THAMIRES DIOGO LIMA

INFLUÊNCIA DO SISTEMA DE POLIMENTO E TRATAMENTOS DE SUPERFÍCIE NA ESTABILIDADE DE COR E RUGOSIDADE DA RESINA COMPOSTA

INFLUENCE OF POLISHING SYSTEMS AND SURFACE TREATMENTS ON COLOR STABILITY AND ROUGHNESS OF COMPOSITE RESIN

Dissertação apresentada à Faculdade de Odontologia da Universidade Federal de Uberlândia, para obtenção do Título de Mestre em Odontologia na Área de Clínica Odontológica Integrada.

Uberlândia, 2020

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Iniciando os trabalhos o(a) presidente da mesa, Dr(a). Murilo de Sousa Menezes, apresentou a Comissão Examinadora e o candidato(a), agradeceu a presença do público, e concedeu ao Discente a palavra para a exposição do seu trabalho. A duração da apresentação do Discente e o tempo de arguição e resposta foram conforme as normas do Programa.

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Nada mais havendo a tratar foram encerrados os trabalhos. Foi lavrada a presente ata que após lida e achada conforme foi assinada pela Banca Examinadora.

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“A persistência é o caminho do êxito.”

Charles Chaplin

SUMÁRIO

Resumo

RESUMO

Objetivos: Avaliar (1) a influência de diferentes sistemas de polimento na estabilidade de cor e rugosidade da superfície da resina composta e (2) a capacidade de diferentes tratamentos de superfície em reduzir a alteração de cor sem afetar a rugosidade da superfície após o manchamento.

Métodos e materiais: Um total de cento e sessenta amostras em forma de disco (8 x 2 mm) foram preparadas usando uma resina composta. As amostras foram divididas de acordo com os sistemas de polimento: controle negativo (NC), sistema 3M (3S), sistema DhPro (DS) e sistema FGM (FS). Depois disso, os espécimes foram imersos em café por 48 horas. Uma nova subdivisão foi realizada de acordo com o tratamento de superfície (n = 10): gel ozonizado (OG), peróxido de hidrogênio (HP), jato de bicarbonato (BJ) e repolimento (R). Mudança de cor (ΔE_{00}), índice de clareamento (WI), opacidade e rugosidade da superfície (Ra) foram avaliadas após o polimento, após o manchamento com café e após o tratamento da superfície. Os dados de ΔE_{00}, WI e opacidade não apresentaram distribuição normal e foram submetidos ao teste de Kruskal-Wallis. Comparações múltiplas foram realizadas pelo teste de Tukey. Teste ANOVA two-way de medidas repetidas foi utilizado para analisar os dados de rugosidade da superfície em diferentes tempos de avaliação. Todos os procedimentos de comparação múltipla aos pares foram conduzidos usando o teste de Tukey. (α = nível de significância 0,05).

Resultados: A maior coloração apresentada foi em NC e DS. 3S e FS obtiveram resultados semelhantes para alteração de cor, o que significa maior estabilidade de cor. Os tratamentos de superfície reduziram significativamente a alteração de cor e afetaram a rugosidade da superfície ($p<0,001$). O repolimento gerou a maior alteração de cor ($p<0,001$) nos grupos NC e DS.

Conclusão: Foi possível concluir que o sistema de polimento 3M resultou maior estabilidade de cor e menor rugosidade de superfície. O repolimento gerou os valores mais altos de alteração de cor e é uma opção viável para evitar a substituição da restauração.

PALAVRAS-CHAVE: Resinas Compostas, Estética Dentária, Polimento Dentário, Clareadores.

Abstract

ABSTRACT

Objectives: To evaluate (1) the influence of differents polishing systems on the stability color and surface roughness of composite resin and (2) the ability of different surface treatments to reduce the color changes without affect the surface roughness after the staining.

Methods and materials: A total of one hundred and sixty disc-shaped specimens (8 x 2 mm) were prepared using a composite resin. The specimens were divided according to polishing systems: Negative control (NC), 3M system (3S), DhPro system (DS) and FGM system (FS). After this, the specimens were immersed in coffee for 48 hours. A new subdivision was performed according to surface treatment (n=10): ozonated gel (OG), hydrogen peroxide (HP), bicarbonate jet (BJ) and repolishing (R). Color change (ΔE_{00}), whitening index (WI), opacity and surface roughness (Ra) were assessed at after polishing, after staining in coffee and after surface treatment. Data from ΔE_{00}, WI and opacity did not present normal distribution and were submitted to Kruskal-Wallis. Multiple comparisons were performed by Tukey`s test. Two-way repeated measures ANOVA was used to analyze data from surface roughness at different assessment times. All pairwise multiple comparison procedures were conducted using the Tukey test. (α=0.05 significance level).

Results: The higher staining presented on NC and DS. 3S and FS obtained similar results for color change, which means greater color stability. Surface treatments significantly reduced color changes and affected the surface roughness ($p<0.001$). Repolishing generated the greatest color change ($p<0.001$) in NC and DS groups.

Conclusion: It was possible to conclude that the 3M polishing system obtained a higher color stability and lower surface roughness. Repolishing generates the highest color change values and is a viable option to avoid replacement the restoration.

KEY WORDS: Composite Resins, Esthetics Dental, Dental Polishing, Bleaching Agents.

Introdução e Referencial Teórico

1. INTRODUÇÃO E REFERENCIAL TEÓRICO

A insatisfação com a aparência do sorriso é um problema comum na população, à vista disso o escurecimento dental é um dos principais motivos que levam a esse descontentamento (Tin-Oo et al., 2011; Miotti et al., 2017). Com o passar dos anos, os pacientes se tornaram mais exigentes com a estética dos dentes, o que os levam a uma busca incessante por procedimentos clareadores e restauradores (Yikilgan et al., 2017). Por conseguinte, tais procedimentos objetivam solucionar as queixas e demandas dos cirurgiões-dentistas em melhorar a autoestima e bem-estar dos pacientes (Samorodnitzky-Naveh et al., 2007; Bersezio et al., 2019). Para tanto, restaurações de resina composta comumente são utilizadas em regiões anteriores, sendo capazes de obter resultados estéticos satisfatórios e passíveis de atender a essas exigências (Demarco et al., 2015; Miotti et al., 2017). Apesar disso, as resinas compostas apresentam falhas comuns com o processo natural de envelhecimento inerente do material restaurador na cavidade oral (Baldissera et al., 2013; Montagner et al., 2018). As principais razões de falhas em restaurações anteriores estão associadas à estética, principalmente pela perda do formato anatômico, dificuldade na seleção correta da cor e manchamento superficial, o que torna essas situações clínicas desafiadoras (Demarco et al., 2015).

Atualmente, as resinas compostas são classificadas de acordo com as variações no tamanho e quantidades de partículas de carga presentes na matriz resinosa (Ferracane et al., 2011). A resina composta Vittra APS, desenvolvida recentemente pela empresa FGM, sendo classificada como submicrométrica e é a primeira resina de fabricação brasileira livre do monômero de bisfenol A (BPA) em sua composição, apresentando como monômeros o dimetacrilato de trietilenoglicol (TEGDMA) e diuretano dimetacrilato (UDMA). A carga do compósito é composta por nanoesferas de um complexo de zircônia, tamanho médio das partículas fundamentais de 200nm e conteúdo total de carga inorgânica na faixa de 73% em peso (Araújo, 2018). A composição da matriz resinosa, assim como as características das partículas, influencia no resultado final do acabamento e polimento e na susceptibilidade ao manchamento extrínseco (Schmitt et al., 2011; Ergucu et al., 2008).

Destarte, as restaurações estão constantemente expostas a desafios químicos, térmicos e mecânicos na cavidade oral, por meio da dieta e hábitos de cada indivíduo (De Paula

AB et al., 2014). Os motivos que provocam o manchamento do material restaurador podem estar relacionados a fatores intrínsecos, como alterações químicas na matriz da resina e oxidação dos monômeros não polimerizados (Ergucu et al., 2008). Ademais, também há os fatores extrínsecos, como acúmulo de biofilme e absorção de corantes de bebidas e alimentos (ABU-BAKR et al., 2000).

O consumo de bebidas com pH ácido, como o café (pH=5,0), causa alterações perceptíveis de cor e maior irregularidade na superfície de materiais resinosos (Ozera et al., 2019). O ação físico-química leva à degradação da matriz dos materiais restauradores, expondo as partículas de carga e, consequentemente, causa a alteração na rugosidade de superfície e estabilidade de cor (Dietschi et al., 1994; Erdemir et al., 2012). A insatisfação dos pacientes com a presença de resinas pigmentadas na cavidade oral requer que as restaurações sejam substituídas ou reparadas, o que gera um gasto adicional e principalmente maior desgaste de estrutura dental sadia (Reinhardt et al., 2019).

Desse modo, uma das formas de minimizar o manchamento e melhorar a estabilidade de cor das resinas é a realização das etapas do acabamento e polimento, as quais reduzem e suavizam a rugosidade de superfície, gerando uma restauração lisa e polida (Moda et al., 2018). Assim, o polimento aumenta o brilho das restaurações e produz uma aparência natural semelhante ao esmalte (Ergucu et al., 2008; Ozera et al., 2019). Essa etapa não deve ser negligenciada, visto que a remoção da camada superficial aumenta a longevidade e influencia no sucesso clínico das restaurações (Gönülol & Yilmaz, 2012; Ergucu et al., 2008; Lago, et al., 2017). Os sistemas de polimento estão disponíveis com diferentes números de etapas, formatos dos polidores, composições e dureza das partículas (Moda et al., 2018). Porém, independentemente do sistema, deve-se utilizar a sequência decrescente de abrasividade das partículas dos polidores para um resultado satisfatório (Jefferies, 2007). A rugosidade de superfície e as irregularidades das restaurações são fatores que contribuem para o manchamento, pois superfícies ásperas colaboram para o acúmulo de biofilme, irritação gengival, cáries secundárias e dificuldade de higienização (Marghalani, 2010).

Além disso, bem como descrito na literatura, também existem alternativas conservadoras para a remoção do manchamento superficial em restaurações de resina composta, por exemplo: escovação, procedimentos clareadores e repolimento (Abd Elhamid & Mosallam, 2010). Dessa maneira, a presença de restaurações de resina composta nas áreas em que estão expostas aos agentes clareadores é muito comum (Rodrigues et al., 2019), sendo normalmente recomendadas as substituições das restaurações após a realização do clareamento, caso a cor não coincida (Lago et al., 2017). Com o passar dos anos, observou-se em estudos *in vitro* que os agentes clareadores causavam alteração de cor nos materiais resinosos, o que os torna uma opção viável de tratamento (Telang et al., 2018).

Para tanto, alguns estudos constataram que a terapia com o gás ozônio (trioxigênio) é uma forma rápida e eficiente de clareamento, a qual obteve resultados superiores na remoção do manchamento superficial em resinas compostas (Abd Elhamid & Mosallam, 2010; A-Omiri et al., 2016). Por ser considerado um dos oxidantes mais efetivos, o qual tem sido amplamente utilizado, principalmente como agente clareador, o tratamento vem ganhando popularidade entre os profissionais da área da saúde (Al-Omiri et al., 2016; Azarpazhooh & Limeback, 2008; Suh et al., 2019).

Logo, os produtos utilizados para clareamento dental poderiam auxiliar na remoção das manchas das restaurações em resina composta (Lago et al., 2017). O agente clareador mais utilizado é o peróxido de hidrogênio, que em determinado estudo produziu os maiores valores par reduções nas alterações de cor entre os materiais testados (Torres et al., 2012; Araujo et al., 2018). Contudo, os efeitos dos géis clareadores na resina composta estão relacionados com o tipo de resina, tempo de exposição, concentração e agente clareador (Wang et al, 2011).

O uso adequado dos procedimentos de profilaxia, tal como jato de bicarbonato, pode eliminar o acúmulo de placa bacteriana (Soares et al., 2010). Ademais, ainda é capaz de reduzir parcialmente as manchas extrínsecas das restaurações de resina composta, como demonstrado em alguns estudos laboratoriais (Samra et al., 2012).

O repolimento também é capaz de possibilitar a remoção do manchamento a níveis clinicamente aceitáveis, sendo uma alternativa viável para prevenir a substituição precoce das restaurações (Mundim et al., 2010; Leite et al., 2014). Porém, existem casos em que as moléculas de pigmentos podem estar presentes na resina de forma mais profunda, devido à oxidação dos componentes da resina ou pela penetração dos agentes extrínsecos (Turkun & Turkun, 2004). Dessa forma, a efetividade dos tratamentos de superfície em restabelecer a cor das restaurações é dependente da profundidade de inserção do pigmento (Anfe et al., 2011).

Sendo assim, de acordo com a literatura, não é possível concluir qual o protocolo ideal para o acabamento e polimento de restaurações com resina composta devido à grande variabilidade de materiais disponíveis no mercado. Outrossim, em relação aos tratamentos de superfície, os resultados encontrados são conflitantes no que diz respeito à efetividade da remoção do manchamento e qual método deve ser utilizado como primeira escolha.

Diante desse contexto, os objetivos deste estudo in vitro foram avaliar (1) a influência de diferentes sistemas de polimento na estabilidade de cor e rugosidade da superfície da resina composta e (2) a capacidade de diferentes tratamentos de superfície em reduzir as alterações de cor sem afetar a rugosidade da superfície após a coloração. Por fim, as hipóteses nulas deste estudo foram: (1) o sistema de polimento não influencia na estabilidade de cor e rugosidade da superfície da resina composta após o manchamento; e (2) os procedimentos de tratamento de superfície não são capazes de reduzir a alteração de cor sem afetar a rugosidade da superfície da resina composta envelhecida pelo procedimento de manchamento com café.

Capítulo Único

Influence of Polishing Systems and Surface Treatments on Color Stability and Surface Roughness of Composite Resin

Influence of polishing systems and surface treatments on composite resin

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Clinical Relevance

Different polishing systems result in a difference in the color stability and surface roughness of the composite resin, changing the discoloration in the composite resins. Repolishing is a viable option to reduce the stain on the composite resin and avoid replacing the restoration.

SUMMARY

Objectives: To evaluate (1) the influence of differents polishing systems on the stability color and surface roughness of composite resin and (2) the ability of different surface treatments to reduce the color changes without affect the surface roughness after the staining.

Methods and materials: A total of one hundred and sixty disc-shaped specimens (8 x 2 mm) were prepared using a submicrometric composite resin. The specimens were divided according to polishing systems: Negative control (NC), 3M system (3S), DhPro system (DS) and FGM system (FS). After this, the specimens were immersed in coffee for 48 hours. A new subdivision was performed according to surface treatment (n=10): ozonated gel (OG), hydrogen peroxide (HP), bicarbonate jet (BJ) and repolishing (R).Color change (ΔE_{00}), whitening index (WI), opacity and surface roughness (Ra) were assessed at after polishing, after staining in coffee and after surface treatment. Data from ΔE_{00}, WI and opacity did not present normal distribution and were submitted to Kruskal-Wallis. Multiple comparisons were performed by Tukey`s test. Two-way repeated measures ANOVA was used to analyze data from surface roughness at different assessment times. All pairwise multiple comparison procedures were conducted using the Tukey test. (α=0.05 significance level).

Results: The higher staining presented on NC and DS. 3S and FS obtained similar results for color change, which means greater color stability. Surface treatments significantly reduced color changes and affected the surface roughness ($p<0.001$). Repolishing generated the greatest color change ($p<0.001$) in NC and DS groups.

Conclusion: It was possible to conclude that the 3M polishing system obtained a higher color stability and lower surface roughness. Repolishing generates the highest color change values and is a viable option to avoid replacement the restoration.

INTRODUCTION

One of the common problems related of recent times is the dissastisfaction with the smile aesthetics.[1] A survey found that approximately 52.8% of the general population is dissastisfied with their smile.[2] Thus, there is a increasing the search for whitening and restorative treatments.[1,3] These techniques generally help to improve the overall harmonious appearance of teeth.[4] Satisfaction with the smile generates a positive psychosocial impact, increasing self-esteem, transmitting self-confidence and well-being.[5] Composite resins show common failures with the natural aging process inherent in the oral cavity.[6,7] These failures are associated to esthetics reasons[7] mainly by loss of anatomical shape and color matching and superficial staining, being a challeging clinical situation.[3]

In the oral cavity, composite resin restorations are exposed to chemical challenges, which causes degradation of the materials.[8] In addition, the restorations are subject to intrinsic and extrinsic factors of color changes.[9] The intrinsic factors including chemical changes, oxidation of unpolymerized monomer and the choice of material, the properties of the matrix, and the interface between the matrix and the fillers.[10] The extrinsic factors are related to plaque accumulation, adsorption and absorption of food and beverage pigments.[11] In this context, coffee is one of the most commonly drink consumed by people worldwide. It is known its acid pH and high staining capacity.[8]

Polishing procedures reduce the irregularities, generating a smooth and polished surface,[12] which will provide a postponement of aging, staining and loss of lightness.[13] Polishing systems are available with different number of steps, shapes, compositions, types and hardness of abrasive particles.[10] These presentations and the way they are used will influence on the quality of polishing.[14] A better execution of this stage lead to a satisfactory longevity of composite restorations.[9,15]

Over the years restorations undergo a natural aging and staining process, so the replacement or repair of restorations became recommended.[16,17] As a conservative way to solution this problem, some alternatives can be used as an attempt to soften the staining,[17] as repolishing and whitening procedures.[18] Ozone (trioxygen) therapy has been growing in both medical and dentistry, achieving satisfactory results for tooth whitening and is comparable to hydrogen peroxide.[19-21] For this reason, numerous investigations have been conducted to evaluate the effect of these procedures to remove extrinsic staining in composites.[22] This approach intend to make compensatory changes in the final restoration planning for a successful esthetic outcome and conservative.[17]

The purposes of this *in vitro* study were to evaluate (1) the influence of differents polishing systems on the color stability and surface roughness of composite resin and (2) the ability of different surface treatments to reduce the color changes without affect the surface roughness after the staining. The null hypotheses of this study were that (1) the polishing systems does not influence on the color stability and surface roughness of composite resin after the stainig, (2) the surface treatments procedures does not able to reduce the color changes without affect the surface roughness of composite resin aged by staining procedure with coffee.

METHODS AND MATERIALS

The characteristics of the materials and the polishing systems used in this study are listed in Tables 1 and 2.

Specimen Preparation

One hundred and sixty specimens were fabricated using composite resin classified as submicrometric according to the manufacturer (Vittra APS, FGM Produtos Odontológicos, Joinville, Santa Catarina, Brazil), shade A1 for enamel. A polytetrafluoroethylene mold (8 mm diameter x 2 mm thickness) was used to prepare the specimen. The composite was inserted in a single increment into the mold, with a spatula. After the insertion of the increment, the teflon matrix was pressed against the glass plate and rectilinear movement was performed in order to obtain smoothness of the specimen. Thus, the finalization was performed using a flat brush nº 4B (Kota, Cotia, São Paulo, Brazil). The specimens were photoactivated for 20 seconds using the light unit with LED (Valo, Ultradent, South Jordan, Utah, USA) in standard power mode of approximately 1000 mW/cm^2 of irradiant intensity. The specimens were stored in deionized water at 37.7 °C for 24 hours. For standardization of the thickness and roughness, the specimens were ground flat with a 320-grit sandpaper (3M, Sumaré, São Paulo, Brazil) for 15 seconds with water. Then, the specimens were ultrassonically cleaned (Thornton, Vinhedo, São Paulo, Brazil) with deionized water for 10 minutes. Specimens were lightly marked on their lateral surface. These markings were used to obtain a standardized position in the spectrophotometer and the roughness tester. Forty specimens were randomly allocated into one of following experimental groups of polishing protocols (n=10).

Polishing and staining procedure

The specimens were again inserted to the cylindrical mold for support to do the polishing and also to be always polished in the same direction. In this study, a single calibrated operator used a low-speed motor (Kavo Dental, Joinville, Santa Catarina, Brazil) associated to a contra angle hand piece at 10.000 rpm (median motor speed) (Kavo Dental, Joinville, Santa Catarina, Brazil).

The procedures were performed following one of the manufacturer's instructions that indicate 20 seconds (3M ESPE) as an optimal time to work, thereby being standardized for the others that did not report this time. The procedure was performed according to the description for each polishing system:

- NC (negative control): no polishing procedure;
- DS (DhPro system): coarse, medium and fine aluminum oxide impregnated silicone rubbers were applied on the specimens for 20 seconds each. Then, the high gloss rubbers followed by goat hair brush and then cotton brush were applied, 20 seconds each.
- 3S (3M system): medium grit disc was used as the first step for 20 seconds. A rubberized pre-polishing disc (beige spiral) was used for 20 seconds and then a diamond disk for polishing (lilac spiral) for polishing was applied for 20 seconds using water in each step, used in anti-clockwise.
- FS (FGM system): medium, fine, and superfine sandpaper discs (Diamond Pro, FGM Produtos Odontológicos, Joinville, Santa Catarina, Brazil) were applied consecutively for 20 seconds each. Then, diamond Ac I finishing and II pre-polishing pastes (Diamond paste Ac I & II, FGM Produtos Odontológicos, Joinville, Santa Catarina, Brazil) and another one paste R (Diamond R, FGM Produtos Odontológicos, Joinville, Santa Catarina, Brazil) was applied with felt

disk (Diamond Flex, FGM, Produtos Odontológicos, Joinville, Santa Catarina, Brazil) for 20 seconds.

Inicially, a digital caliper (Absolute, Mitutoyo, Tokyo, Japan) was used to measure the specimen thickness. Variations by more than 0.1 mm were discarded. The specimens were thoroughly cleaned with air-water for 20 seconds between each application step. In the end of the polishing system procedure, the specimens were ultrassonically cleaned (Thornton, Vinhedo, São Paulo, Brazil) with deionized water for 10 minutes.

After polishing, the unpolished surfaces of all specimens were sealed using a transparent nail polish (Risqué, Coty Brazil, Goiânia, Goiás, Brazil) during the staining procedure. Each specimen was stored in 1.5 mL of a coffee solution (Nescafe Original, Nestle, São Paulo, São Paulo, Brazil) at 37.7 °C for 48 hours.[23] The solution was standardized by dissolving 2.0g of power in 50 mL of boiling deionized water. After the first 24 hours, the coffee solution was replaced. After 48 hours of storage in an incubator (Solab, Piracicaba, São Paulo, Brazil), the specimens were rinsed with deionized water using ultrasound (Thornton, Vinhedo, São Paulo, Brazil) for 10 minutes and dried with absorbent paper.

Surface Treatments after staining procedure

The specimens were randomly distributed into four groups according to surface treatment. The procedures were performed as follows:

- Ozonated gel (OG): the ozone gas was generated by O&L 3.0 RM (Ozone&Life, São José dos Campos, São Paulo, Brazil) with a concentration of 60 µg/ ml at 1 ml^3/second and then incorporated into the neutral water soluble gel (KY, Semina Indústria e comércio Ltda, São Paulo, São Paulo, Brazil) for 40 minutes. The ozonated gel was applied by using a syringe so that it covered its entire surface, for 40 minutes.
- Hydrogen peroxide (HP): 35% hydrogen peroxide whitening agent (Whiteness HP AutoMixx, FGM, Joinville, Santa Catarina, Brazil) was placed over the specimens for 50 minutes without any replacement, following the manufacturer's recommendations.

- Bicarbonate jet (BJ): the sodium bicarbonate jet (Jet Sonic, Gnatus, Barretos, São Paulo, Brazil) was applied at a position of 5.0 mm from the surface and with the nozzle orifice positioned at 90º during 20 seconds for each specimen.[24]
- Repolishing (R): All steps polishing with the group 3S were performed as described previously for repolishing group.

The specimens were thoroughly washed with air-water for 20 seconds between each application step. After complete surface treatment, the specimens were ultrasonic cleaner with deionized water for 10 minutes to remove debris and dried with absorbent paper.

Color Evaluation

The color and opacity of the specimens were measured with a spectrophotometer (Ci6X, X-Rite, Pantone, Grand Rapids, Michigan, USA), in reflectance mode, using CIE L*a*b* system (L*: white/black; a*: red/green; b*: yellow/blue). Specimens were positioned in focus and the measurements were performed with a D65 illuminant, a 10° observer angle. Measurements were repeated three times for each specimen, and the average value was calculated automatically by the spectrophotometer. The color parameters were measured over a neutral gray background ($L^*_{gray} = 45.77$, $a^*_{gray} = 1.23$, $b^*_{gray} = 1$) while the opacity was assessed by the difference in the color measurement against white and black backgrounds ($L^*_{black} = 0.2$, $a^*_{black} = 0.3$, $b^*_{black} = 0.2$). Color changes (ΔE_{00}) for all phases were calculated using the CIEDE2000 formula:

$$\Delta E_{00} = [(\Delta L'/ K_L S_L)^2 + (\Delta C'/ K_C S_C)^2 + (\Delta H'/ K_H S_H)^2 + R_T (\Delta C'/ K_C S_C) (\Delta H'/ K_H S_H)]^{½}$$

where ΔL', ΔC', and ΔH' are the diferences between color measures in lightness, chroma, and hue, respectively. R_T is the function (the so-called rotation function) that accounts for the interaction between chroma and hue differences in the blue region. Weighting functions S_L, S_C, and S_H adjust the total color difference considering the location variation of L*, a* and b*coordinates. The parametric factors K_L, K_C, and K_H are correction terms for deviation from reference experimental conditions.

The whitening indexes (WI) of specimens was calculated using the following formula: WI = 0.551*L - 2.324*a - 1.1*b.[25]

Surface Roughness Evaluation

Quantitative measurements of surface roughness were performed with a previously calibrated roughness tester (Mitutoyo Surftest 301J, Mitutoyo, Tokyo, Japan), with a 0.25 mm cut-off value and 0.8 mm tracing length. Three measurements in different directions and locations to the polishing were recorded. The average surface roughness (Ra) was determined for each specimen for statistical purposes.

Statistical analysis

Color change (ΔE_{00}), whitening index (WI), opacity and surface roughness (Ra) data were analyzed by the statistical software SigmaPlot, version 12.5 (Systat Software Inc, San Jose, California, USA). The data were tested for normality (Shapiro-Wilk test) and homoscedasticity (Levene test). Data from ΔE_{00}, WI and opacity did not present normal distribution and were submitted to Kruskal-Wallis. Multiple comparisons were performed by Tukey`s test. Two-way repeated measures ANOVA was used to analyze data from surface roughness at different assessment times. All pairwise multiple comparison procedures were conducted using the Tukey test. The significance level was pre-set at 95% for all analyzes.

RESULTS

Polishing protocol and staining

Results of ΔE_{00} are described in Figure 2. Higher color change values after staining procedure were observed for NC and DS group, with no difference statistical between them. 3S and FS obtained similar results for color change, which means greater color stability.

Whitening index (WI) and opacity values after the polishing and staining procedures are described in Table 3. After staining the lowest WI values were found for the NC and SD groups ($p<0.001$), with no difference statistical between them. A small reduction in opacity was observed in the NC group ($p<0.001$).

Surface roughness (Ra) results evaluated on polished and stained specimens are described in Table 4. The highest values of Ra were obtained in the NC group. The lowest values of Ra were obtained in the S3 group ($p<0.001$), which it justifies the choice of this polishing system for the repolishing group. The staining in coffee affects the surface roughness of the specimen by increasing the Ra values ($p<0.001$).

Surface treatment after staining

Color change (ΔE_{00}) values for surface treatment are described in Table 5. The highest values of color change using hydrogen peroxide were found in the NC ($p<0.001$). The lowest values for repolishing were found in the FGM system, however in the NC, DS and 3S groups, R generated the greatest color change ($p<0.001$).

The results of the whitening indexes calculation are presented in Table 6. The highest WI values using hydrogen peroxide were found in the NC and the lowest in the SF ($p<0.001$). With bicarbonate jet the highest values were found for the SD group ($p<0.001$). Repolishing generated higher levels of whiteness in the NC and SD groups ($p<0.001$).

Opacity values for surface treatment are described in Table 7. Opacity variations were not statistically influenced by polishing systems for ozonated gel and bicarbonate jet ($p=0.402$ and $p=0.568$, respectively). In the S3 group there was an increase in opacity using repolishing.

Surface roughness (Ra) results by post-stained treatments are shown in Table 8. There was a reduction in the Ra values using repolishing in the NC ($p>0.001$). For the SF polishing system, the roughness was similar between all surface treatments. For HP and BJ, the values of Ra were similar between the polishing systems ($p=0.009$).

DISCUSSION

The staining of composite resins varies according to the type and composition of resins used, since particles characteristics and the resin matrix may related to roughness and predisposition to staining.[9,26] In the present study a submicrometric composite resin was evaluated, with free in its composition of the bisphenol A (BPA), featuring the triethylene glycol dimethacrylate (TEGDMA) and diurethane dimethacrylate (UDMA) monomers. TEGDMA is a more hydrophilic monomer compared to Bis-GMA and

UDMA.[27] The presence of TEGDMA may be directly related to higher absorption of fluids and pigments, thereby increasing the staining.[27,28] Different levels of color and surface roughness changes were obtained with differents polishing systems after the staining and the surface treatments reduced the color changes and affected the surface roughness of composite resin aged by staining procedure with coffee, increasing the values of Ra, rejecting the two null hypothesis.

Coffee was the beverage of choice of this study because of its high staining capacity. Some studies have reported that coffee cause the higher color changes in composite resins among others beverages tested.[29-31] The drink used directly influences the change in color and roughness.[32] The absorption and adsorption in the organic matrix of composite resins may be responsible for the penetration of the yellow pigments present in the coffee compatible with the polymer phase, resulting in a severe staining.[33] Acidic drinks and colorants promotes degradation and optical changes that negatively interfere on esthetics of restoration.[8]

Polishing procedures enhance esthetics and improve the color stability of composite resins by delaying staining, and prevent biofilm accumulation, gingival irritation and secondary caries.[10] The results are attributed not only for the quality of the polishers, but also for the relationship between polishing system and composite resin. Polishing systems do not behave the same for all types of composite resin.[14] Some variables can affect the final result of finishing and polishing (F/P) such as speed, pressure and time, as well as operator experience.[34] To reduce bias in this study, there was operator standardization, always remaining the same, previously calibrated, time and randomized specimens. In addition of esthetic improvements as gloss, texturing and smoothness in restorative procedures, F/P also provide comfort to patients.[35] Rough restorations bring discomfort due to the tactile perception of the tongue.[36] The value of Ra stipulated in the literature as appropriate is 0.2µm.[34,37] The closest polishing system to the ideal value in this study was S3 (±0.24).

The color changes were evaluated based on the CIEDE2000 formula that approximated the evaluation of the device with the differences perceived by the human eye.[38] This evalution was done by a spectrophotometer, being indicated to calculate color change of dental materials,[39] with no subjectivity in the analysis. As a complement to the color analysis, opacity and whiteness index formula (WI) was used in this study. The WI values it is possible to quantify the whitening level. Higher values of the WI, higher the specimens whiteness and the lower values presenting lower the whiteness.[25]

Higher color change values were found for the group SD, being comparable to the group NC. For a satisfactory result, the F/P should be performed following the decreasing order of steps, starting of the highest particle size to lowest.[41] There are no studies in the literature with this specific DS polishing system yet. Possible explanations for the results may be related to differences in the hardness of the rubbers. It is important to point out though, with the higher hardness of the rubbers of this system, greater surface wear was generated during the standardized time,[34] being necessary that the manufacturer inform the time to be used to obtain the most satisfactory polishing with your system. For alterations founded in NC, the justifications could be about the presence of deep scratching of the surface caused by sandpaper. Spaces between scratches and micro-cracks generated accumulates larger amounts of pigments, making the specimen more susceptible to severe staining.[42] The polishing systems S3 and SF obtained greater color stability, with S3 having the lowest roughness value. However, it is important to note that an additional study is of paramount importance to assess whether these differences in roughness favor bacterial adhesion and biofilm formation.

More importantly, since the material's inherent ability to stain exists, ways to relieve staining within minimally invasive dentistry, the surface treatments become a possibility. Thus, significant effects in reduction of color change after surface treatments on composite resin stained by coffee, were observed in this study. The effect of whitening agents on restorative materials were able to reduce color changes caused by staining in some studies.[17,43]

Two whitening agents were evaluated in this study, ozonated gel and 35% hydrogen peroxide. The ozonated gel mode of action is unclear in the literature. It is supposed that the ozonated gel form high reactive molecules due to the decomposition of O_3, which results in the peroxide (HO_2-) and hydroxyl (OH-). It is enabled to promove the whitening as well it happens in dental tooth.[44,45] The ozonated gel reduced color near the baseline in a previous study *in vitro*,[44] confirming the efficacy of ozonated gel as a whitening agent of composite resin. In the present study there was change color, obtaining less or similar effectiveness when compared to other surface treatments. In addition to the low results presented by this technique, it requires equipment and specific techniques, which makes it difficult for some dentists to use it.

The whitening effect with hydrogen peroxide varies according to the type of composite resin, whitening agent, frequency and exposure time.[46] In the present study, hydrogen peroxide was used within the maximum time suggested by the manufacturer for dental whitening. Free radicals formed from the hydrogen peroxide reaction affect the surface composite resin, with the filler-resin matrix interface debonding.[47] The whitening effect can be attributed to surface amine oxidation and reflectance changes.[48] The use of peroxide caused the largest values changes on WI and ΔE_{00}, in the negative control group.

Prophylaxis using sodium bicarbonate jet is an efficient technique capable of removing extrinsic pigmentation in dental enamel.[49] Few studies are found in the literature evaluating color and roughness changes after prophylaxis with bicarbonate jet in composite resins. Bicarbonate jet can reduce partially staining in composite resins.[24] In this study, BJ was more effective in the polished specimens with DhPro system.

Repolishing can reduce staining but not enough to completely remove, through reduction only to clinically acceptable levels.[51] The repolishing was determined from previous variable statistics in this study. The system with the best performance was the 3M system. Surface stains caused by coffee require a 20 µm wear to be removed.[52] Staining removal is dependent depth and may result in residual staining. It was also able to decrease the opacity of the DS, 3S and FS groups. Repolishing was more favorable for color changes int the groups with greater NC and DS staining, justified by the Ra values and also for being a procedure that generates greater depth of wear. However, the overuse may lead to excessive wear, being in these cases required further repair of the restorations can be recommended. The groups that showed greater color stability, therefore less staining, behaved similarly among all surface treatments. Differents surface treatments do not behave similarly for different polishing systems.

In the present study, surface treatments were able to reduce staining, but were not able to restore after polishing (T1). The results should be interpreted with caution, as other factors involved in the aging of the restorative material were not performed, as brushing and termocycling. Besides that, the results obtained are limited only to the materials tested in this study. We believe it is of great importance that different brands and types of composite resin are tested. It is suggested that further studies be carried out by diversifying the materials to be evaluated and the association between the surface treatments. Including other methodologies in the study such as brushing, gloss and especially biofilm accumulation may be also relevant.

CONCLUSION

Within the limitations of this study, it was possible to conclude that the polishing system 3M obtained higher color stability and lower surface roughness. Repolishing generates the highest color change values and is a viable option to avoid replacement the restoration.

Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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Table 1: Materials Used in This Study

Composite Resin	Manufacturer	Type/Color	Composition	Batch Number
Vittra APS	FGM, Produtos Odontológico, Joinville, SC, Brazil	Nanofill/ A1 Enamel	Zirconium Oxide Glass (70-80%) Urethane Dimethacrylate (UDMA) (10-20%) TEGDMA (5-15%) Silane Treated Silica (<10%) Ethyl 4-dimethylaminobenzo (<1%) Camphorquinone (<1%)	240519
Products Surface Treatment	**Manufacturer**		**Composition**	
K-Y	Semina Indústria e comércio Ltda, São Paulo, São Paulo, Brazil		Water, Glycerin, Propylene glycol, Hydroxyethylcellulose, Monobasic sodium phosphate, Methylparaben, Dibasic sodium phosphate and Propylparaben	06019
Whiteness HP AutoMixx	FGM, Produtos Odontológico, Joinville, Santa Catarina, Brazil		35% hydrogen peroxide*	090719
Polident	Polidental, Cotia, São Paulo, Brazil		Pure Sodium Bicarbonate (99.6%), Anhydrous, Silica, Essence	59769

The asterisk (*) indicates that it was not informed by the manufacturer.

Table 2: Composition and Application Time of Polishing Systems Used in this Study

Polishing System	N° of Application Steps	Type	Manufacturer	Material	Application Time, s	Batch Number
SD	6	Three rubbers	DH Pro Tecnologia Profissional, Paranaguá, Paraná, Brazil	Aluminum oxide	20 for each step	1238/653
		High gloss silicone tip		Silicon carbide	20	1238/659
		Goat hair brush		Goat hair	20	1280/492
		Cotton brush		Shredded cotton	20	1270/890
SM	3	Medium rubber polishing disc	3M, St Paul, Minnesota, USA	Aluminum oxide	20	1828300721
		Pre-polishing Rubberized Spiral Disc		Aluminum oxide	20	1820700509
		Diamond disk for polishing		Diamond particles	20	1820700509
SF	6	Three rubbers polishing discs	FGM, Produtos Odontológicos, Joinville, Santa Catarina, Brazil	*	20 for each step	230919/071019/220419
		Diamond Ac I & II (finishing and pre-polishing pastes)		Aluminum oxide	20 for each paste	011118
		Diamond paste R		Aluminum oxide	20	080719
		Diamond Flex		Felt discs	-	120819

The asterisk (*) indicates that it was not informed by the manufacturer. NC: Negative control; DS: DhPro system; 3S: 3M system; FS: FGM system.

Table 3: Medians (1st and 3rd quartiles) of Whitening Index and Opacity Measured After the Polishing and Staining Procedures. Difference Indicates the Effect on Whitening Index and Opacity Caused by Staining Procedures (n = 40).

Polishing System	Whitening index			Opacity (%)		
	Polished	**Stained**	**Difference**	**Polished**	**Stained**	**Difference**
NC	28.9 (28.4/ 29.6) B	23.8 (23.0/ 24.4) B	-5.4 (-6.0/ -4.7) B	81.4 (79.9/ 82.7) A	79.7 (78.9/ 81.4) B	-1.4 (-2.5/ -0.3) B
DS	29.4 (29.1/ 30.7) A	24.4 (23.2/ 25.4) B	-5.1 (-6.9/ -4.2) B	78.8 (78.0/ 80.0) B	82.5 (81.7/ 83.3) A	3.3 (2.5/ 4.7) A
3S	28.6 (28.2/ 29.0) B	25.6 (25.1/ 26.2) A	-3.0 (-3.4/ -2.7) A	79.1 (78.2/ 79.5) B	81.6 (80.7/ 82.5) A	2.7 (1.8/ 3.6) A
FS	29.4 (28.8/ 30.1) A	26.4 (25.8/ 26.7) A	-3.1 (-4.0/ -2.4) A	77.8 (75.8/ 78.9) B	80.4 (79.1/ 81.8) B	2.9 (1.8/ 3.6) A
p-value*	< .001	< .001	< .001	< .001	< 0.001	< .001

* Calculated by Kruskal-Wallis. Distinct letters indicate statistical difference among the polishing systems at Tukey`s test ($p<.05$). NC: Negative control; DS: DhPro system; 3S: 3M system; FS: FGM system.

Table 4: Means (Standard Deviation) for Values of Ra Measured on Polished and Stained Specimens as Function of Polishing System (n=10).

Polishing System	**Assessment Time**		**Pooled Averages**
	Polished	**Stained**	
NC	0.49 (0.10)	0.51 (0.15)	0.50 (0.12) A
DS	0.31 (0.05)	0.33 (0.12)	0.32 (0.09) B
3S	0.24 (0.09)	0.27 (0.07)	0.25 (0.08) C
FS	0.30 (0.05)	0.30 (0.07)	0.30 (0.06) B
Pooled averages	0.33 (0.12) A	0.35 (0.14) B	

For pooled averages, distinct letters indicate statistical difference at Tukey`s test (p<.05). NC: Negative control; DS: DhPro system; 3S: 3M system; FS: FGM system.

Table 5: Medians ($1^{st}/ 3^{rd}$ quartiles) of Overall Color Changes (ΔE_{00}) Calculated by Differences Between the Values Measured After the Post-Stained Treatments and Those of Stained Specimens (n =10).

Polishing System	Post-Stained Treatment				p-value*
	OZ	HP	BJ	R	
NC	0.91 (0.80/ 1.43) ^{Ab}	1.77 (1.40/ 1.85) ^{Aa}	0.59 (0.50/ 0.75) ^{ABb}	1.84 (1.72/ 1.94) ^{ABa}	< .001
DS	0.64 (0.55/ 0.86) ^{ABb}	0.69 (0.65/ 1.05) ^{Bb}	1.06 (0.89/ 1.28) ^{Aab}	2.32 (1.72/ 2.78) ^{Aa}	< .001
3S	0.60 (0.51/ 0.73) ^{ABb}	0.66 (0.57/ 0.84) ^{Bb}	0.49 (0.43/ 0.52) ^{Bb}	1.45 (1.22/ 1.46) ^{Ba}	< .001
FS	0.52 (0.41/ 0.61) ^{Ba}	0.56 (0.48/ 0.79) ^{Ba}	0.20 (0.16/ 0.24) ^{Cb}	0.59 (0.53/ 0.69) ^{Ca}	< .001
p-value*	.001	< .001	< .001	< .001	

* Calculated by Kruskal-Wallis. Distinct letters (uppercase comparing the polishing systems; lowercase comparing the post-stained treatments) indicate statistical difference at Tukey`s test ($p<.05$). NC: Negative control; DS: DhPro system; 3S: 3M system; FS: FGM system; OG: ozonated gel; HP: hydrogen peroxide; BJ: bicarbonated gel; R: repolishing.

Table 6. Medians (1st/ 3rd quartiles) of Changes in Whitening Index Calculated by Subtracting the Values Measured After the Post-Stained Treatments from Those of Stained Specimens (n =10).

Polishing System	Post-Stained Treatment				p-value*
	OZ	HP	BJ	R	
NC	0.91 (0.86/ 1.05) ABb	3.35 (2.32/ 3.52) Aa	0.71 (0.50/ 1.16) Bb	2.36 (1.51/ 2.54) Aa	< .001
DS	0.62 (0.30/ 1.02) ABb	1.39 (1.20/ 2.35) Bab	2.13 (1.55/ 2.64) Aa	2.26 (1.83/ 4.20) Aa	.005
3S	1.05 (0.76/ 1.17) Aa	1.15 (0.97/ 1.37) BCa	0.62 (0.49/ 0.68) Ba	0.73 (0.53/ 1.13) Ba	.075
FS	0.38 (0.10/ 0.61) Ba	0.58 (0.30/ 0.86) Ca	0.27 (0.11/ 0.35) Ba	0.16 (0.06/ 0.50) Ba	.406
p-value*	.030	< .001	< .001	< .001	

* Calculated by Kruskal-Wallis. Distinct letters (uppercase comparing the polishing systems; lowercase comparing the post-stained treatments) indicate statistical difference at Tukey`s test (p < .05). NC: Negative control; DS: DhPro system; 3S: 3M system; FS: FGM system; OG: ozonated gel; HP: hydrogen peroxide; BJ: bicarbonated gel; R: repolishing.

Table 7: Medians ($1^{st}/ 3^{rd}$ quartiles) of Changes in Opacity (%) Calculated by Subtracting the Values Measured After the Post-Stained Treatments from Those of Stained Specimens (n =10).

Polishing System	Post-Stained Treatment				p-value*
	OZ	HP	BJ	R	
NC	0.59 (-0.73/ 1.27) ^{Aa}	0.16 (-0.22/ 0.56) ^{Aa}	0.20 (-0.55/ 0.50) ^{Aa}	0.05 (-2.86/ 0.69) ^{Ba}	.644
DS	0.92 (0.25/ 1.38) ^{Aab}	-0.73 (-0.87/ -0.59) ^{Bbc}	-0.44 (-0.68/ 0.13) ^{Ac}	1.35 (0.74/ 1.82) ^{Aa}	< .001
3S	-0.20 (-0.64/ 0.24) ^{Ab}	-0.17 (-1.50/ 0.24) ^{ABb}	-0.42 (-1.71/ 0.34) ^{Ab}	1.53 (0.82/ 1.85) ^{Aa}	.027
FS	0.62 (-0.06/ 1.36) ^{Aab}	-0.39 (-0.72/ 0.16) ^{ABb}	-0.45 (-0.66/ -0.11) ^{Ab}	1.12 (0.66/ 2.01) ^{ABa}	.006
p-value*	.402	.024	.568	.013	

* Calculated by Kruskal-Wallis. Distinct letters (uppercase comparing the polishing systems; lowercase comparing the post-stained treatments) indicate statistical difference at Tukey`s test ($p < .05$). NC: Negative control; DS: DhPro system; 3S: 3M system; FS: FGM system; OG: ozonated gel; HP: hydrogen peroxide; BJ: bicarbonated gel; R: repolishing.

Table 8: Means (Standard Deviation) of Changes in Ra Values Caused by Post-Stained Treatments According With the Polishing Systems (n = 10).

Polishing Systems	**Post-Stained Treatments**			
	OZ	**HP**	**BJ**	**R**
NC	0.12 (0.09) Aab	0.07 (0.10) Aa	0.09 (0.09) Aa	-0.37 (0.20) Bb
DS	0.03 (0.17) ABb	0.01 (0.11) Ba	0.05 (0.07) ABa	0.19 (0.26) Aa
3S	0.23 (0.20) Aa	0.05 (0.14) Ba	0.10 (0.20) ABa	0.07 (0.12) ABa
FS	0.04 (0.07) Ab	0.07 (0.09) Aa	-0.02 (0.15) Aa	0.07 (0.19) Aa

Distinct letter (uppercase comparing the post-stained treatments; lowercase comparing the polishing systems) indicate statistical difference at Tukey`s test ($p < .05$). OG: ozonated gel; HP: hydrogen peroxide; BJ: bicarbonated gel; R: repolishing.

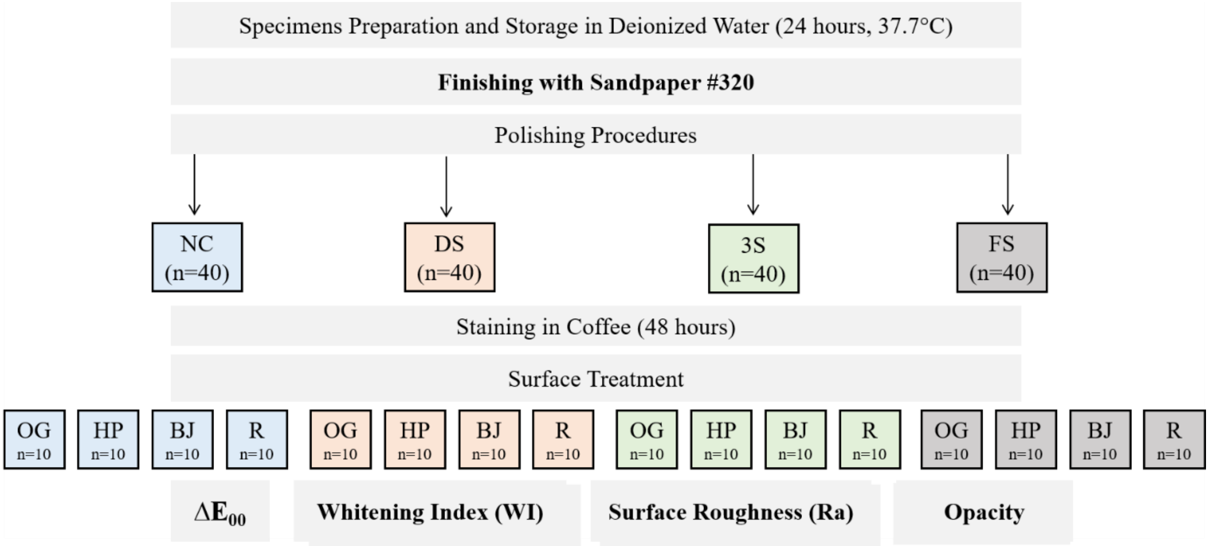

Figure 1. Flow chart of the study design. (NC): Negative control; (DS): DhPro system; (3S): 3M system; (FS): FGM system. (OG): Ozonated gel; (HP): Hydrogen peroxide; (BJ): Bicarbonate jet; (R): Repolishing.

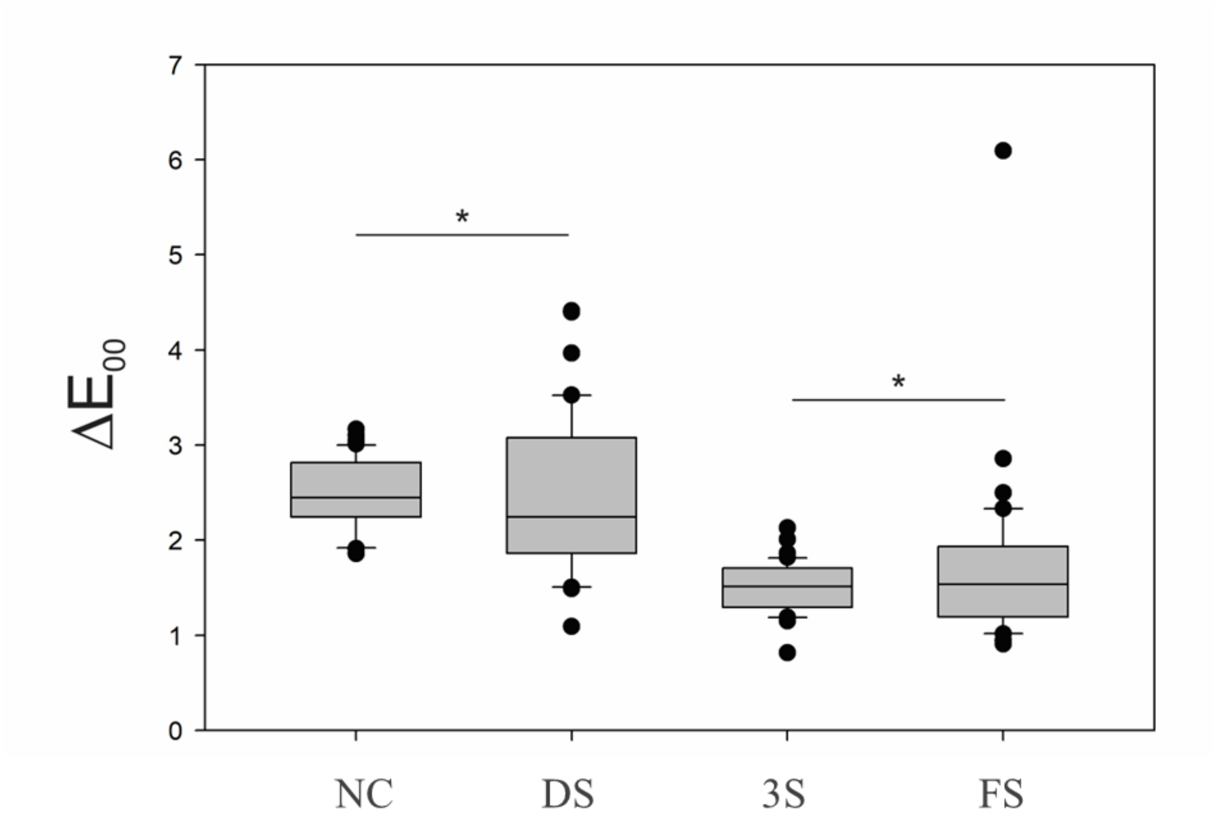

Figure 2. Boxplot presenting the overall color changes caused by the staining procedure as function of polishing system. * Indicate absence of statistical difference ($p > .05$). (NC): Negative control; (DS): DhPro system; (3S): 3M system; (FS): FGM system.

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Anexos

5. Normas para submissão ao periódico Operative Dentistry (Quallis A1)

INSTRUCTIONS TO AUTHORS

New Instructions as of 20 September 2008

Operative Dentistry requires electronic submission of all manuscripts. All submissions must be sent to Operative Dentistry using the Allen Track upload site. Your manuscript will only be considered officially submitted after it has been approved through our initial quality control check, and any problems have been fixed. You will have 6 days from when you start the process to submit and approve the manuscript. After the 6 day limit, if you have not finished the submission, your submission will be removed from the server. You are still able to submit the manuscript, but you must start from the beginning. Be prepared to submit the following manuscript files in your upload:

- A Laboratory or Clinical Research Manuscript file must include:
  - a title
  - a running (short) title
  - a clinical relevance statement
  - a concise summary (abstract)
  - introduction, methods & materials, results, discussion and conclusion
  - references (see Below)
  - The manuscript **MUST NOT** include any:
    - identifying information such as:
      - Authors
      - Acknowledgements
      - Correspondence information
    - Figures
    - Graphs
    - Tables
- An acknowledgement, disclaimer and/or recognition of support (if applicable) must in a separate file and uploaded as supplemental material.
- All figures, illustrations, graphs and tables must also be provided as individual files. These should be high resolution images, which are used by the editor in the actual typesetting of your manuscript. Please refer to the instructions below for acceptable formats.
- All other manuscript types use this template, with the appropriate changes as listed below.

Complete the online form which includes complete author information and select the files you would like to send to Operative Dentistry. Manuscripts that do not meet our formatting and data requirements listed below will be sent back to the corresponding author for correction.

GENERAL INFORMATION

- All materials submitted for publication must be submitted exclusively to Operative Dentistry.
- The editor reserves the right to make literary corrections.
- Currently, color will be provided at no cost to the author if the editor deems it essential to the manuscript. However, we reserve the right to convert to gray scale if color does not contribute significantly to the quality and/or information content of the paper.
- The author(s) retain(s) the right to formally withdraw the paper from consideration and/or publication if they disagree with editorial decisions.
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- Acknowledgement of receipt is sent automatically. If you do not receive such an acknowledgement, please contact us at editor@jopdent.org rather than resending your paper.
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REQUIREMENTS

- **FOR ALL MANUSCRIPTS**

    1. **CORRESPONDING AUTHOR** must provide a WORKING / VALID e-mail address which will be used for all communication with the journal.
    NOTE: Corresponding authors MUST update their profile if their e-mail or postal address changes. If we cannot contact authors within seven days, their manuscript will be removed from our publication queue.

    2. **AUTHOR INFORMATION** must include:
        - full name of all authors
        - complete mailing address for each author
        - degrees (e.g. DDS, DMD, PhD)
        - affiliation (e.g. Department of Dental Materials, School of Dentistry, University of Michigan)

    3. **MENTION OF COMMERCIAL PRODUCTS/EQUIPMENT** must include:
        - full name of product
        - full name of manufacturer
        - city, state and/or country of manufacturer

    4. **MANUSCRIPTS AND TABLES** must be provided as Word files. Please limit size of tables to no more than one US letter sized page. (8 ½ ” x 11”)

    5. **ILLUSTRATIONS, GRAPHS AND FIGURES** must be provided as TIFF or JPEG files with the following parameters
        - line art (and tables that are submitted as a graphic) must be sized at approximately 5” x 7” and have a resolution of 1200 dpi.

- gray scale/black & white figures must have a minimum size of 3.5” x 5”, and a maximum size of 5” x 7” and a minimum resolution of 300 dpi and a maximum of 400 dpi.
- color figures must have a minimum size of 2.5” x 3.5”, and a maximum size of 3.5” x 5” and a minimum resolution of 300 dpi and a maximum of 400 dpi.
- color photographs must be sized at approximately 3.5” x 5” and have a resolution of 300 dpi.

- **OTHER MANUSCRIPT TYPES**

1. **CLINICAL TECHNIQUE/CASE STUDY MANUSCRIPTS** must include:
   - a running (short) title
   - purpose
   - description of technique
   - list of materials used
   - potential problems
   - summary of advantages and disadvantages
   - references (see below)

2. **LITERATURE AND BOOK REVIEW MANUSCRIPTS** must include:
   - a running (short) title
   - a clinical relevance statement based on the conclusions of the review
   - conclusions based on the literature review…without this, the review is just an exercise
   - references (see below)

- **FOR REFERENCES**

REFERENCES must be numbered (superscripted numbers) consecutively as they appear in the text and, where applicable, they should appear after punctuation.

The reference list should be arranged in numeric sequence at the end of the manuscript and should include:

1. Author(s) last name(s) and initial (ALL AUTHORS must be listed) followed by the date of publication in parentheses.
2. Full article title.
3. Full journal name in italics (no abbreviations), volume and issue numbers and first and last page numbers complete (i.e. 163-168 NOT attenuated 163-68).
4. Abstracts should be avoided when possible but, if used, must include the above plus the abstract number and page number.
5. Book chapters must include chapter title, book title in italics, editors’ names (if appropriate), name of publisher and publishing address.
6. Websites may be used as references, but must include the date (day, month and year) accessed for the information.
7. Papers in the course of publication should only be entered in the references if they have been accepted for publication by a journal and then given in the standard manner with “In press” following the journal name.
8. **DO NOT** include unpublished data or personal communications in the reference list. Cite such references parenthetically in the text and include a date.

EXAMPLES OF REFERENCE STYLE

- Journal article: two authors
  Evans DB & Neme AM (1999) Shear bond strength of composite resin and amalgam adhesive systems to dentin *American Journal of Dentistry* **12(1)** 19-25.

- Journal article: multiple authors
  Eick JD, Gwinnett AJ, Pashley DH & Robinson SJ (1997) Current concepts on adhesion to dentin *Critical Review of Oral and Biological Medicine* **8(3)** 306-335.

- Journal article: special issue/supplement
  Van Meerbeek B, Vargas M, Inoue S, Yoshida Y, Peumans M, Lambrechts P & Vanherle G (2001) Adhesives and cements to promote preservation dentistry *Operative Dentistry* **(Supplement 6)** 119-144.

- Abstract:
  Yoshida Y, Van Meerbeek B, Okazaki M, Shintani H & Suzuki K (2003) Comparative study on adhesive performance of functional monomers *Journal of Dental Research* **82(Special Issue B)** Abstract #0051 p B-19.

- Corporate publication:
  ISO-Standards (1997) ISO 4287 Geometrical Product Specifications Surface texture: Profile method – Terms, definitions and surface texture parameters *Geneve: International Organization for Standardization* **1st edition** 1-25.

- Book: single author
  Mount GJ (1990) *An Atlas of Glass-ionomer Cements* Martin Duntz Ltd, London.

- Book: two authors
  Nakabayashi N & Pashley DH (1998) *Hybridization of Dental Hard Tissues* Quintessence Publishing, Tokyo.

- Book: chapter
  Hilton TJ (1996) Direct posterior composite restorations In: Schwarts RS, Summitt JB, Robbins JW (eds) *Fundamentals of Operative Dentistry* Quintessence, Chicago 207-228.

- Website: single author
  Carlson L (2003) Web site evolution; Retrieved online July 23, 2003 from: http://www.d.umn.edu/~lcarlson/cms/evolution.html

- Website: corporate publication
  National Association of Social Workers (2000) NASW Practice research survey 2000. NASW Practice Research Network, 1. 3. Retrieved online September 8, 2003 from: http://www.socialworkers.org/naswprn/default

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