Journal of
Kerman University of Medical Sciences

https://jkmu.kmu.ac.ir
10.34172/jkmu.2024.39
Vol. 31, No. 5, 2024, 253-258

Original Article

Evaluation of Color Stability of a Composite Resin Using Different Instrument Lubricants After One Month of Water Storage

Nafiseh Elmamooz[1], **Farnaz Abdollahi**[1*], **Ali Eskandarizadeh**[1], **Mehrnaz Karimi Afshar**[2], **Mehran Amirinejad**[1]

[1]Department of Restorative Dentistry, School of Dentistry, Kerman University of Medical Sciences, Kerman, Iran
[2]Prosthodontics Department, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran

***Corresponding Author:** Farnaz Abdollahi, Email: farnazabdollahi1995@gmail.com

Abstract

Background: Clinicians use several lubricants to reduce composite sticking to instruments and facilitate composite modeling. This study evaluated the effect of instrument lubricants on the color stability of a resin composite after one month of water storage.

Methods: 60 disc-shaped specimens (2×10 mm) of Tetric N-Ceram composite were prepared using four lubricants, isopropyl alcohol 70%, Adper single bond adhesive (SB), margin bond (MB) and composite wetting resin (CW) (12 samples for each group). No lubricant was used in the control group. Color measurement was done twice, 24 hours after sample preparation and after one month of water storage. Color differences were calculated, and the data were analyzed using ANOVA and Tukey's post hoc tests.

Results: The use of single bond as instrument lubricant caused the most color change ($\Delta E = 4.26$), and the control group (no lubricant) showed the least color change ($\Delta E = 1.77$). Using composite wetting resin as an instrument lubricant resulted in lower color changes than other instrument lubricants ($P < 0.05$).

Conclusion: Composite Wetting Resin used as instrument lubricant had better color stability than other lubricants. Bonding agents are not recommended for composite restorations as instrument lubricants due to the higher risk of affecting color stability. Clinicians should be aware that using instrument lubricants might influence the color properties of dental composites

Keywords: Composite, Color stability, Lubricant, Water storage

Citation: Elmamooz N, Abdollahi F, Eskandarizadeh A, Karimi Afshar M, Amirinejad M. Evaluation of color stability of a composite resin using different instrument lubricants after one month of water storage. *Journal of Kerman University of Medical Sciences*. 2024;31(5):253–258. doi: 10.34172/jkmu.2024.39

Received: October 15, 2023, **Accepted**: December 2, 2023, **ePublished**: October 30, 2024

Introduction

Composite materials are widely used due to their suitable physical, mechanical, and aesthetic properties (1,2). When the composite material is placed in the prepared cavity and the application force is removed, the composite must remain in the preparation and fill the desired areas (3). One of the main disadvantages of composite materials is their sticking to dental instruments, resulting in difficulty with sculpting and shaping the composites (4). Non-sticky rheological parameters are important for clinicians in composite restorations (5). In addition to handling, dentists face other clinical problems related to composite stickiness, including porosities and voids in the restoration bulk caused by the pullback of material during the restorative process (3,6). Opdam et al. reported that the risk of the formation of voids and porosities increases when the material sticks to the instrument (6). Tyas and Eidelman also showed that the marginal opening of restorations is related to composite materials sticking to the instrument (7,8). Several techniques have been suggested, e.g., using instruments with titanium/aluminum coating, rubber tips, and composite brushes, to overcome this problem. Another technique includes using lubricants such as isopropyl alcohol, acetone, adhesives, and special commercial products. This approach reduces surface tension, inhibits stickiness, and makes composite handling and placement easier (9-14). Despite the lack of an official description of the lubrication technique in literature and possible destructive changes in the properties of the applied composites, instrument lubrication with modeling resin, adhesives, and alcohol has become a common practice in the clinic to improve handling and prevent drag. Incorporation of additional substance into the modeled composite may change the composition and properties of the applied composite, especially the hydrophilic molecules present in adhesive systems (15-17) Color is one of the most essential characteristics of composite restorations. For aesthetic reasons, the color stability of dental composites is an important issue. Color can be measured by two visual and instrumental techniques since color perception differs between people and in the same person at different times. Instrumental measurement is more accurate and repeatable than visual evaluation. Spectrophotometers are standard instruments for measuring color expressed in three coordinate values, which indicate the object's color with the CIE lab color space. The L* coordinate represents the lightness, while a* and b* are chromaticity coordinates. The following formula (ΔE^*) can determine the color difference (11,18,19).

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Thus, although instrument lubricants may facilitate placement, it may be unclear whether these lubricants affect the composites' physical and surface properties. Few studies have examined the effect of instrument lubricants on composite properties. Hence, this study aimed to evaluate the effect of different instrument lubricants on the color change of a composite resin after one month of water storage.

The null hypothesis assumed that using instrument lubricant will not affect the color stability of the composite.

Materials and Methods

This in-vitro experimental study (ethics code: IR.Kmu.REC.1396.1079) used Tetric N-Ceram composite (shade A2 Ivoclar Vivadent Liechtenstein) to prepare the specimens. A stainless-steel split cylindrical mold, 10 mm in diameter and 2 mm in depth, was used for this purpose. The mold was placed on a glass slide; after placing a piece of composite in the mold, the instrument (stainless steel plugger) was dipped into one of the following lubricants [70% isopropyl alcohol, composite wetting resin Ultradent Products, South Jordan UT, USA), Adper single bond 2 (3M, ESPE, St. Paul, MN, USA), and margin bond (Coltene, Germany)] for 10 seconds up to the 3 mm mark on the instrument and allowed it to drip/drain for 2 seconds prior to molding the composite (20). No lubricant was used in the control group (Table 1). Therefore, 60 composite specimens were made in 5 groups (12 specimens per group according to experimental groups). The composite was inserted into a mold in a single increment. The sculpting process of the composite consisted of six sweeping motions of the lubricated dampened instrument against the circular composite sample surface (The number of motions was estimated in a fabricated pilot sample). The samples were cured under a mylar strip covered with a fine glass slide to ensure a flat surface and standard positioning of the light cure unit head. The curing process included 120 s from each side and at three points overlappingly using a light-emitting diode (Demi ultra, Kerr, USA, 1200 mW/cm^2 of irradiance) curing unit. After fabrication with running water, the samples were polished with 600 and 800-grit silicon carbide paper. The final thickness of the specimens was measured using a digital caliper (Mitutoyo, Japan), and specimens thinner than 1.95 mm or thicker than 2.05 mm were replaced. The samples were stored in distilled water at 37 °C in a light-proof environment for 24 hours.

The color parameters ($L^*a^*b^*$) according to the CIELAB color scale were measured at baseline with a spectrophotometer (Gretag Macbeth, Color Eye 7000A, USA).

This device used a xenon lamp with a reflective measurement range of 360–750 nm, and a measuring geometry of d/8° was used. The aperture size of the device was 7 mm. After the baseline measurements, the samples were immersed in water and stored in a dark incubator at 37 °C for one month. The measurements were repeated after one month. Color change (ΔE^*) was calculated using the following equation:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

In the CIELAB system, the L^* values correspond to lightness, the a^* values to the red-green content, and the b^* values to the yellow-blue content.

$\Delta E \geq 3.3$ was considered to be clinically perceptible.

The color parameters in different groups were analyzed by ANOVA and Tukey's post hoc tests ($\alpha = 0.05$) (SPSS, version 20; SPSS, Chicago, IL, US).

Results

Table 2 presents the mean and standard deviation of the color parameters and the amount of ΔE of the study groups. The maximum and minimum color changes occurred in the single bond and control (no lubricant) groups after

Table 1. Composition of materials used in the study

Product	Manufacturer	Lot	Composition
Composite wetting resin	Ultradent Products; South Jordan UT, USA	BCN21	Bis-GMA, TEGDMA
Adper single bond	3M ESPE, St. Paul, MN, USA	N690847	Bis-GMA, HEMA, methacrylate, methacrylate functional copolymer of polyacrylic and itaconic acid, water, alcohol, photoinitiator, nanofiller
Margin bond	Coltène Whaledent, Switzerland	MB020	Bis-GMA; TEGDMA
Tetric N-Ceram	Ivoclar Vivadent, Schaan, Liechtenstein	R08354	Bis-GMA, UDMA, Ba glass, Ytterbium trifluoride, mixed oxide 80-81 (wt%)

BisGMA, bisphenol A diglycidyl ether dimethacrylate; HEMA, 2-hydroxyethyl methacrylate; Nanofiller, silane-treated silica; TEGDMA, triethylene glycol dimethacrylate; UDMA, diurethane dimethacrylate.

one month of storage, respectively. The single bond and margin bond groups showed clinically perceptible color changes ($\Delta E \geq 3.3$) (Table 2).

Tukey's HSD test revealed that there was a significant difference in the amount of ΔE between the control group and all other groups except the composite wetting resin group ($P < 0.05$) (Table 3). The single bond and margin bond groups differed significantly from all the other studied groups. However, the composite wetting resin group did not differ significantly from the control and alcohol groups (Table 3).

Table 2. Mean (standard deviation) of color difference (*ΔE*) and color parameters ((*ΔL*, *Δa*, and *Δb*) after one month of water storage

Group	ΔE	ΔL	Δa	Δb
Control	1.77 (0.4)	-1.2 (0.59)	0.31 (0.15)	-1.02 (0.6)
Single bond	4.26 (0.5)	-3.10 (2.14)	0.97 (0.47)	-1.76 (0.48)
Margin bond	3.46 (0.35)	-3.06 (0.3)	0.91 (0.51)	-1.21 (0.4)
Composite wetting resin	2.29 (0.68)	-1.84 (0.63)	0.37 (0.19)	-1.21 (0.54)
Alcohol	2.59 (0.55)	-2.08 (0.59)	0.29 (0.2)	-1.4 (0.48)

Discussion

During the restoration process of resin composites, some defects (e.g., air voids and unpacked areas) may remain in the bulk of the composite, resulting in accelerated hydrolytic degradation of the resin matrix or crack initiation/propagation while the material is undergoing a stress event. These sequels accelerate the reduction of physical and mechanical properties (17,21,22). The technique of using modeler liquids during composite restorations is reported as a way to handle resin composite adequately, but there are limited reports in the literature on this topic (17).

The null hypothesis tested in this study was rejected, and it was revealed that instrument lubricants affect the color stability of composites. The optical properties of a composite can be altered over time as a function of intrinsic and extrinsic factors.

The composition and quality of the material's polymerization reaction are considered the main intrinsic factors. The extrinsic factors are related to the interaction of the composite structure with colored materials (23). Several in vitro tests have been proposed to understand and predict the optical behavior of composites while aging. Most of these tests include exposure to water environments, thermal changes, irradiation, or a combination of these conditions (24).

In this study, the specimens were stored in water in a light-proof environment for one month. This period was used to evaluate the short-term effects of water storage on the optical properties of the composites, which was similar to the aging protocol in previous studies (24, 25). Studies have revealed that the maximum amount of water sorption occurs in the first week (26-28).

The optical properties of composites can change over time with water sorption, followed by hydrolysis and chemical reactions related to components such as tertiary amine and camphorquinone. Physical and chemical factors influence composite hydrolysis.

The hydrophobicity of the resin matrix and the bonding quality of the silane and filler can affect water sorption and color stability. The color change of composites in water is due to the penetration of water into the matrix and filler/matrix interface and the presence of hydrophilic monomers. Another main reason for the color change of composites is the oxidation of unreacted carbon-carbon double bonds, which leads to the production of colored products (24,29,30). Various studies have reported the color change of dental composites after water storage due to the destruction of resin monomers and filler lixiviation (24,31,32).

This study observed the best color stability in the control group, in which no lubricant was used ($\Delta E = 1.77$). The single bond and margin bond groups showed clinically perceptible color change ($\Delta E > 3.3$). Incorporating additional resin monomer portions while modeling composites with lubricated instruments may cause disturbance in its internal structure (15). Another issue is the reduction of the polymerization degree of the composite following the use of lubricants. de Paula et al. and Melo et al. have reported decreased composite conversion when using instrument lubricants (16,33). It has been proven that the degree of conversion of resin composites can greatly affect the optical properties of composites. Decreasing the degree of polymerization can intensify the water sorption of composites and also increase unreacted carbon-carbon double bonds, and their oxidation produces colored peroxide products (6,24,30,34). Furthermore, solvents in the single bond

Table 3. Results of Tukey's HSD test for pairwise comparison of *ΔE* values between groups after one month of water immersion

Group 1	Group 2	P value
Control	Single bond	0.001
	Margin bond	0.001
	Composite wetting resin	0.12
	Alcohol	0.003
Single bond	Margin bond	0.004
	Composite wetting resin	0.001
	Alcohol	0.001
Margin bond	Composite wetting resin	0.001
	Alcohol	0.001
Alcohol	Composite wetting resin:	0.63

group can plasticize the composite structure, open the spaces between the chains of the composite network, and increase the diffusion coefficient, leading to more water uptake (20,35). Patel et al. reported increased water sorption in resin composites following the use of instrument lubricants (20).

On the other hand, single bond has HEMA as a hydrophilic agent in its composition (in addition to water and alcohol as solvents) that increases the water sorption process, and this issue justifies the color change of the composite in this group. HEMA is a hydrophilic functional monomer widely used in dental adhesives; it acts as a cosolvent, helping to mix hydrophilic and hydrophobic ingredients in a single homogenous blend. HEMA cannot form crosslinking like methacrylate monomers, and it only links in linear space positions, resulting in a polymer network that is more prone to hydrolytic degradation (33).

The group in which ethanol was used as lubricant showed less color change than groups placed with bonding agents, which is related to much less water sorption in the ethanol group (36). Alcohol is also a resin solvent that softens the composite resin and creates powder particles, which affect the bulk of the composite at the interface of the layers (10,37).

The amount of color change in the margin bond group was clinically perceptible ($\Delta E > 3.3$) (Table 2). However, the change was less in the single bond group, which is related to the absence of HEMA and water in the composition of the margin bond compared to single bond adhesives (33).

The alcohol group's color change was greater than the composite wetting resin and control groups, probably due to alcohol's softening effect on the composite. This causes a more open structure in the composite and facilitates water absorption between the polymer chains (10,37).

In this study, the composite wetting resin group showed better color stability than the single bond and margin bond groups. In terms of color stability, this group had no significant difference from the control group (no lubricant). Using composite wetting resin as a hydrophobic agent improves the physicochemical stability of the material, limits the hydrolysis phenomenon, and provides better color stability. According to the manufacturer's instructions, composite wetting resin is a light-curing resin containing 45% filler. This resin has no solvent or HEMA, which is an advantage for composite wetting resin as a modeler liquid (36,38). Since water sorption occurs mainly through the organic components, the presence of fillers in composite wetting resin composition, compared with margin bond, leads to lower water sorption and hydrolytic degradation (39,40); this may justify the better color stability in the composite wetting resin group compared with the margin bond group.

The *L* value decreased in all groups, and this change was more evident in the single bond and margin bond groups. This issue is related to entrapped solvent molecules within the composite during polymerization. Then, after water storage, the solvent was eliminated from the bulk of the material, leading to free spaces that could be filled with water; this process facilitates light propagation, which increases the composite's translucency. Several studies have shown that water storage increases composites' translucency, which is consistent with the results of the present study (32,33). The limitations of this study are that one brand of composite was tested, and only one method of aging was tested on the samples. Therefore, further investigations are recommended.

According to the results of the present study, although lubricants may minimize the stickiness and improve the handling of composites, they probably have adverse effects on the optical properties of composite restorations.

Conclusion

Using lubricants to improve the handling of the composite can affect its color stability. Compared to other modelers, the composite wetting resin group showed the best color stability. Single bond and margin bond as modeler liquids caused clinically perceivable color changes.

Authors' Contribution

Conceptualization: Nafiseh Elmamooz, Farnaz Abdollahi.
Data curation: Nafiseh Elmamooz, Farnaz Abdollahi, Ali Eskandarizadeh, Mehrnaz Karimi Afshar, Mehran Amirinejad.
Formal analysis: Nafiseh Elmamooz, Farnaz Abdollahi.
Investigation: Nafiseh Elmamooz, Farnaz Abdollahi.
Methodology: Nafiseh Elmamooz.
Project administration: Nafiseh Elmamooz, Farnaz Abdollahi.
Resources: Nafiseh Elmamooz, Farnaz Abdollahi.
Software: Nafiseh Elmamooz, Farnaz Abdollahi.
Supervision: Nafiseh Elmamooz.
Validation: Nafiseh Elmamooz, Farnaz Abdollahi, Ali Eskandarizadeh.
Visualization: Nafiseh Elmamooz, Farnaz Abdollahi.
Writing–original draft: Nafiseh Elmamooz, Farnaz Abdollahi.

Competing Interests

The authors declared no conflict of interest.

Ethical Approval

Not applicable.

Funding

This study received no funding .

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