinco e ao ionômero de vidro (Manso et al., 2017). Os cimentos resinosos ganharam popularidade por apresentar diferentes modos de ativação, boa adesão à estrutura dentária e permitirem melhor estética após a cimentação, sendo atualmente o principal material cimentante para restaurações protéticas em dentes anteriores e posteriores (Schenke F et al., 2012). O processo de cimentação influencia na retenção e longevidade das restaurações indiretas, sendo fundamental para o seu sucesso clínico (Haddad et al., 2011).

Como as propriedades mecânicas dos cimentos resinosos são inferiores às cerâmicas e à estrutura de esmalte, a área de cimentação é considerada a região mais crítica (Tian T et al., 2014). Devido à composição dos materiais cimentantes, eles podem sofrer degradação hidrolítica, dissolução e desgaste frente a vários agentes externos, como a escovação. Isso pode produzir infiltração marginal, fenda, pigmentação marginal e cárie recorrente, que reduzem a longevidade da peça protética. (Heintze S et al., 2008; Stansbury JW, 2012; Frankenberger R et al., 2015; Durgesh BH et al., 2016; Xu Z et al., 2019). Além disso, falhas na adaptação da peça protética cimentada ou grande espessura de cimento resinoso também pode afetar a longevidade da restauração indiretas, com acúmulo de biofilme e aumento doa degradação das margens (Mushashe et al., 2020).

Os cimentos resinosos são classificados de acordo com sua polimerização. Atualmente, O cimento resinoso de dupla polimerização tem sido muito utilizados devido a sua ampla aplicabilidade clínica e potencial adesão às cerâmicas (Schenke F et al., 2012). Nesses cimentos resinosos são incorporados iniciadores químicos para favorecer os processos de polimerização e adesão. Por outro lado, os cimentos resinosos autoadesivos incluem monômeros funcionais ácidos idealizados para aderir à estrutura do dente sem a necessidade de um adesivo ou condicionamento separado. Porém, a presença de monômeros ácidos pode alterar as propriedades químicas e mecânicas do material caso não haja polimerização completa. Além disso, monômeros não reagidos podem ser lixiviados, causando irritação tecidual local e formação de fendas marginais precoces que talvez propicie à cárie recorrente (Salz U et al., 2005).

Uma alternativa para melhorar a integridade marginal das restaurações é a utilização de resina composta restauradora pré-aquecida para diminuir sua viscosidade. Evidências mostram que esse aquecimento de compósitos melhora a fluidez do material e, consequentemente, a adaptação marginal da restauração (Goulart M et al., 2018). Além de apresentarem menor custo e maior disponibilidade de tonalidades, as resinas compostas apresentam menor contração de polimerização e melhores propriedades mecânicas quando comparadas aos cimentos resinosos, devido à maior quantidade de partículas de carga e monômeros de alto peso molecular em sua composição, o que as torna mais resistentes à degradação intraoral (Coelho et al., 2019; Ferracane JL. Et al., 2011). Dentre os fatores externos, a escovação dental ao longo do tempo pode comprometer da linha de cimentação, visto que dependendo do tipo de material cimentante, eles apresentam comportamentos variados frente à escovação.

2. ARTIGO: EFFECT OF TOOTHBRUSHING ON THE ROUGHNESS SURFACE AND WEAR OF CEMENTING MATERIAL AT THE BONDED ENAMEL-CAD/CAM GLASS CERAMIC INTERFACE

Artigo submetido na Revista "Odontology"

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ABSTRACT

Purpose: This study evaluated the effect of toothbrushing on enamel-cementing material-ceramic bonded interfaces, using different cementing materials.

Materials and Methods: Thirty enamel and thirty ceramic blocks were bonded with three types of cementing materials to produce the samples that were bonded with 3 cementing materials: 1- resin cement RelyX Ultimate (REXU), 2- self-adhesive resin cement RelyX Unicem 2 (REU2) and 3- heated Z100 restorative composite (60°C). Bonded interfaces of the samples were toothbrushed and the surfaces of the 3 cementing materials were evaluated for roughness (RG, in µm), roughness profile (RP, in µm) and volume loss (VL, in μm^3) (before or baseline and after 20,000 and 60,000 toothbrushing cycles). Data were evaluated by Generalized Linear Analysis (two factors: "material" and "toothbrushing cycle") and Bonferroni test ($\alpha=0.05$).

Results: REXU and Z100 exhibited lower RUS than that presented by REU2, except after 60,000 toothbrushing cycles when only Z100 differed from REU2. The increase in toothbrushing cycles increased the RG and RP for all materials. REU2 also showed higher RP than those sowed by REXU and Z100, when analyzed regarding the enamel. The VL of Z100 was the lowest with 20,000 toothbrushing cycles, regarding the enamel and ceramic. For

[*] De acordo com as normas da UNICAMP/FOP, baseadas na padronização do International Committee of Medical Journal Editors - Vancouver Group. Abreviatura dos periódicos em conformidade com o PubMed.

60,000 cycles, REXU showed the lowest VL regarding the ceramic and REU2 the highest VLO regarding the enamel and ceramic.

Conclusion: In general, REXU and Z100 showed the best results regarding the evaluations performed and the REU2 exhibited the greatest RG, RP and VL.

KEYWORDS

Resin cement, resin composite, dental enamel, dental ceramic, toothbrushing, indirect restorations.

INTRODUCTION

The procedure for bonding resin cements to dental ceramics play a fundamental role in the clinical longevity of the indirect restorations. Following the advent of all-ceramic materials, resin cements gained popularity for presenting different activation modes, good adhesion to the tooth structure and aiding in esthetics after cementation, Thus, resin cements are the main cementing material for prosthetic restorations in anterior and posterior teeth [1, 2].

Supragingival margin preparations for indirect restorations have the advantages, such as facilitate impression, cementation and biofilm control at the tooth-restoration interface [3, 4]. However, the restoration-tooth interface at supragingival margins is directly affected by the toothbrushing, which can lead to degradation and removal of the resin cement layer. Also, the shrinkage stress generated during the polymerization reaction can debond the resin cement to ceramic or tooth, damaging the adhesive interface by the gap formation [5,6].

The mechanical properties of the resin cement are inferior compared with ceramics and dental enamel, making it the most critical region at the cementation area [7]. In cases of poor adaptation of the indirect restoration to the cavity margins, the resin cement can be thick, compromising the marginal sealing of tooth structure [8].

Resin cements are classified according to their activation mode and bonding mechanism. Dual-cured resin cement has been widely used due to clinical applicability [2] and the self-adhesive resin cements do not require the use of etchant or adhesive for bonding to the tooth structures. However, self-adhesive resin cements are not cementing materials with only resin matrix and therefore can suffer more from toothbrushing and chemical degradation than purely resin cements [9].

An alternative to improve the marginal integrity of indirect restorations is the use of pre-heated restorative resin composite as a cementing material. The composite heating decreases its viscosity, allowing the cementation procedure [10]. This variety of cementing materials has been used by the dentists, but their different compositions might lead to different clinical performance regarding the chemical and mechanical challenges in the oral cavity [11-14].

This study evaluated the effect of toothbrushing on three types of cementing materials: one conventional dual-cured cementing system, one self-adhesive dual-cured resin cement and one heated, light-cured restorative resin composite. The research hypothesis were that: (1) simulated toothbrushing do not affect the roughness surface of cementing materials, (2) the roughness profile after toothbrushing varies among cementing materials, (3) and toothbrushing cycles increase the volume loss of these materials.

MATERIALS AND METHODS

Specimen Preparation, Experimental Groups and Toothbrushing

The materials used in the study and their respective compositions are shown in Table 1. The following materials were used: a feldspathic ceramic (Cerec Blocs, Dentsply Sirona, Bensheim, Germany), two etchants: 35% phosphoric acid (Gluma Etch 35, Kulzer GbmH, Hanau, Germany) and 5% hydrofluoric acid (Maquira Dental Group, Maringá, PR, Brazil), a silane coupling-agent: (RelyX Ceramic Primer, 3M Oral Care, St. Paul, MN, USA), a bonding agent (Scotchbond Universal, 3M Oral Care), two resin cements: RelyX Ultimate (REXU, 3M Oral Care) and RelyX Unicem 2 (REU2, 3M Oral Care) and one restorative resin composite (Z100, 3M Oral Care).

Table 1. Compositions and lot numbers of the dental materials used in this study.

Material	Composition	Lot number
Cerec Blocs	Glass matrix feldspatic crystalline particles	53950
Gluma Etch 35 (etchant)	Phosphoric acid, thickener, pigments, water	k010174
5% Hydrofluoric acid (etchant)	Hydrofluoric acid, thickener, pigments, water	033019
Ceramic Primer (silane)	Ethyl alcohol, water, 3-Trimethoxysilylpropyl methacrylate	NA56502
Scotchbond Universal (adhesive)	Bis-GMA, 2-hydroxyethyl methacrylate, silane treated silica, ethyl alcohol, decamethylenedimethacrylate, water, 1,10-decanediol phosphate methacrylate, acrylic	2007700379

	and itaconic acid copolymer, camphorquinone, N,N-dimethylbenzocaine, 2-dimethylaminoethyl methacrylate, acetone	
Z100 (restorative composite)	Treated silanized ceramic, Bis-GMA, TEGDMA, 2-benzotriazolyl-4-methylphenol	2031400560
RelyX Ultimate (resin cement)	Base paste: methacrylate monomers, radiopacifiers, silanized filler particles, initiators, stabilizers Catalyst paste: methacrylate monomers, radiopacifiers, alkaline filler particles, stabilizers, pigments, thickener, fluorescent components, chemical polymerization activator	5201468
RelyX Unicem 2 (resin cement)	Base paste: methacrylate monomers containing phosphoric acid groups, methacrylate monomers, silanated fillers, initiator component. Catalyst paste: methacrylate monomers, alkaline fillers, silanated fillers, initiator	6675996

Monomer abbreviations: Bis-GMA: Bisphenol A diglycidyl ether dimethacrylate; TEGDMA: Triethylene glycol dimethacrylate.

Thirty incisor bovine teeth were used for this study. The roots of the teeth were removed and 30 enamel blocks (3 mm thick x 5 mm wide x 5 mm long) were obtained using a diamond disc (Buehler Ltd., Lake Bluff, IL, USA). The buccal enamel was flattened with 600-grit sandpaper (Norton Abrasivos, Guarulhos, SP, Brazil) sandpaper under water irrigation. Thirty ceramic blocks with the same dimensions as the enamel blocks were obtained from the CAD/CAM Cerec Blocs. The three types of cementing materials formed the three experimental groups for this study: REXU, REU2 and Z100.

Ceramic blocks were etched with 5% hydrofluoric acid for 60 seconds, washed with water for 30 seconds and subjected to an ultrasonic bath in an ultrasonic cleaner (USC 1400; Unique, Indaiatuba, SP, Brazil), containing distilled water for 5 minutes, followed by drying with air. The etched ceramic surfaces were silanated and the Scotchbond Universal adhesive was applied, but kept uncured.

For the cementation with Z100 and REXU, the dental enamel surfaces were etched with 35% phosphoric acid for 20 seconds, washed with water for 30 second and dried with air. Scotchbond Universal adhesive was applied, keeping uncured as those applied to enamel block. For REU2, the enamel was not etched, keeping untreated as recommended by its manufacturer.

Z100 was heated until 60°C before cementation [15], using a dental composite heating device (HotSet, Technolife, Joinville, SC, Brazil), while REXU and REU2 were used in room temperature (23°C). The cementing materials were manipulated and applied to the silanated and bonded ceramic surface, which was then placed on the enamel surface with 500 g load. Excess of cementing materials was removed with microbrush disposable applicators, and they were light-cured from all surfaces for 20 seconds each surface (1474 mW/cm^2, Valo Cordless, Ultradent Products Inc., South Jordan, UT, USA). The thickness of the cementing materials between the ceramic and the dental enamel varied between 200 and 350 µm.

Bonded samples were stored in deionized water for 24 hours at room temperature, embedded in epoxy resin (Buehler Ltd.) and the ceramic-cementing material-enamel interfaces were polished with sandpapers (800, 1000, 1200 and 2000-grits, Norton Abrasivos) under water irrigation and diamond paste (1 µm, Buehler Ltd.).

Samples were submitted to 20,000 and 60,000 cycles (150 cycles/min) of toothbrushing (MEV-4X 3D, Odeme Dental Research, Luzerna, SC, Brazil). A 200 g load was delivered by soft toothbrushes (Oral-B Indicator 35, Procter & Gamble, Seropédica, RJ, Brazil) and samples were covered in a slurry of toothpaste (Oral-B Pro-Health, Procter & Gamble) solution (16 g of dentifrice with 100 mL of deionized water). After each simulated toothbrushing cycle, the samples were thoroughly washed and air-dried before analyzing.

Confocal Microscopy Analysis

The surface roughness (Sa, in µm), roughness profile (Rv, in µm), and volume loss (µm^3) were measured using a confocal microscopy (LEXT 3D Measuring Laser Microscope OLS4000, Olympus Corp., Tokyo, Japan) and the OLS4000 software (Olympus Corp). The Sa parameter describes the arithmetic height deviation from a mean plane three-dimensionally, and corresponds to the two-dimensional parameter Ra, which measure surface roughness by detecting the maximum peak to valley heights of a specific surface profile.

An image containing 0.5 mm of the ceramic or enamel sides of each sample was obtained to calculate the roughness profile and the volume loss. The roughness profile was determined from the largest valley depth deviation from the mean line within a given length (10 readings at each image). To calculate the volume loss, a reference plan from the top of ceramic or enamel area was defined and the software calculated the volume loss of cementing material located below this reference. Surface roughness, roughness profile and volume loss data were analyzed by Generalized Linear Analysis (two factors: “cementing material” and “toothbrushing cycles”) and Bonferroni test (α = 0.05).

Representative 3D and 2D images containing the cementing materials, ceramic and enamel were obtained to visualize the surfaces of samples at baseline and after toothbrushing cycles. A 5x objective lens (1x zoom) was used to obtain the images (1024 x 1024 pixels, XYZ fast scan) with a 405 nm laser (Gaussian filter).

RESULTS

Surface Roughness

Table 2 presents the surface roughness results for the cementing materials at baseline, 20.000 and 60.000 toothbrushing cycles. REXU and Z100 showed lower surface roughness than that obtained for REU2 at baseline and 20.000 toothbrushing cycles. However, only Z100 differed from REU2 at 60.000 cycles. The increase in the number of toothbrushing cycles increased the surface roughness for the three cementing materials.

Table 2. Surface roughness means (Sa, in µm) for the cementing materials (95% CI).

Material	Baseline	20,000 cycles	60,000 cycles
REXU	0.12 (0.08 - 0.17) bC	0.26 (0.17 - 0.34) bB	0.67 (0.45 - 0.89) abA
REU2	0.32 (0.21 - 0.42) aB	0.49 (0.33 - 0.65) aB	1.00 (0.67 - 1.33) aA
Z100	0.11 (0.07 - 0.14) bB	0.16 (0.11 - 0.22) bB	0.51 (0.33 - 0.69) bA

Lower case letters compare cementing materials for the same toothbrushing cycle. Upper case letters compare toothbrushing cycles for the same cementing material.

Roughness Profile

Table 3 presents the roughness profile results for the cementing materials at baseline, 20.000 and 60.000 toothbrushing cycles. As for the surface roughness, the roughness profile also increased with the greater number of toothbrushing cycles. Regarding resin cement-ceramic interface, Z100 presented higher roughness profile than that obtained for REU2, while REXU did not differ from Z100 and REU2 at the baseline. For 20.000 cycles, REU2 showed the lowest roughness profile, while for 60.000 cycles, no statistical difference was found among cementing materials. Regarding resin cement-enamel interface, REU2 showed the highest roughness profile at the baseline and both toothbrushing cycles, while Z100 and REXU did not differ between them.

Table 3. Roughness profile means (Rv, in µm) for the cementing materials (95% CI).

Resin Cement-Ceramic	Resin Cement-Enamel

Materials	Baseline	20,000 cycles	60,000 cycles	Baseline	20,000 cycles	60,000 cycles
REXU	0.04 (0.03 – 0.05) abB	0.10 (0.07 – 0.13) bA	0.18 (0.12 – 0.24) aA	0.03 (0.02 – 0.05) bB	0.09 (0.06 – 0.13) bA	0.13 (0.09 – 0.17) bA
REU2	0.07 (0.05 – 0.09) aB	0.18 (0.12 – 0.24) aA	0.28 (0.19 – 0.37) aA	0.11 (0.07 – 0.15) aB*	0.18 (0.12 – 0.24) aAB	0.26 (0.18 – 0.35) aA
Z100	0.04 (0.02 – 0.05) bC	0.07 (0.05 – 0.09) bB	0.17 (0.12 – 0.23) aA	0.04 (0.02 – 0.05) bB	0.07 (0.05 – 0.09) bA	0.13 (0.09 – 0.17) bA

Lower case letters compare cementing materials for the same toothbrushing cycle and interface. Upper case letters compare toothbrushing cycles for the same cementing material and interface. (*) Differ from “Resin Cement-Ceramic interface” for the same cementing material and toothbrushing cycle.

Volume Loss

The volume loss of cementing materials after toothbrushing is present in the Table 4. Regarding resin cement-ceramic interface, Z100 showed the lowest volume loss at 20,000 toothbrushing cycles, while the REXU the lowest and REU2 the highest at 60,000 cycles. For resin cement-enamel interface, Z100 also showed the lowest volume loss at 20,000 toothbrushing cycles and RXU and REU2 did not differ between them. For 60,000 cycles, REXU and Z100 presented higher volume loss than that obtained for REU2. The increase in the number of toothbrushing cycles increased the volume loss only for the REU2 and Z100 cementing materials.

Table 4. Volume loss (x 10^5) means (in μm^3) for the cementing materials (95% CI).

Material	Resin Cement-Ceramic (CC)		Resin Cement-Enamel (CE)	
	20,000 cycles	60,000 cycles	20,000 cycles	60,000 cycles
REXU	2.60 (1.51 - 3.69) aA	2.43 (1.41 - 3.45) cA	2.18 (1.27 - 3.10) aA	2.15 (1.25 - 3.05) bA
REU2	3.08 (1.79 - 4.37) aB	15.93 (9.25 - 20.30) aA	1.87 (1.08 - 2.65) aB	14.3 (8.32 - 20.31) aA
Z100	0.42 (0.25 - 0.63) bB	5.89 (3.42 - 8.36) bA	0.44 (0.26 - 0.63) bB	3.64 (2.11 - 5.17) bA

Lower case letters compare cementing materials for the same toothbrushing cycle and interface (CC or CE). Upper case letters compare toothbrushing cycles for the same cementing material and interface (CC or CE). There is no difference between CT and CC interfaces.

Confocal Microscopy Images

The Figures 1 and 2 show the topography of the samples before and after toothbrushing cycles in 3D and 2D modes, respectively. Z100 seemed to lose less material than REXU and REU2 following the toothbrushing (Figure 1).

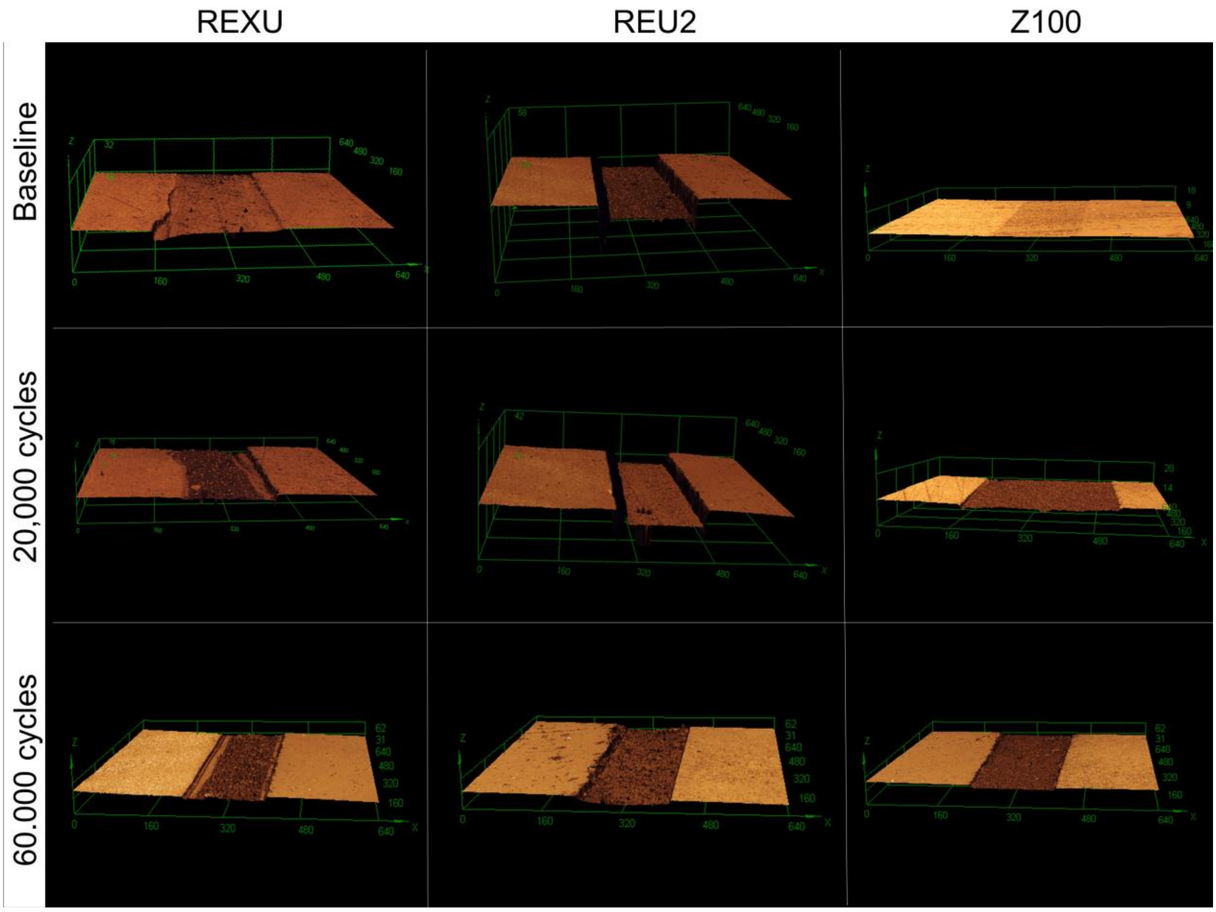

Figure 1. Three-dimensional confocal images showing the unbrushed samples (first line) and brushed ones (second and third lines) of ceramic (at the left side)/cementing material (REXU, REU2 or Z100 at the central area of the samples)/enamel (at the right side) bonded interfaces.

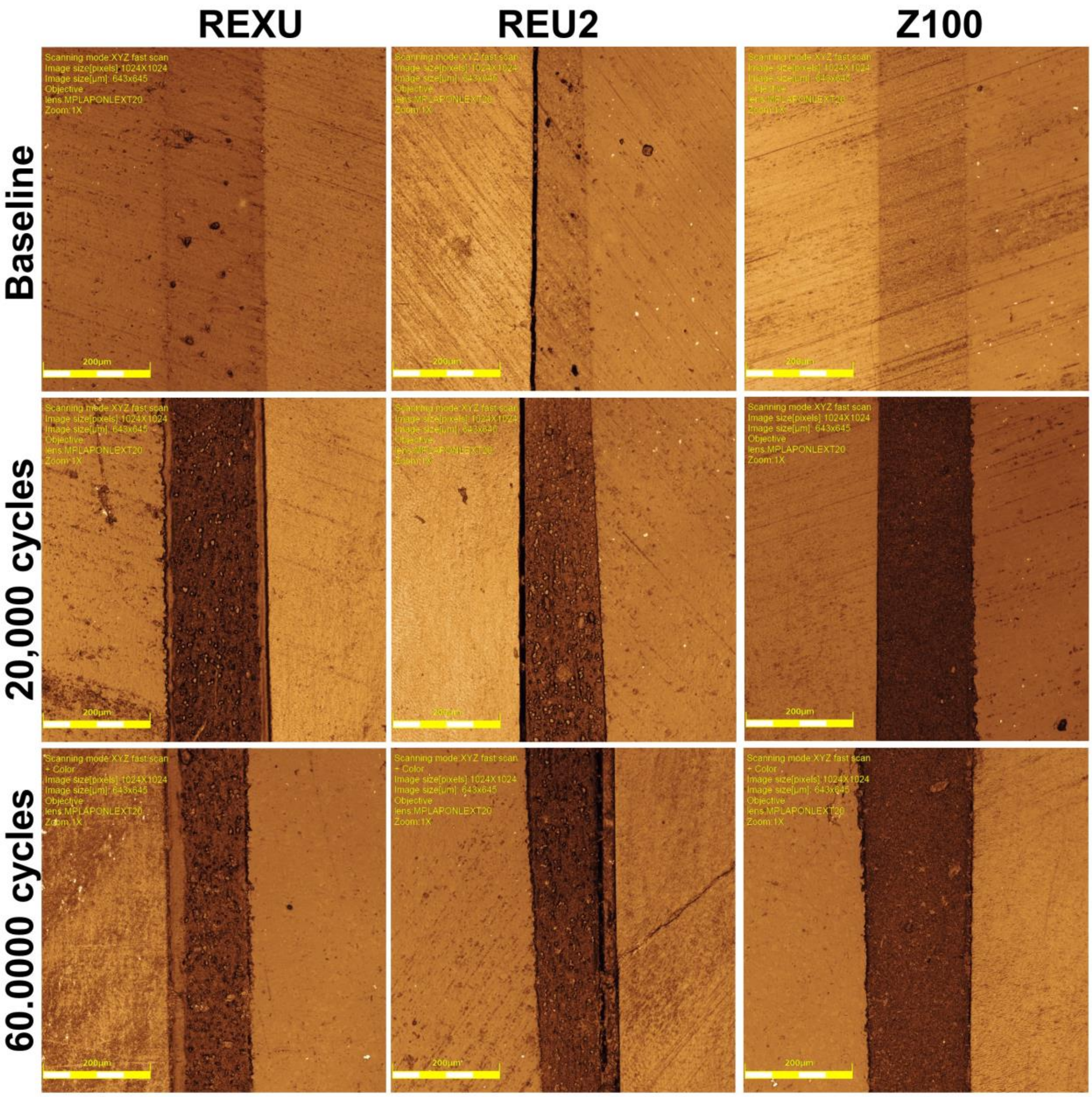

Figure 2. Two-dimensional confocal images showing the unbrushed samples (first line) and brushed ones (second and third lines) of ceramic (at the left side)/cementing material (REXU, REU2 or Z100 at the central area of the samples)/enamel (at the right side) bonded interfaces.

DISCUSSION

The first research hypothesis that the simulated toothbrushing do not affect the surface roughness of cementing materials was rejected, because the toothbrushing until 60.000 cycles significantly increase the surface roughness for all materials. Although cementing materials have different compositions, the alterations on the their topography were observed in all these materials following the abrasion effects caused by toothbrushing. The 20,000 and 60,000 toothbrushing cycles used in this study correspond to approximately two and six years of toothbrushing, respectively [16, 17] and might estimate the clinical performance of these materials when used to bond feldspathic ceramic to enamel [18].

The heating of Z100 resin composite reduced its viscosity, allowing it to serve as cementing material in this study. The results of this composite for surface roughness, roughness profile and volume loss analysis were better or similar to other materials tested. In theory, current restorative composites have lower polymerization shrinkage, adequate degree of conversion and mechanical strength due to the higher amount of filler particles and the presence of high molecular weight monomers in their composition [19]. Thus, the composite resin layer exposed in the cementation area seem to be more resistant against intraoral challenges [20, 21].

Besides reducing the viscosity, composite heating can increase the monomer conversion, reduce the shrinkage stress [22] and improves the marginal adaptation of the indirect restoration [10]. A previous study tested the film thickness of various heated restorative resin composites (69ºC) and it did not identify any relationship between filler loading, viscosity, and/or film thickness. Preheating reduced viscosity between 47% and 92% for the composites, which were generally more viscous than the flowable ones [23]. As a limitation, preheated resin composites have a short working time, because composite does not keep the heating and changes quickly the viscosity, when it is not recommended to be used as cementing material [24].

The REXU resin cement was used in combination with Scotchbond Universal adhesive, similarity to Z100, but in the first case, they belong to the same cementing system. It is a dual-cure resin cements with two activation modes: chemically and light-activation [25]. The chemical mode tries to ensure sufficient polymerization in regions where there is no light exposure, but the light-activation can increase degree of conversion and wear resistance, showing that light-activation is the best curing conditions during the cementation procedures [26-30].

This conventional resin cement showed results similar to the heated Z100 composite. Its surface roughness and roughness profile did not differ from Z100, regardless the toothbrushed cycle. For volume loss at 60,000 cycles, it and Z100 presented lower volume loss than that obtained for REU2. REXU did not differ from REU2 when analyzed at 20,000 cycles and it was the only cementing material that did not show an increase in volume loss with an increase in the number of toothbrushing cycles.

The second hypothesis that roughness profile after both toothbrushing varies among cementing materials was accepted, because significant differences were obtained among cementing materials. In general, REXU and Z100 showed lower roughness profile than REU2 after toothbrushing. The third hypothesis that the toothbrushing cycles increase the volume loss of the cementing materials was accepted, because significant higher volume loss was observed for REU2 e Z100 at 60,000 cycles compared with 20,000 cycles.

REU2 material presented to highest the mean of surface roughness at baseline

(0.32 µm) and after 20.000 toothbrushing cycles (0.49 µm). In general, the highest roughness profile was observed for this self-adhesive resin cement. For volume loss, the REU2 presented higher values than REXU and Z100 at 60,000 cycles. In general, self-adhesive cements have lower mechanical properties than conventional resin cements [31]. REU2 contains an acidic monomer to favor the adhesion processes, initiators and other methacrylate monomers that during the curing process change from hydrophilic to hydrophobic cementing material.

The confocal 3D images (Figure 1) show the loss of cementing materials, regarding the enamel and ceramic margins. The loss of material following the toothbrushing cycles seems quite evident for REU2. Toothbrushing exposed the alkaline fillers and silanated fillers of REU2 that increased the surface roughness and changed the roughness profile. Minor alterations in the topography of the enamel-cementing material-ceramic bonded interface and cementing material loss were observed when the cementing material was Z100.

CONCLUSION

The toothbrushing altered the topography of enamel-cementing material-ceramic bonded interface and influenced the surface roughness, roughness profile, and volume loss results of the cementing materials. In general, REXU and heated Z100 showed the best results regarding the surface roughness, roughness profile, and volume loss evaluations after toothbrushing. On the other hand, REU2 exhibited the highest surface roughness, roughness profile, and volume loss values following the toothbrushing cycles.

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3. CONCLUSÃO

a) O compósito resinoso Z100 aquecido à 60°C e o cimento resinoso convencional RelyX Ultimate apresentaram menor rugosidade de superfície que o cimento autoadesivo RelyX Unicem 2, antes da escovação e após 20.000 mil ciclos. O cimento resinoso autoadesivo RelyX Unicem 2 apresentou maior rugosidade de superfície que a resina composta Z100, após 60.000 ciclos de escovação simulada.

b) Todos os materiais cimentantes apresentaram tiveram aumento do perfil de rugosidade com a escovação, tanto na região Cimento-Cerâmica quanto na região Cimento-Dente. Em geral, a resina composta aquecida e o cimento resinoso RelyX Ultimate apresentaram os menores valores de perfil de rugosidade.

c) O cimento resinoso autoadesivo RelyX Unicem 2 apresentou os maiores valores de perda de volume nos 60.000 ciclos de escovação e portanto, maior desgaste, quando comparado aos outros dois materiais cimentantes testados.

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ANEXOS

ANEXO 1 – Verificação de originalidade e prevenção de plágio

EFFECT OF TOOTHBRUSHING ON THE ROUGHNESS SURFACE AND WEAR OF CEMENTING MATERIAL AT THE BONDED ENAMEL-CAD/CAM GLASS CERAMIC INTERFACE

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Bolsa: PIBIC/CNPq

Processo: **134233/2020-4**

Vigência: 01/09/2020 a 31/08/2021

PARECER

O relatório apresenta os resultados obtidos e discussão dos mesmos, seguindo o projeto apresentado. A aluna apresenta excelente desempenho escolar.

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Aprovado

Pró-Reitoria de Pesquisa, 23 de novembro de 2022.

Marcos Yakuwa Mekaru

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Anexo 3 – Comprovante de submissão do artigo

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