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INFLUÊNCIA DO USO DE LÍQUIDOS MODELADORES NA ESTABILIDADE CROMÁTICA DE RESINAS COMPOSTAS

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Dissertação de mestrado apresentada ao Programa de Pós-Graduação em Ciências Odontológicas da Universidade Federal de Santa Maria (UFSM), como requisito parcial para a obtenção do título de **Mestre em Ciências Odontológicas com ênfase em Dentística**

Orientador: Prof. Dr. Alexandre Henrique Susin

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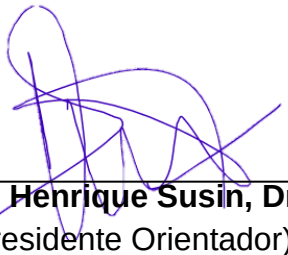

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RESUMO

INFLUÊNCIA DO USO DE LÍQUIDOS MODELADORES NA ESTABILIDADE CROMÁTICA DE RESINAS COMPOSTAS

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ORIENTADOR: Alexandre Henrique Susin

Resinas modeladoras e adesivos dentários são propostos como agentes facilitadores da manipulação de resinas compostas. No entanto, os possíveis efeitos sobre a estabilidade cromática das resinas compostas ainda representam uma lacuna a ser explorada, considerando sua ampla utilização clínica. O objetivo do presente estudo *In Vitro* é avaliar a estabilidade cromática e a influência de diferentes líquidos modeladores sobre quatro marcas comerciais de resinas compostas. Oitenta corpos de prova foram distribuídos a partir da combinação entre uma das resinas compostas: IPS Empress Direct; Charisma Diamond; Filtek Z350XT e Forma, modeladas com os líquidos modeladores: Wetting Resin, Modeling Resin, Adesivo Ambar APS ou um grupo controle (sem aplicação de modelador). Cada grupo contou com cinco espécimes. (n=5) e foram avaliados cromaticamente, com auxílio de um espectrofotômetro (SP60, X-Rite) nos períodos: T0 (imediato), T1 (30 dias), T2 (4 meses) e T3 (6 meses). Os corpos de prova foram envelhecidos em água deionizada em estufa com temperatura controlada. A partir da mensuração das coordenadas cromáticas L*, a* e b*, avaliou-se os resultados pela equação do sistema CIEDE2000. Os resultados foram submetidos a análise de variância (ANOVA) e teste de Bonferroni's *post-hoc*, considerando níveis de significância de 5% e interpretado quanto aos limiares de perceptibilidade, aceitabilidade e avaliação individual das coordenadas cromáticas. Não foram encontradas significâncias estatísticas na escolha do modelador ($p=0,31$) ou na tripla interação modelador/resina/tempo ($p=0,92$). Porém, a resina composta e os tempos de leitura foram estatisticamente significantes (ambos $p<0,00$). Notou-se um aumento para os valores de $\Delta E00$ quando (T0-T1) foi confrontado com (T0-T2). Em contrapartida, ao final de 180 dias (T0-T3), os espécimes parecem alcançar a estabilidade cromática, seja por sua redução ou equidade aos valores apresentados no período anteriores (T0-T2). De acordo com os parâmetros de interpretação, ao final de 180 dias, as resinas compostas IPS Empress e Z350XT apresentaram boas interações com os modeladores, a resina Forma apresenta o melhor comportamento com o modelador Ambar e a resina Charisma apresentou resultados aceitáveis quando modelada com o líquido Wetting. Os grupos controles de todas as resinas apresentaram valores para $\Delta E00$ superiores aos considerados aceitáveis pelo estudo. Valores referentes a $\Delta E00$ variaram de 0.50 (Z350 + Wetting T0-T1) até 3.26 (Charisma + Ambar T0-T3). A avaliação individual das coordenadas L*, a* e b* permite visualizar, de forma geral, uma redução na luminosidade dos corpos (escurecimento), bem como aumento da tonalidade azulada (redução de a*) e avermelhada (aumento de b*). O uso de líquidos modeladores apresenta influencia na estabilidade cromática das resinas, no entanto, as alterações de cor foram mais influenciadas pela escolha da resina composta. Assim, de acordo com os resultados e limitações do estudo, algumas resinas compostas apresentam resultados aceitáveis para estabilidade cromática, quando combinadas com líquidos modeladores.

Palavras-chave: Dentística Operatória. Materiais Dentários. Estética Dental. Restaurações Dentárias Permanentes. Cor.

ABSTRACT

INFLUENCE OF THE MODELING LIQUIDS ON COLOR STABILITY OF RESIN COMPOSITE

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ADVISOR: Alexandre Henrique Susin

Modeling resins and dental adhesives are proposed as agents that facilitate the manipulation of composite resins. However, the possible effects on the chromatic stability of composite resins still represent a gap to be explored, considering their wide clinical use. This *In Vitro* study aimed to evaluate the color stability and the influence of different modeling liquids on four commercial brands of composite resins. Eighty specimens were distributed based on the combination of one of the composite resins: IPS Empress Direct; Diamond Charisma; Filtek Z350XT and Forma, modeled with modeling liquids: Wetting Resin, Modeling Resin, Ambar APS Adhesive or a control group (without modeler application). Each group had five specimens. (n = 5) and were evaluated chromatically, with the aid of a spectrophotometer (SP60, X-Rite) in the periods: T0 (immediate), T1 (30 days), T2 (4 months) and T3 (6 months). The specimens were aged in deionized water at controlled temperature. From the measurement of chromatic coordinates L *, a * and b *, the results were evaluated using the CIEDE2000 system equation. The results were subjected to analysis of variance (ANOVA) and Bonferroni's post-hoc test, considering significance levels of 5% and interpreted in terms of perceptibility, acceptability and individual evaluation of chromatic coordinates. No statistical significance was found in the choice of the modeler ($p = 0.31$) or in the triple modeler / resin / time interaction ($p = 0.92$). However, the composite resin and the reading times were statistically significant (both $p < 0.00$). An increase to the values of $\Delta E00$ was noted when (T0-T1) was confronted with (T0-T2). In contrast, at the end of 180 days (T0-T3), the specimens seem to achieve chromatic stability, either due to their reduction or equity to the values due in the previous period (T0-T2). According to the interpretation parameters, at the end of 180 days, the IPS Empress and Z350XT composite resins have similar good interactions with the modelers, a Forma resin shows the best behavior with the Ambar modeler and the Charisma resin presents acceptable results when modeled with the model. Watering liquid. The control groups of all resins evaluate values for $\Delta E00$ higher than those considered acceptable by the study. Values refer to a variation ranging from 0.50 (Z350 + Humidification T0-T1) to 3.26 (Charisma + Ambar T0-T3). The individual evaluation of the coordinates L *, a * and b * allows to visualize, in general, a reduction in the luminosity of the bodies (darkening), as well as an increase in blue hue (reduction of a *) and red hue (increase of b *). The use of modeling liquids has an influence on the chromatic stability of the resins. However, the color changes were more influenced by the choice of composite resin. Thus, according to the results and limitations of the study, some composite resins present acceptable results for chromatic stability, when combined with modeling liquids.

Keywords: Operative Dentistry. Dental Materials. Dental Esthetic. Permanent Dental Restoration. Color.

SUMÁRIO

1-INTRODUÇÃO

A percepção e a aceitabilidade da forma, cor dos dentes e dos materiais restauradores são tópicos bastante estudados atualmente. Esse fato pode ser comprovado pela crescente valorização da odontologia estética (BARZYK; SMARDZ; WIECKIEWICZ, 2018; ISIEKWE et al., 2016). Dessa forma, é imprescindível que o cirurgião-dentista conheça as técnicas para confecção de restaurações e também as técnicas utilizadas para avaliação de cor, mimetização, texturização e, também a sua influência no sucesso dos procedimentos (CHU; TRUSHKOWSKY; PARAVINA, 2010; DELLA BONA et al., 2019; PARAVINA; PÉREZ; GHINEA, 2019).

Esses limiares correspondem à maneira como a percepção humana entende e processa informações capturadas pelo olho. Os limiares de variação de cor e luminosidade são denominados de aceitabilidade e perceptibilidade(PARAVINA; PÉREZ; GHINEA, 2019; SALAS et al., 2018; SRIPHADUNGPORN; CHAMNANNIDIADHA, 2017). O primeiro diz respeito ao limite onde a capacidade humana passa a diferenciar variações de uma mesma cor, indicando que a partir desse ponto, as diferenças são visíveis. Ao passo que o limiar de aceitabilidade corresponde ao grau de diferenciação, entre duas tonalidades semelhantes que não causam estranheza ao observador a ponto de identificar diferenças, ainda que leves(ARDU et al., 2011; GALLINARI et al., 2019; LOPES et al., 2019).

Resinas compostas são materiais bastante versáteis e apresentam indicações para uso em dentes anteriores e posteriores, baseado em suas boas propriedades estéticas e mecânicas (ARDU et al., 2017; MICHAUD; MACKENZIE, 2016). Este material pode ser utilizado de diversas formas em técnicas diretas ou indiretas, de acordo com a escolha do profissional e da necessidade que o caso apresente (DA VEIGA et al., 2016).

A dificuldade da execução do procedimento pode residir em diferentes etapas do processo restaurador. Seja na dificuldade da aplicação dos incrementos, que podem apresentar uma melhor aderência a espátula do que ao substrato adesivado, ou na própria manipulação das resinas, tendo em vista a complexas anatomias a serem reconstituídas.(CHANG; HONG, 2014; SEDREZ-PORTO et al., 2016, 2017).

Assim, surgem materiais e técnicas que visam facilitar o procedimento restaurador sistematizando o procedimento que permite ao cirurgião-dentista um bom

dimensionamento da forma anatômica que está reconstruindo, aumentando as chances de sucesso clínico. As técnicas restauradoras com resinas compostas se consagram como aliadas em restaurações amplas, que necessitem da utilização de materiais com propriedades ópticas semelhantes aos tecido dentinário e esmalte, sendo aplicadas por método de estratificação. (ALP et al., 2018; CHANG; HONG, 2014; DIETSCHI; FAHL, 2016; MIOTTI et al., 2017).

No que diz respeito a utilização de materiais e técnicas para qualificar o procedimento restaurador, no sentido da melhor manipulação dos compósitos, encontram-se diferentes abordagens na literatura, como a limpeza das espátulas com álcool ou acetona (DE PAULA et al., 2016; PERDIGÃO; GOMES, 2006; SNEED; DRAUGHN, 1980; TJAN; GLANCY, 1988) ou a incorporação de adesivos odontológicos entre os incrementos (ARAUJO et al., 2018; BARCELLOS et al., 2008; DE PAULA et al., 2016). (MÜNCHOW et al., 2016; SEDREZ-PORTO et al., 2016). Porém, ainda há pouca divulgação sobre a influência dessa técnica nas propriedades do conjunto composto pelo substrato dental e o material restaurador associado a algum tipo de agente (ARAUJO et al., 2018; MUNCHOW et al., 2016).

Em vista disso, agentes especificamente dedicados à modelagem de resina composta foram desenvolvidos(BARCELLOS et al., 2008; CHONG GAMERO, 2015; SEDREZ-PORTO et al., 2016, 2017). Esses materiais apresentam composições semelhantes às resinas, contudo com fluidez adequadas para o uso associado a pincéis e com baixo conteúdo de carga inorgânica, em torno de 45%, em volume. Assim, quando em contato com as resinas compostas convencionais, tornam sua manipulação facilitada, visto que não aderem facilmente aos instrumentos de aplicação e, ao mesmo tempo, facilitam a manipulação do mesmo (TUNCER et al., 2013).

Esses agentes são indicados para aplicação direta sobre os incrementos de resina composta(BARCELLOS et al., 2008; TUNCER et al., 2013) e não necessitam de remoção de excessos, previamente à fotoativação, uma vez que se incorporam ao material restaurador (SEDREZ-PORTO et al., 2016; TUNCER et al., 2013).

A incorporação de líquidos modeladores (etapas adicionais) pode levar a importantes alterações cromáticas(USHA; RAO; GEORGE, 2018), conduzindo a restauração para o insucesso, do ponto de vista estético (PARAVINA; PÉREZ; GHINEA, 2019). Sabe-se que o resultado final de uma restauração está diretamente

associado a harmonia cromática que se estabelece entre os tecidos dentários e o material restaurador (DA SILVA et al., 2013; KARAMAN et al., 2015).

Métodos matemáticos de coleta e aferição, como CIELab e CIEDE2000, possibilitam a leitura do estado da cor. As fórmulas utilizadas consideram coordenadas e estão discriminadas pela Comissão Internacional de Iluminação (Comission Internationale de l'Eclairage) (SALAS et al., 2018; XU et al., 2012). A partir da coleta instrumentalizada dos dados, referentes às coordenadas, é possível a quantificação de alterações na cor, translucidez e iluminação de um objeto, comparado consigo mesmo em diferentes tempos(PARAVINA; PÉREZ; GHINEA, 2019; TAKENAKA et al., 2009).

Assim, os métodos propostos permitem quantificar parametricamente as alterações sofridas pela amostra. Ambos os métodos são amplamente citados na literatura odontológica (AZER et al., 2011; CARRABBA et al., 2020; FARHAN et al., 2014; PERRONI et al., 2017; TABATABAIAN et al., 2017) e tornaram-se bastante populares em estudos focados no estado da cor, principalmente para avaliação de resinas compostas(BASEGIO et al., 2019; DINIZ et al., 2019; ROSELINO et al., 2015).

Sabe-se que, apesar da popularização de ambas as fórmulas, atualmente a literatura odontológica vem adotando o sistema CIEDE2000 por sua maior sensibilidade para detecção de alterações cromáticas em pequenas escalas (BASEGIO et al., 2019; DINIZ et al., 2019; ROSELINO et al., 2015).

Portanto, estabilidade cromática está intimamente associada ao sucesso estético das restaurações (CHONG GAMERO, 2015; DE MORAES REGO ROSELINO; TIRAPELLI; DE CARVALHO PANZERI PIRES-DE-SOUZA, 2018). Considerando o potencial de alterações destas propriedades, quando aplicados de maneira convencional, surge o questionamento sobre a possível influência advinda da incorporação de líquidos modeladores na técnica restauradora. A literatura atual não contempla, com a devida importância, o tema. Apresenta-se, portanto, uma lacuna para investigações acerca de aspectos de manutenção de cor para aumentar a segurança da indicação do uso de modeladores.

2. ARTIGO

DOES MODELING LIQUIDS INFLUENCE THE COLOR STABILITY OF RESIN COMPOSITE?

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DOES MODELING LIQUIDS INFLUENCE THE COLOR STABILITY OF RESIN COMPOSITE?

Running title: Modeling liquids on color stability

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ABSTRACT: The aim of this study was to evaluate the color stability of resin composites modeled with different liquids. The groups were divided according to the four available resin composite and subdivided by combining the composite with three modeling liquids or a control group (no modeling), with five specimens each (n = 5). Color measurements were performed using a spectrophotometer (SP60, X-Rite), evaluated in four periods: T0 (Immediate-baseline); T1 (30 days); T2 (4 months) and T3 (6 months). The results were applied to CIEDE2000 equation, then analyzed by the ANOVA and Bonferroni's post-hoc test at significance level of 5%, interpreted by the acceptability and perceptibility thresholds considering limit values considered clinically acceptable (∆Eab less than 2.7 and ∆E00 less than 1.8) and evaluation on the behavior of the chromatic coordinates (L*, a* and b*) individually. No statistical significance was found in the modeling choice (p = 0.31) or in the triple interaction modeling/resin/time (p = 0.92). However, the resin composite and times of measure presented statistically significance difference (both p < 0.00). An increase to the values of ∆E00 was noted when (T0-T1) was confronted with (T0-T2). In contrast, at the end of 180 days (T0-T3), the specimens seem to achieve chromatic stability, either due to their reduction or equity to the values due in the previous period (T0-T2). According to the interpretation parameters, at the end of 180 days, the IPS Empress and Z350XT composite resins have similar good interactions with the modelers, a Forma resin shows the best behavior with the Ambar modeler and the Charisma resin presents acceptable results when modeled with the model. Watering liquid. The control groups of all resins evaluate values for ∆E00 higher than those considered acceptable by the study. Values refer to a variation ranging from 0.50 (Z350 + Humidification T0-T1) to 3.26 (Charisma + Ambar T0-T3). The individual evaluation of the coordinates L *, a * and b * allows to visualize, in general, a reduction in the luminosity of the bodies (darkening), as well as an increase in blue hue (reduction of a *) and red hue (increase of b *). The use of modeling liquids has an influence on the chromatic stability of the resins. However, the color changes were more influenced by the choice of composite resin. Thus, according to the results and limitations of the study, some composite resins present acceptable results for chromatic stability, when combined with modeling liquids.

Clinical relevance: Resin composites are sensitive regarding color stability. In addition to configuring as an additional step to the restorative process, the effect of modeling resin on color stability of composite materials depends on the type of resin composite.

Keywords: Operative dentistry. Dental materials. Dental aesthetics. Permanent dental restoration. Color.

INTRODUCTION

Resin composites are very versatile materials which may be the first choice in restorative dentistry,[1] although color selection and reproduction of small details such as the intricate anatomy of posterior teeth can be considered critical steps in the procedure.[2] Systematizing the restorative procedure offers a possibility to more easily perform the tooth/restoration sculpture by establishing an order to reconstruct the tooth surface by performing it in resin composite increments and by using modeling liquids with the purpose of attaining better resin handling.[2,3,4] In addition to a lack of evidence, dentists frequently use dental adhesives to help them handle the resin in the ordinary restorative practice.[2,5-7]

Resin modeling has recently been presented as an option for handling conventional resins.[5,8] Similar to adhesives, these products present little evidence of their effects on resin composite properties in the short-term and the long-term in view of unknown consequences over color stability of the resin composite.[5,8] Modeling liquids enable better manipulation of the composites; however, they are incorporated into the restoration since they are not removed from the surface of the resin composite before being photoactivated.[5] The use of these liquids aims to reduce a condition related to resin composites, namely their difficulty in handling, due to the adhesion to the spatula, making restorations a complex task. However, other factors must be considered associated with this, such as the operator's experience and the precise indication of the materials.[5,8]

The use of modeling liquids, whether part of the clinician's material routine such as like dental adhesives, or the inclusion of an additional step such as the use of resin modeling liquids can be responsible for important color instabilities,[7,9-14] as high rates of chromatic changes provoke esthetic failures in the restoration, in anterior teeth.[9,10,12]

Color changes can be perceived using devices and equations which allow their measurement. In this sense, it is possible to measure changes in the lighting and the chromatic vectors of an object based on the coordinates established by the international lighting commission (Commission Internationale de l'Eclairage).[9] Thus, even small changes can be detected by developing CIEDE2000 equation, facilitating comparison of the potential of the materials to induce or inhibit this effect in different periods of time.[9-14]

In view of the above, the aim of this study was to evaluate the effect of modeling liquids on changing the color of resin composites. The null hypothesis is that the modeling does not influence the color stability of resin composites.

MATERIALS AND METHODS

The methodological reporting followed the precepts established by CRIS Guidelines (Checklist for Reporting In-vitro Studies)[15].

In the present in vitro study, four resin composites (IPS Empress Direct, Ivoclar Vivadent, Schaan, Liechtenstein; Charisma Diamond, Heraeus Kulzer, Hanau Hessen, Germany; Filtek Z350 XT, 3M-ESPE, St. Paul, MN, USA; Forma, Ultradent, South Jordan, USA all in shade A2) were combined with three modeling liquids (Wetting Resin, Ultradent, South Jordan, USA; Modeling Resin, Bisco Inc, Schaumburg, Illinois, USA; Ambar, FGM, Joinville, Santa Catarina, Brazil). The main outcome evaluated was the color stability of the resin-modeler set over time.

All of the products' manufacturers, chemical composition, shade, and lot number are shown in Table 1. Specimens without modeling were produced as a control group. The number of each group was based on previous studies which used stratification

techniques to assess blinding and using ΔE_{00} as the main outcome (45,46), with n=5 subsequently being established (Figure 1).

SPECIMEN CONFECTION

Eighty specimens of composite resin were randomly made from four composite resins (n = 20) combined with three modeling liquids and a control group (no modeling), with five specimens each (n = 5) (Table 2). All specimens were produced by the same operator, previously trained and calibrated.

A metallic matrix was specially designed for the produced specimens (Figure 2).[16] The circular specimens had dimensions of 11mm in diameter and 1mm in height. The distribution of the groups occurred with the combination of each one of the resin composites with each one of the modeling liquids (including a group with “no modeling” as control). The resin composite was applied in a single increment until completely filling the matrix. Thus, 20µl of the modeling liquid was applied over the increment before the resin composite was photocured. A polyester strip and glass plate as a static 1 kg load were positioned on the matrix and the resin/modeling was light-cured for 40 seconds with a 1200 mW/cm^2 irradiance monitored light emitting diode (LED; Bluephase, Ivoclar Vivadent).

After removal of the metallic matrix, the specimens were checked for dimensions, discarding those that were not in the desired proportions. The specimens were polished for 20 seconds with the aid of a felt disc and diamond-based polishing paste. Specimens were stored in groups in deionized water weekly renewed at 37º C, until the color measuring periods:

- T0 (Baseline), in 24 h;

- T1, in 1 month;
- T2, in 4 months, and,
- T3, in 6 months.

COLOR MEASUREMENT AND ANALYSIS

All measures for chromatic evaluations were performed by a single and blinded operator using a spectrophotometer (SP60, EX-Rite, Grand Rapids, MI, USA). An A2 shade ceramic with a thickness of 4mm and a diameter of 11mm (A2; L* = 82.14; a* = 2.19; b* = 20.40) was used as background. The interface resulting from the specimen positioning on the ceramic background was filled with a thin layer of bi-distilled glycerin. Each measurement of each specimen was repeated three times, and the obtained average was assumed as the specimen's value.

The collection-dependent variables were L*, a* and b*, representing the black-white scale (L*); green-red (a*) and yellow-blue (b*). These coordinates enable the use of chromatic change measurement equation known as CIEDE2000. The equation that refers to the CIEDE2000 calculation is presented below:[17,18]

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

STATISTICAL ANALYSIS AND INTERPRETATION OF PARAMETERS

Three-Way analysis of variance (ANOVA) and Bonferroni's post hoc test were performed at a significance level of 5% in the SPSS (IBM Co. Armonk, NY, USA). Additionally, an individual analysis of the chromatic coordinates L *, a * and b * was performed.

The interpretation of the results followed the parameters established by previous studies, considering values for 50:50% perceptibility and acceptability thresholds. This study considered as acceptable when values for ΔE_{00} were lower than 0.81 for perceptibility and lower than 1.77 for acceptability. Although these combinations were not excellent combinations, they are still classified as clinically acceptable.[18]

RESULTS

The groups will be named combining the simplification of resin composites and modeling liquids names. Therefore, the resins will be called: IPS (IPS Empress Direct); Charisma Diamond (Charisma Diamond); Z350 (Filtek Z350 XT); Form (Form). The modeling liquids will be referred as: Wetting (Wetting Resin); Bisco (modeling resin); Ambar (Ambar APS) and Control (Control group - no modeling).

Three-Way ANOVA for color measures in CIED2000 revealed that statistical significance was not found for modeling liquid (p=0.31) or for the triple interaction (modeling/resin/time) (p=0.92). The resin composite (p=0.00) and time (p=0.00) showed significant differences. Table 3 details the results and significances in pairwise comparisons.

The interpretations are described in three levels to better understand the statistical differences in Table 3 for the same times of each modeling liquid on each resin composite, as well as the same modeling liquids on all resins, as follows:

1. The effect of each modeling liquid on each resin composite –measurement times (capital letters).

In general, for ΔE00 statistically different, there is an increase in chromatic alteration when T0-T1 and T0-T2 are compared. However, a certain remission occurs

when the groups are evaluated at T0-T3. Grupo Charisma Control (T0-T1) presents statistical differences for chromatic alterations, when compared with the other periods. This event can also be observed for the groups IPS Empress Wetting (T0-T1), Forma Bisco (T0-T1) and Forma Wetting (T0-T1).

2. The effect of the different modeling liquid versus each resin composite (roman numbers)

Statistically significant differences for chromatic changes were only found in the groups which Charisma was the adopt resin composite. In light of this, Charisma Control group (T0-T1) was different from Charisma Ambar and Bisco groups. Although, at the end of 180 days (T0-T3) only the groups Charisma Ambar and Wetting present significant differences for chromatic changes.

3. The effect of each modeling liquid versus all resin composites (lower letters)

Therefore, no significant differences were found for color stability in the Control and Wetting groups, for any of the adopted resins. At the end of 180 days (T0-T3), the Bisco modeler is also not statistically significant for color change in any composite resin. However, for the Ambar group (T0-T3), the Charisma resin showed the highest values for ΔE00 (3.26), being statistically different from all components in the category.

The mean color differences showed by CIED2000 (ΔE_{00}) was also verified to produce a table with each measured time compared with baseline (T0) (Table 4). Values referent to ΔE_{00} ranged from 0.50 (Z350 Wetting T0-T1) to 3.26 (Charisma Ambar T0-T3). At 180 days, all the combinations that included resin Z350 or IPS, except control, showed acceptable results. In addition, Charisma modeled with Wetting

and Forma modeled with Ambar were also clinically acceptable after the period of 180 days.

The L* a* b* coordinates for each grouping has the performance represented by graphs. It shows a tendency of each coordinate (features) on each measured time, as presented in Figures 3-5. In general, the groups showed a reduction in the coordinates (L*) and (a*) and an increase in (b*). In other words, there was a reduction of luminosity (L *), tendencies an increase in hue of blue pigments (increase of b*) and red (decreased of a*).

DISCUSSION

Modeling liquids can facilitate the handling of conventional resin composites[6,7,8,14]. However, to the best of the authors' knowledge, the current literature is not sufficient to safely support this practice. Modeling liquids are widely used to manipulate resins. These products can be of resinous origin (Modeling Resin and Wetting Resin), with the advantage of easier handling of conventional composites. However, this process is an additional step to the procedure and has a financial increase. The use of dental adhesives can be an option, since they are products that are part of the restorative sequence, responsible for adhesion. However, as they do not have a direction indication for modeling composites, they may present harmful elements for the restoration[2, 7, 8].

The results obtained herein established that the null hypothesis of the study was reject, since the use of modeling liquids influenced the color stability in some groups. This study aimed to evaluated the effects of using modeling liquids on the surface of resin composites considering the color stability over time.

The Charisma resin groups showed the worst behaviors, regardless of whether they were modeled or not (control group). This resin has the highest values for interpretation of parameters since the first evaluation period, and in 180 days some modelers showed unacceptable values for Δ00 (Charisma Ambar 3.26). The composite resins Z350 and IPS present the best results when modeled, with the control groups of both resins being the worst Δ00 of the categories, respectively. Forma resin showed good interaction with Ambar adhesive as a modeler, this combination is the best in its category and the only one considered acceptable.

The use of adhesives as modeling liquids has been reported in previous *in vitro* studies, based in its influence on resin composite proprieties.[2,6-8,19,20] Some of these studies indicate that the composition of adhesives has an influence on resin composite's color stability. Therefore, adhesives containing solvents or camphorquinone can negatively affect the color of restorations.[2,5] This study adopts Ambar APS (Advanced Polymerization System) as chosen adhesive, since the incorporation of alternative photoinitiators, not including camphorquinone.[21,22]

Charisma resin showed significant chromatic changes associated with Ambar, at different times when compared with others modeling liquids. In this sense, considering our findings, it can be understood that this resin presents better behavior when combined with modeling liquids due a similar nature of composition, not indicating its association with dental adhesives for handling. In general, the Ambar groups presented statistical differences when compared to other options of modeling liquids; this can be justified (as previously described) due to the incorporation of solvents in its composition such as ethanol.[6,7,8,14]

Although chromatic changes in resin composites are expected over time, the sources which propitiate these alterations are diverse or associated with the intrinsic

resin properties, inappropriate finishing and polishing, or diet composition.[1,3,9] An expected outcome of the use of modeling liquids on resin layers has been noticed referring to the protector effect against the deposition of pigments and dyeing which cause aesthetic deterioration in the long-term.[7,14,22-26] However, the present study stored the specimens in water, and it was possible to observe a general trend of chromatic alteration in all groups over time, regardless of the modeling liquid or the resin composite evaluated.

The literature on resinous modeling liquids is still very scarce. The results found in this study agree with the current literature, the use of resin modelers has good interactions with some composite resins[8,23]. The present study believes that the Z350XT and IPS Empress resins showed positive results when modeled with Wetting Resin or Bisco Modeling Resin, since these groups performed less than Δ00 changes than the control groups.

Restorations in smooth surfaces have presented more indicative color stability long-term.[24-27] Aspects such as surface roughness have important roles for color stability. Conventional resin composites presenting smooth surfaces do not favor the retention of extrinsic pigments[24-27]. The present study used the same polishing protocol in all groups, standardizing all specimens by the same system. Even so, previous studies have shown that the use of modeling liquids did not dismiss the finishing and polishing steps.[7,8,14]

The color stability of resin composite is a widely studied topic in dentistry.[2, 4, 6-9] The coordinates proposed by the International Commission on Illumination (Commission Internationale de l'Eclairage) enable a more accurate measurement when compared with visual scales, which is based on identifying changes by

comparing tones[16]. The present study considered a CIEDE2000 analysis due its sensibility of detection in small color differences.[16]

Statistical methods are commonly applied in studies focused on evaluating the influence of modeling liquids on the color stability of resin composites, since evaluation by acceptability and perceptibility scores are not sensitive enough to detect possible influences promoted by modeling liquids, which can be detected by statistical tests.[2, 6,7,14]. Evaluations only by qualitative criteria can consider some level of suggestibility, so the combination of this assessment with statistics analysis can better measure[28,29] if the use of modeling liquids exert (or not) any influence on color stability, since the changes found by statistical tests are not necessarily in tune with the criteria of acceptability and perceptibility.[4,11] Thus, the present study used both qualitative and quantitative evaluation to evaluate the effects of the modeling liquids.

The present study considered the alterations as "excellent match" and "clinically acceptable" as categories in which the chromatic alteration is satisfactory.[18] Therefore, the other categories could generate aesthetic discomfort for patients. Considering the expected shelf-life of a resin composite restoration, six months of evaluation could be a short time period to provide a reliable evaluation of chromatic alterations.[7,14] Even so, the results of this study showed different behavior of the groups. The majority of the groups presented an “excellent match” at 30 days of storage time. Furthermore, an increase in the values was noted for all groups at 120 days of follow-up. This period presented the largest number of groups presenting some of the higher values. Finally, at 180 days, there was a certain reduction in the color changes, since the groups presented values close to those established in the first evaluation period.

After interpreting the thresholds, it can generally be considered that the modeling liquids promoted a distinct influence on the color stability changes, however

all control groups (without any modeling liquid) showed values considered to be unacceptable after follow-up. Similar findings have been described by authors who carried out similar study designs.[6, 7, 14]

It should be emphasized that the objective of the present study was to identify color changes in resin composites modeled with different modeling liquids. Considering the limitations of this study, as an *in vitro* evaluation with 6 months of follow up, it seems clear the need for further studies with considering pigmenting challenges, evaluations of mechanical properties and the proposal of clinical designs. However, based on the results of this study and in agreement with others previous published,[6,7,14] the use of modeling liquids exert certain influence on color stability considering aspects such as the time, the resin composite, proper modeling and combinations between them.

CONCLUSIONS

According to the study's findings, the optical resin properties are not significantly impaired to the point of contraindicating the use of these products, as long as the manufacturer's instructions are followed correctly. Also, the resin choice should guide the possibility of association with modeling liquids, and considering that different composite resins present different levels of chromatic changes when combined with modeling liquids. No important differences were identified among the modeling liquids tested in the study, indicating that other aspects must be considered for using this product.

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Figures, tables and graphs

Table 1. Resin composites used in this study, manufacturer, shade and lot number.

	Manufacturer	Matrix Composition	Shade	Lot Number
Resin Composite Charisma Diamond	Heraeus Kulzer, Dormagen, Germany	TCD-DI-HEA from UDMA (contains 64% charge per volume, 5nm– 20µm); Barium and aluminum fluoride glass and highly dispersed Nano particles.	A2	KA10737
Resin Composite Forma	Ultradent®, South Jordan, USA	Bisphenol-A Diglycidyl Dimethacrylate (Bis-GMA), Triethylene Glycol Dimetracrylate (TEGDMA), Bisphenol-A Diglycidyl Dimethacrylate Ethoxylated (Bis-EMA) and Urethane Dimethacrylate (UDMA); inorganic filler based on zirconia / silica and barium glass.	A2E	D09FT
Resin Composite Filtek Z350XT	3M ESPE, St. Paul - MN, USA	Bisphenol A Diglycidyl Methacrylate, Urethane dimethacrylate , Triethylene glycol dimethacrylate, Bisphenol hydroxyethyl methacrylate, Polyethylene glycol dimethacrylate, BHT, silicate, zirconia	A2E	1818300172
Resin Composite IPS Empress Direct	Ivoclar, Schaan, Liechtenstein	Bis-GMA, UDMA / barium glass, ytterbium trifluoride, mixed oxides, silica dioxide	A2E	Y09576
Dental Adhsesive Mono Ambar APS	FGM Produtos Odontológicos, Joiniville, SC, Brazil	MDP (10-methacryloyloxidecyl dihydrogen phosphate), methacrylate monomers, photoinitiator complex (APS), co-initiators and stabilizers. Inert cargo (silica particles) and vehicle (Ethanol)	Incolor	061217
Composite Wetting Resin	Ultradent®, South Jordan, USA	UDMA (20-40%), Amorphous Silica (30-50%), BisEMA (10-30%), TEGDMA (5-20%), THFMA (1-5%), Bisphenol A Dimethacrylate (1-5%)	-	D0997
Modeling Resin	Bisco Inc, Schaumburg, Illinois, USA	UDMA (20-40%), Amorphous Silica (30-50%), BisEMA (10-30%), TEGDMA (5-20%), THFMA (1-5%), Bisphenol A Dimethacrylate (1-5%)	-	1900001777

Table 2. Grouping

Resin Composite	Modeling Liquid	n	Total n
CHARISMA (CHA)	Control (CTR)	5	20
	Ambar (AMB)	5	
	Bisco (BIS)	5	
	Wetting (WET)	5	
Z350 XT (Z350)	Control (CTR)	5	20
	Ambar (AMB)	5	
	Bisco (BIS)	5	
	Wetting (WET)	5	
IPS EMPRESS (IPS)	Control (CTR)	5	20
	Ambar (AMB)	5	
	Bisco (BIS)	5	
	Wetting (WET)	5	
FORMA (FOR)	Control (CTR)	5	20
	Ambar (AMB)	5	
	Bisco (BIS)	5	
	Wetting (WET)	5	

Table 3. CIED 2000 Delta E mean and (SD) values, considering resin composite versus modelling.

	CHARISMA				Z350				IPS				FORMA			
	CTR	**AMB**	**BIS**	**WET**	**CTR**	**AMB**	**BIS**	**WET**	**CTR**	**AMB**	**BIS**	**WET**	**CTR**	**AMB**	**BIS**	**WET**
T0-T1	0.59 (0.23) B a II	2.49 (0.49) A a I	2.30 (0.90) A a I	1.53 (0.27) A a I II	0.92 (0.48) A a I	0.87 (0.29) A a I	0.62 (0.19) A b I	1.09 (1.45) B a I	1.85 (2.27) A a I	0.62 (0.22) A b I	1.16 (0.48) A ab I	0.98 (0.88) A a I	1.87 (0.59) A a I	0.70 (0.29) A b I	1.17 (0.74) B ab I	1.30 (1.05) B a I
T0-T2	2.16 (0.30) A a I	3.09 (0.94) A a I	3.02 (0.65) A a I	1.87 (0.45) A a I	1.74 (0.39) A a I	1.72 (0.53) A b I	1.78 (0.41) A ab I	2.35 (1.43) A a I	2.49 (1.75) A a I	1.67 (0.39) A b I	1.52 (0.47) A b I	1.96 (0.37) A a I	2.37 (0.40) A a I	1.48 (0.41) A b I	2.68 (1.42) A ab I	2.59 (1.05) A a I
T0-T3	1.97 (0.35) A a I II	3.26 (0.69) A a I	3.06 (0.86) A a I II	1.71 (0.32) A a II	1.82 (0.40) A a I	1.33 (0.40) A b I	1.86 (0.33) A a I	2.14 (1.12) AB a I	2.32 (1.39) A a I	1.71 (0.33) A b I	1.87 (0.42) A a I	1.52 (0.34) A a I	1.99 (0.28) A a I	1.16 (0.30) A b I	2.35 (0.80) AB a I	2.22 (1.39) AB a I

Capital letters for comparisons in columns. Lower letters for comparisons in line (same modeling x all resin composites). Roman numbers for comparisons in line for the different modeling x each resin composite).

Table 4. Mean DE_{00} color difference values of all resin composite and modeling liquid combination groups in the different evaluation periods.

Groups	Δ00/T0-T1 (24h-30d)	Δ00/T0-T2 (24h-120d)	Δ00/T0-T3 (24h-180d)
Charisma + Ambar (CHA-AMB)	2.50	3.10	3.26
Charisma + Bisco (CHA-BIS)	2.30	3.03	3.07
Charisma + Wetting (CHA-WET)	**1.54**	1.88	**1.72**
Charisma + Controle (CHA-CTR)	**0.59**	2.16	1.98
Z350 + Ambar (Z350-AMB)	**0.71**	**1.64**	**1.46**
Z350 + Bisco (Z350-BIS)	**0.71**	1.87	**1.68**
Z350 + Wetting (Z350-WET)	**0.50**	**1.78**	**1.73**
Z350 + Controle (Z350-CTR)	**1.55**	2.34	2.32
IPS Empress + Ambar (IPS-AMB)	**0.67**	**1.73**	**1.74**
IPS Empress + Bisco (IPS-BIS)	**0.94**	**1.60**	**1.80**
IPS Empress + Wetting (IPS-WET)	**1.26**	1.84	**1.56**
IPS Empress + Controle (IPS-CTR)	**1.73**	2.46	2.31
Forma + Ambar (FOR-AMB)	**0.71**	**1.68**	**1.25**
Forma + Bisco (FOR-BIS)	**1.17**	2.33	2.25
Forma + Wetting (FOR-WET)	**1.31**	2.60	2.22
Forma + Controle (FOR-CTR)	1.88	2.38	2.00

The evaluation criterion adopted by the present study considered acceptable values when Δ_{00} was lower than 0.81 for perceptibility and lower than 1.77 acceptability as clinically acceptable thresholds, these values are highlighted in the columns.

Figure 1. Methodological representation of the groups.

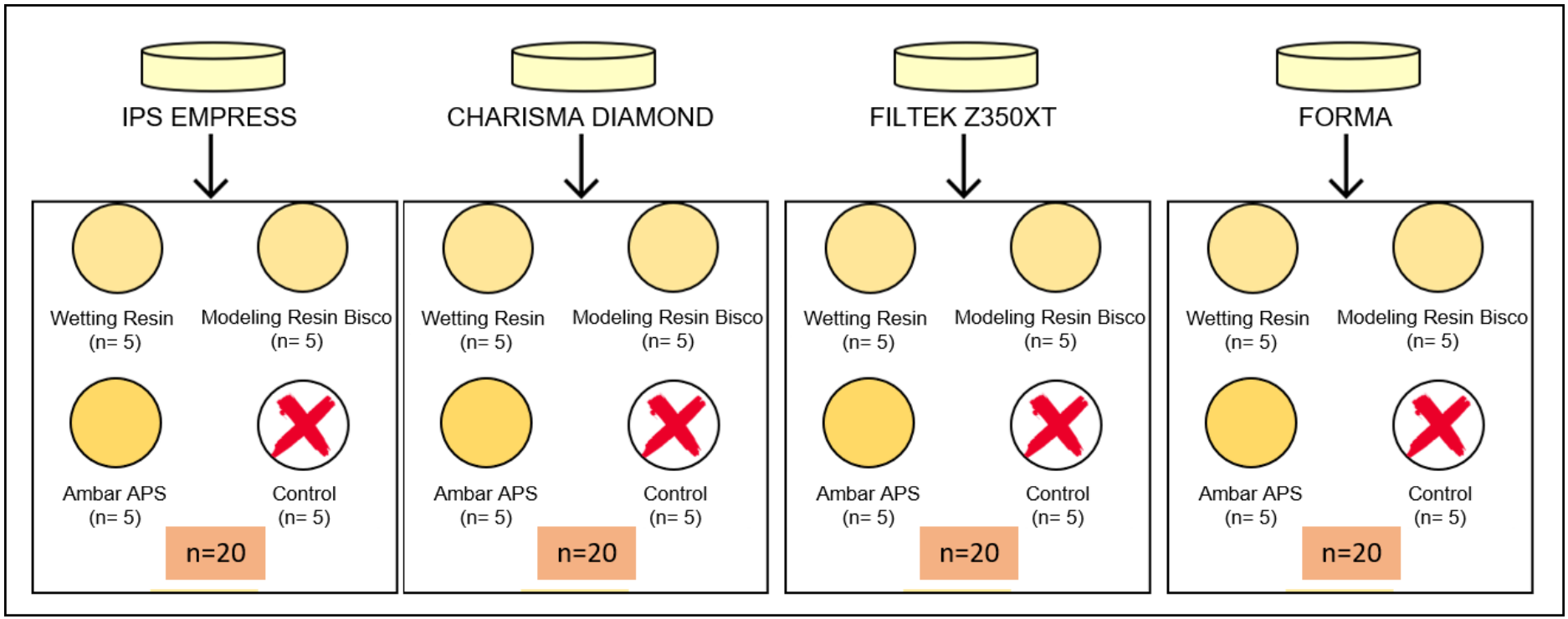


Figure 2. Schematic representation of the metallic matrix device for the confection of specimens.

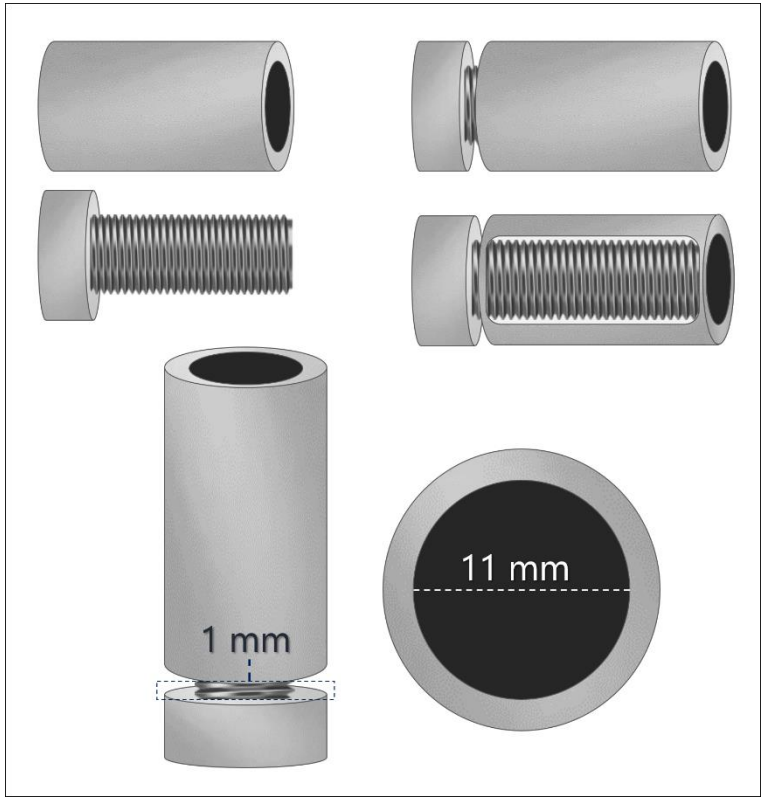
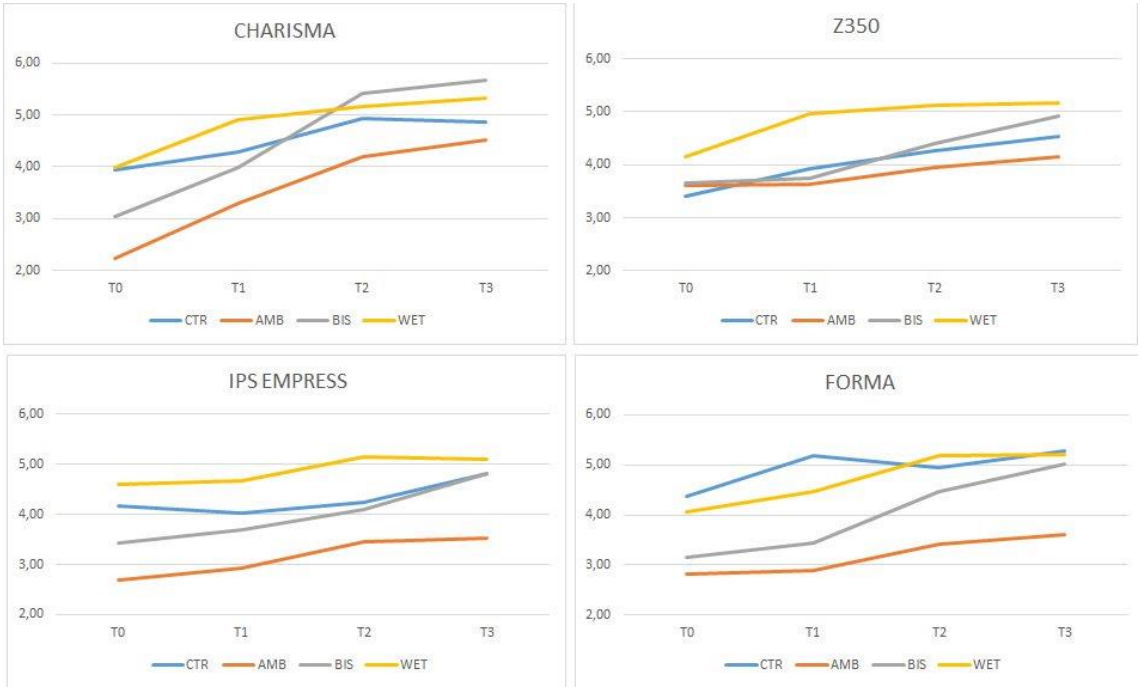


Figure 3. Color changes represented by the L* coordinate (lightness) in all groups after different time periods.

Figure 4. Color changes represented by the a* coordinate (red-green) in all groups after different time periods.

Figure 5. Color changes represented by the b* coordinate (blue-yellow) in all groups after different time periods.



3. CONSIDERAÇÕES FINAIS

A presente dissertação teve como objetivo avaliar a estabilidade cromática de diferentes marcas comerciais de resinas quando manipuladas por líquidos modeladores, de natureza resinosa ou adesiva. Foi utilizado um espectrofotômetro para a avaliação em diferentes momentos do tempo permitindo a comparação a longo prazo do comportamento dos materiais. A utilização de materiais para modelar resinas compostas é amplamente difundida nas escolas e clínicas odontológicas, no entanto, a literatura vigente até o momento não permite embasamento para essa indicação.

Em vista do exposto, associada a uma minuciosa busca na literatura, encontram-se poucos estudos que contemplem o assunto, sendo todos de delineamento do tipo *in vitro*. Considerando as limitações desse tipo de estudo, entendeu-se a necessidade da contribuição para a literatura com mais resultados provenientes desse tipo de desenho de estudo, para que delineamentos mais avançados, como estudos clínicos, possam ser futuramente desenvolvidos.

Quanto os resultados deste estudo, de maneira geral, entendem-se que os modeladores apresentam certa influencia na alteração de cor de resinas compostas. Porém, nota-se um maior impacto na escolha da resina composta do que na escolha do tipo de modelador aplicado. Assim, considera-se acertado a utilização de diferentes compósitos, bem como, seu acompanhamento a longo prazo.

Por fim, compreende-se que a literatura atual ainda necessita de novos estudos in vitro sobre o tema, uma vez que aspectos estéticos com desafios pigmentantes e testes mecânicos ainda podem ser melhores explorados para o completo entendimento da influência da combinação de resinas compostas com diferentes líquidos modeladores.

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ANEXOS

ANEXO A- NORMAS PARA SUBMISSÃO DE MANUSCRITOS E INSTRUÇÕES PARA AUTORES EM PUBLICAÇÕES NO PERIÓDICO OPERATIVE DENTISTRY.

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  - 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
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2. **AUTHOR INFORMATION** must include:
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3. **MENTION OF COMMERCIAL PRODUCTS/EQUIPMENT** must include:
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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.
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- **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
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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.
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EXAMPLES OF REFERENCE STYLE

- Journal article: two authors
  Evans DB & Neme AM (1999) Shear bond strength of resin composite 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.
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  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.
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