The effect of alcoholic beverages on stainability of direct esthetic restorative materials

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Abstract

Objectives: To investigate the effect of alcoholic beverages (beer, whiskey, and wine) on stainability of nanofilled resin composite, nanohybrid resin composite, and giomer.

Material and Methods: Forty disc-shaped specimens (10.0 mm in diameter and 2.0 mm in thickness) of each resin composite and giomer were prepared. Before immersion, baseline color values of each specimen were recorded. Four groups of discs (n = 10) were immersed in 25 mL of each alcoholic beverage and deionized water (served as a control) for 14 days. After immersion, the specimens were evaluated with a spectrophotometer in L*, a* and b* values and calculated to color changes (ΔE^*). Data were analyzed by two-way ANOVA and Tukey's HSD (α = .05).

Results: Color changes ($\Delta E^* > 3.3$) in all materials were significantly found after being immersed in beer, whiskey, and wine (p-value < .05). Giomer had more significant color changes than resin composites (p-value < .05). Wine caused the highest color change of the materials (p-value < .05).

Conclusions: The effect of alcoholic beverages on the stainability of the restorative materials evaluated depended upon the chemical composition of the restorative materials and alcoholic beverages.

Keywords: alcoholic beverage, giomer, stainability, restorative materials, resin composite, esthetic restorative

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Introduction

Esthetics and the minimal invasive concept are two of the key current topics of modern restorative dentistry. Nowadays, there are many direct esthetic restorative materials in dentistry. Giomers are introduced as hybrid direct esthetic restorative materials. They are based on pre-reacted glass (PRG) technology where PRG fillers are included in an organic resin matrix.[1,2] The sizes of PRG fillers range between 0.01-5 μm and they are derived from the complete or partial reaction of ion-leachable fluoroaluminosilicate glasses with polyalkenoic acids in water before being interfaced with the organic matrix.[1,2] There are two types of PRG fillers. Surface pre-reacted glass ionomer filler or S-PRG filler is a filler where the pre-action involves only the surface of the glass particles , while fully pre-reacted glass ionomer filler or F-PRG filler involves almost the entire glass particle.[3] The giomers are light-activated with blue light wavelength of 470 nm. The chemical compositions of giomer facilitates fluoride ion release and recharge with the potential for restoration of recurrent caries.[4-7]

Nanocomposites are the latest types of resin composite at present. They are composed of nano fillers that are inserted into the resin matrix in order to obtain high wear resistance, reduce polymerization shrinkage and to improve esthetic value to the restorations and provide a superior polish.[8-9] Nanocomposites are used routinely for restoring both anterior and posterior teeth. Nanocomposites are composed of two types, nanofilled and nanohybrid resin composite. Both of them are becoming popular because they combine physical, mechanical and esthetic properties.[8-10] Nanofilled resin composites consist of nanomers (5 nm to 75 nm particles) and "nanocluster" agglomerates as the fillers. Nanoclusters are agglomerates (0.6 μm to 1.4 μm) of primary zirconia/silica nanoparticles (5 nm to 20 nm in size) fused together at points of contact, and the resulting porous structure is infiltrated with silane.[10] The nanohybrid type contains milled glass fillers and discrete nanoparticles (40–50 nm).[9]

The color change of restorative materials is one of the most common reasons for the replacement of restorations. Color change in resin composites occur due to intrinsic and extrinsic factors. Intrinsic factors involve chemical changes in the material. Extrinsic factors such as adsorption or absorption of stains pose a major problem for esthetic restorations.[11] Over the past years, wine consumption has dramatically increased across most markets and wine sectors.[12] Several recent research findings claimed that wine has a beneficial effect on health (preventing heart disease, cancer and Alzheimer's disease).[13-15] Consumption of alcoholic beverages may affect the esthetic and physical properties of the resin composite restoration.[16] Alcohol is also thought to act as a plasticizer of the polymer matrix.[17]

Acidity and/or alcohol cause surface degradation and staining of resin composites. In addition, surface degradation and susceptibility to staining resin materials is related to the content of the fillers, distribution of the fillers, composition of the matrix resin, and the effect of silane surface treatment on the fillers.[18-19]

Therefore, the aim of the present study was to evaluate the effect of alcoholic beverages (red wine, whiskey and beer) on susceptibility to staining direct esthetic restorative materials (giomer, nanofilled resin composite, and nanohybrid resin composite) in vitro.

Materials and methods

Specimen preparations

Forty disc-shaped specimens of each

nanohybrid resin composite (Premise and Herculite, Kerr Corp., Orange, CA, USA), nanofilled resin composite (Filtek Z350 XT, 3M ESPE, St.Paul, MN, USA), and giomer (Beautifil II, Shofu Inc., Kyoto, Japan) were prepared (Table 1) in a polytetrafluoroethylene cylindrical mold (10.0 mm in diameter and 2.0 mm in thickness) on a glass plate (1.5 mm in thickness). The cylindrical mold was covered with a mylar matrix strip, and a second glass plate was placed over the mylar strip. A static load of approximately 200 g was applied to extrude excess material and to obtain a smooth and flat surface on each specimen. The specimens were then polymerized for 40 s with a light-activated polymerization unit (12 mm in tip diameter, Elipar 2500, 3M ESPE, St. Paul, MN, USA), and the light intensity (555.33 ± 11.02 mW/cm²) was verified with a measuring device (Cure Rite, L.D. Caulk, Milford, DE, USA). After polymerization, the mylar strip and the glass plate on the top and bottom of the mold were removed. The specimen was then removed from the cylindrical mold. No mechanical preparation or abrasions were performed on the specimens.

The pH and titratable acidity measurements

Three alcoholic beverages were used in this study including red wine, whiskey, and beer (Table 2). The pH of each beverage was determined using a pH meter (Orion 900A, Orion Research, Boston, MA, USA). Ten pH readings of each alcoholic beverage were obtained so as to give a mean pH measurement of each beverage.

To verify titratable acidity (buffering capacity),[20] 20 mL of each alcoholic beverage was added with 0.5 mL increments of 1 mol/L sodium hydroxide (NaOH). The amount of NaOH required to reach pH levels of 5.5, 7.0, and 10.0 was recorded. The titrations for each alcoholic beverage were also repeated ten times to attain a mean value.

Table 1 Materials used in this study

Material	Product	Manufacturer	Composition		Average Particle size (μm)
			Matrix	Filler	
Nanofilled resin composite	Filtek Z350 XT	3M ESPE, St. Paul, MN, USA	Bis-GMA, TEGDMA, UDMA, Bis-EMA	Zirconia, silica	0.2
Nanohybrid resin composite	Premise	Kerr Corp., Orange, CA, USA	Bis-GMA, TEGDMA	Prepolymerized filler, barium glass, silica	0.4
	Herculite	Kerr Corp., Orange, CA, USA	Bis-GMA, TEGDMA	Prepolymerized filler, nanoparticles, submicron hybrid filler	0.6
Giomer	Beautifil II	Shofu Inc., Kyoto, Japan	Bis-GMA, TEGDMA, catalyst	S-PRG, Fluoroboroalumino -silicate glass	1.0

Bis-GMA: Bisphenol-A glycidyl methacrylate; TEGDMA: Triethyleneglycol dimethacrylate;
UDMA: Urethane dimethacrylate; Bis-EMA: Ethoxylated bisphenol A dimethacrylate;
S-PRG: Surface pre-reacted glass ionomer

Table 2 Tested alcoholic beverages used in the present study

Beverage	Product	Manufacturer	Composition
Beer	Heineken	Heineken N.V. Global Corporate Relations, Amsterdam, Netherlands	5% Alcohol by volume, water, malted barley, hops, yeast
Whiskey	Johnnie Walker Black Label	Diageo, London, UK	Alcohol 40% by volume, blend of about 40 different malt and grain whiskies
Wine	PB Valley	B.B. Groups Trading Co., Ltd., Wattana, Bangkok	Alcohol 13.5% by volume

Alcoholic beverage immersion and color measurement

Forty discs of each nanofilled resin composite, nanohybrid resin composite, and giomer were randomly divided into 4 groups of 10 specimens. For baseline color measurement, each group was subjected to a spectrophotometer (ColorQuest XE, Hunter Associates Laboratory Inc., Reston, VA, USA) for assessing the Commission Internationale de l'Eclairege L*a*b* (CIELAB) color . L* indicates the lightness of the color measured from black (L* = 0) to white (L* = 100), a* determines color in the red (positive a* > 0) and green (negative a* < 0) dimension, and b* determines color in the yellow (positive b* > 0) and blue (negative b* < 0) dimension. Three measurements were obtained from each disc and the average L*, a* and b* values were used for the final analyses.

Subsequently, four groups of discs were immersed manually in 25 mL of three alcoholic beverages and deionized water (which served as a control) at 37°C for 14 days. A period of immersion was performed to examine the extensive effect of each media. During the test period, the glass storage containers containing the specimens were kept in an incubator. To maintain a constant pH of the alcoholic beverages, each alcoholic beverage was changed daily throughout the experiment. After the immersion sequence was completed, the specimens were rinsed with deionized water (200 mL), blotted dry and subjected to post-immersion color measurement.

Overall color change (ΔE*) was calculated using the following equation: $\Delta E^* = ([\Delta L^*]^2 + [\Delta a^*]^2 + [\Delta b^*]^2)^{1/2}$. Mean ΔE* values for the experimental groups were calculated between baseline and after immersion. Values ΔE* ⩾ 3.3 were considered clinically unacceptable.[21,22]

Statistical analysis

The color change values (ΔE*) were subjected to a two-way ANOVA measurement and Tukey's Honestly Significant Difference (HSD) test for multiple comparisons (at α = 0.05).

Results

The mean pH, standard deviations and titratable acidity of the alcoholic beverages with 1 mol/L NaOH is shown in Table 3. Wine had the lowest pH (3.48 ± 0.04) and beer had the highest pH (4.04 ± 0.06). The titratable acidity was lowest for whiskey (0.92 ± 0.07 mL) and highest for wine (16.53 ± 2.52 mL). The results of the two-way ANOVA (Table 3) found statistically significant differences among the different beverages (*p*-value = .001), the different types of resin composites (*p*-value = .004) and the interaction between the two (*p*-value = .005). The color change values of the materials used before and after immersion are presented in Table 5. Overall, giomer had more significant color changes than resin composites (p-value < .05). Wine caused the highest color change of the materials (p-value < .05).

Discussion

Discoloration of esthetic restorative materials can be a reason for replacement in esthetic areas. The present study was conducted on two types of resin composites (nanofilled resin composite and nanohybrid resin composite) and a giomer to simulate clinical performance in color stability of these materials. Determination of color change in dentistry can be evaluated by visual and instrumental techniques.[23] A spectrophotometer

Table 3 Two-way ANOVA statistical analysis

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2469.594	15	164.640	12.770	.001
Intercept	5075.298	1	5075.298	393.667	.001
beverage	1976.356	3	658.785	51.099	.001
material	148.409	3	49.470	3.837	.004
beverage * material	344.829	9	38.314	2.972	.005
Error	825.111	64	12.892		
Total	8370.003	80			
Corrected Total	3294.705	79			

Table 4 The mean pH and standard deviation (SD) and titratable acidity (volume of NaOH (mL) to bring the pH to 5.5, 7.0 and 10.0) in beverages tested

Beverage	Mean pH ± SD	Cumulative volume of NaOH solution used to titrate to each pH (mL)		
		5.5	7.0	10.0
Beer	4.04 ± 0.06	1.95 ± 0.05	4.10 ± 0.50	7.39 ± 0.60
Whiskey	3.86 ± 0.05	0.57 ± 0.04	0.78 ± 0.04	0.92 ± 0.07
Wine	3.48 ± 0.04	10.39 ± 1.43	12.43 ± 1.71	16.53 ± 2.52

Table 5 Changes in overall color (ΔE*) from baseline of nanofilled resin composite, nanohybrid resin composite, and giomer after immersion

Beverage	ΔE* value			
	Nanofilled resin composite	Nanohybrid resin composite		Giomer
	Z350XT	Herculite	Premise	Beautifil II
Deionized water	2.69 ± 0.50^{d}	2.58 ± 1.59^{d}	2.44 ± 1.09^{d}	2.26 ± 4.39^{d}
Beer	7.77 ± 2.46^{b}	7.58 ± 2.80^{b}	7.60 ± 4.99^{b}	8.39 ± 2.99^{b}
Whiskey	5.45 ± 1.19^{c}	5.54 ± 2.81^{c}	5.35 ± 1.18^{c}	6.13 ± 0.79^{c}
Wine	14.76 ± 2.29^{a,B}	12.54 ± 5.67^{a,B}	12.08 ± 4.31^{a,B}	24.30 ± 9.23^{a,A}

$^{a-d}$ Different superscript letters (in column) state statistically significant difference between alcoholic beverages (p-value < .05)
^{A,B} Different superscript letters (in row) state statistically significant difference between materials (p-value < .05)

and the CIE L*a*b* coordinate system were used in this study. A spectrophotometer is more exact than the naked eye in measuring slight color change (ΔE) in objects on flat surfaces. It also has other advantages including repeatability, sensitivity, and objectivity. ΔE values that are greater than 3.3 are clinically unacceptable.[21,22]

According to the results of this study, all materials were significantly stained after immersion in the alcoholic beverages. Stain susceptibility of restorative materials can be a result of various factors. The resin matrix used in the materials has also been shown to play an important role in staining susceptibility.[23,24] Urethane dimethacrylate (UDMA) seems to be more stain-resistant than Bis-GMA because of its low water absorption and solubility characteristics.[25] It was reported that the water uptake in Bis-GMA based resins increased from 3 to 6%, while that in TEGDMA increased only from 0 to 1%.[24]

Filtek Z350 XT composes of major components including Bis-GMA, TEGDMA, Bis-EMA and UDMA, while Premise, Herculite and resin matrix of Beautifil II composes of only Bis-GMA and TEGDMA. Hence the results of this study to be showed that Filtek Z350XT (nanofilled resin composite) presented ΔE values greater than Herculite and Premise (nanohybrid resin composite) but lower than Beautifil II (giomer).

Staining of resins by alcoholic beverages is additionally caused by the adsorption or absorption of colorants by the resins.[26] The extrinsic staining of resins is modulated by its water sorption rate.[27] Dimethacrylate and methacrylate-modified polysiloxane resins may have greater water sorption than silorane resin. Siloranes are hydrophobic, possibly making the oxirane groups difficult to be attacked by water or water-soluble materials.[28] The increased synergism between the filler particles and resin matrix may be responsible for the reduction in water sorption and solubility.[29] A previous study reported that color change and water sorption values of giomers were higher than that of resin composites.[30] According to the present results, giomer presented more higher ΔE values than resin composites. Moreover, the interface between the resin matrix and filler particles is one of the weak points of the composite material, with a high sensitivity to water sorption. It may be supposed that hydrolytic degradation of this interface can modify the way in which light is scattered by the particles.[31]

Giomer is composed of PRG filler particles in a resin matrix. PRG fillers function on the basis of a reaction between polyacrylic acid and fluoroaluminosilicate glass, and are capable of fluoride release as well as recharge.[30] The release of fluoride from a restorative material is known to be mediated by its capacity for water diffusion. At the same time, absorption of large amounts of water may cause chemical degradation of the material, debonding of the matrix and release of residual monomers.[30] Both the characteristics of hydrophilicity in a resin matrix and high water sorption capacity may explain the higher ΔE values of giomer than the values of resin composite in the present study.

The particle content also play an important role in esthetic restorative material for color stability.[32,33] A previous study showed that the filler particle size and distribution directly correlated to optical properties, and that nanofiller particles provide low visual opacity in non-pigmented dental composites.[34] In addition, a smaller filler size might contribute to a decrease in staining and enhance esthetic appearance.[35] Likewise the nanocomposite presented less staining than giomer because nanocomposites have smaller particles than giomers.

This present study showed that when all experimental specimens were immersed in distilled water for two weeks, the ΔE values were less than 3.3. However, the groups soaked in alcoholic beverages showed that ΔE values were more than 3.3, which is considered visually perceptible, especially in wine groups showing the highest ΔE, followed by beer and whiskey.

Staining susceptibility of restorative materials has several factors including titratable acidity, the degree of resin polymerization as well as beverage colorant absorption/penetration, which may also contribute to the amount of staining observed. In this present study, wine had the lowest pH of all alcoholic beverages. However, the results showed that the color changes after immersion in the various alcoholic beverages did not relate to the pH of beverages alone. The pH of the beverage reflects the strength of acidity, while titratable acidity shows the total amount of acid present (total acidity) and is measured by titration against a standard solution of sodium hydroxide. There is no direct relation between pH and total acidity. Wine has the highest titratable acidity because its main acid constituents are malic and tartaric acids, with a joint concentration of 5-8 g/L. Moreover, wine also has tannin while beer is composed of malted barley, hops, and yeast, and whiskey is composed of malt and grain.

In addition, resin composite color stability has also been associated with the degree of conversion.[36] Incomplete polymerized resin composite and giomer have greater susceptibility to discoloration due to the larger amount of residual mononers available to form colored degraded products.[37]

The results of the present study provided infomation on the stain susceptibity of direct esthetic restorations by some commonly consumed drinks in daily life. However, the present study evaluated only in vitro effects with some limitations. The dilution effects of saliva and other fluids including pH change in the oral cavity should also be considered. Therefore, further studies are required to examine the effects of these beverages in vivo.

Within the limitation of this study, the following conclusions could be drawn: Alcoholic beverages significantly affected the stainability of materials after evaluation at the end of the 14 days immersion period, in addition, giomer showed significantly greater color change than resin composites.

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International Abstract

Biology of soft tissue woundhealing and regeneration – Consensus Report of Group 1 of the 10th European Workshop onPeriodontology

H€ammerle CHF, Giannobile WV. Biology of soft tissue wound healing and regeneration. Consensus Report of Group 1 of the 10th European Workshop on Periodontology.

J ClinPeriodontol 2014; 41 (Suppl. 15): S1–S5. doi: 10.1111 /jcpe.12221.

Abstract

Background: The scope of this consensus was to review the biological processes of soft tissue wound healing in the oral cavity and to histologically evaluate soft tissue healing in clinical and pre-clinical models.

Aims: To review the current knowledge regarding the biological processes of soft tissue wound healing at teeth, implants and on the edentulous ridge. Furthermore, to review soft tissue wound healing at these sites, when using barrier membranes, growth and differentiation factors and soft tissue substitutes.

Collection of data: Searches of the literature with respect to recessions at teeth and soft tissue deficiencies at implants, augmentation of the area of keratinized tissue and soft tissue volume were conducted. The available evidence was collected, categorized and summarized.Fundamental principles of oral soft tissue wound healing: Oral mucosal and skinwound healing follow a similar pattern of the four phases of haemostasis, inflammation, proliferation and maturation/matrix remodelling. The soft connective tissue determines the characteristics of the overlaying oral epithelium.Within 7–14 days, epithelial healing of surgical wounds at teeth is completed.Soft tissue healing following surgery at implants requires 6–8 weeks for maturation.The resulting tissue resembles scar tissue. Well-designed pre-clinical studiesproviding histological data have been reported describing soft tissue wound healing,when using barrier membranes, growth and differentiation factors and softtissue substitutes. Few controlled clinical studies with low numbers of patientsare available for some of the treatments reviewed at teeth. Whereas, histologicalnew attachment has been demonstrated in pre-clinical studies resulting fromsome of the treatments reviewed, human histological data commonly report alack of new attachment but rather long junctional epithelial attachment andconnective tissue adhesion. Regarding soft tissue healing at implants human dataare very scarce.

Conclusions: Oral soft tissue healing at teeth, implants and the edentulous ridgefollows the same phases as skin wound healing. Histological studies in humanshave not reported new attachment formation at teeth for the indications studied.Human histological data of soft tissue wound healing at implants are limited.

Five-year clinical results fortreatment of intrabonydefects with EMD, guidedtissue regeneration andopen-flap debridement:a case series

Mitani A, Takasu H, Horibe T, Furuta H, Nagasaka T, Aino M, Fukuda M, Fujimura T, Mogi M, Noguchi T. Five-year clinical results for treatment of intrabony defects with EMD, guided tissue regeneration and open-flap debridement: a case series.

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Background and Objective: Although regenerative periodontal surgery with EMDor guided tissue regeneration (GTR) has been shown to enhance periodontalregeneration, there are limited data on the long-term results following these treatmentmodalities. The purpose of the present study was to investigate the long-termclinical outcomes in intrabony defects following regenerative periodontal surgerywith EMD or GTR compared with open-flap debridement (OFD).

Material and Methods: Data from 40 subjects (44 teeth), with no history ofsmoking or systemic diseases that could interfere with periodontal disease andwho received one of three surgical procedures (EMD, GTR or OFD) for twoorthree-wall intrabony defects, were analyzed. Postoperative reduction inprobing pocket depth, gain in clinical attachment level, gingival recession andpercentage bone fill were compared at 1, 3 and 5 years.

Results: Reduction in probing pocket depth after GTR was significantly higherthan after OFD at 1 and 3 years postoperatively, but there was no differencebetween the groups at 5 years. The gains in clinical attachment level for EMD (at 3 and 5 years) and for GTR (at 1, 3 and 5 years) were significantly greaterthan for OFD. Gingival recession after treatment with EMD and GTR showeda tendency toward positive results, whereas no such tendency was observed for OFD. Postoperative percentage bone fill for EMD and GTR was significantlygreater than for OFD at 3 and 5 years.

Conclusions: This is a retrospective study and an exploratory report with a highrisk of bias. Within the limits of the current study, it may be concluded thatsuperior gains in clinical attachment level and improved percentage bone fill canbe obtained with EMD and GTR when compared with OFD, and these can bemaintained over a period of 5 years.