

EFFECTS OF HYDROGEN PEROXIDE-BASED MOUTHWASHES ON COLOUR CHANGES OF STAINED DIRECT COMPOSITE RESINS RESTORATIONS

Original Article

Khushboo Shah*, Prateek Pachore**, Kushani Shah***, Shraddha Chokshi****, Zarna Sanghvi*****, Nishit Patel*****

ABSTRACT

Aim: The aim of this study was to evaluate the effect of three mouthwashes on colour changes of two different composite resins stained with tea. **Materials and Methods:** Twenty Five specimens were prepared for each of the two composite resins Filtek Z350 (Z350) and Polofil Supra (PS), and the specimens were then stained in a tea solution. Each composite group was randomly divided into five subgroups (n = 5) according to the immersion solution: Distilled water (DW) (negative control); Crest 3D White mouthwash (CR); Listerine whitening mouthwash (LS); Colgate Optic White Mouthwash(CO), and Opalescence PF gel (OP) (16% carbamide peroxide, positive control). The colour of the specimens was measured with a spectrophotometer according to the CIEL*a*b* colour scale at baseline, after staining, and on the 7th, 28th, and 56th days of the treatment period. The colour differences (ΔE) were analysed with a two way ANOVA followed by Tukey's test ($P < 0.05$). **Results:** The discoloration of the specimens after immersion in the mouthwashes decreased significantly over time. Only the staining of the Z350 specimens treated with CR, LS, and OP decreased to a clinically acceptable level at the end-treatment period. **Conclusion:** The nanohybrid composite (Z350) showed the least discoloration, followed by the microhybrid (Polofil Supra).

Received: 01-08-2018; **Review Completed:** 19-11-2018; **Accepted:** 29-01-2019

INTRODUCTION:

Composite resins are commonly used in restorative dentistry because they have excellent esthetic properties and can be bonded to dentin and enamel.¹ Their increasing popularity can be ascribed to esthetic demands from patients for tooth-coloured restorative materials. Although the initial esthetic outcome may be excellent, one of the major disadvantage of composite resins is discoloration after prolonged exposure to varied conditions in the oral cavity.²⁻⁴ The change in colour and loss of shade matching with the surrounding tooth structure cause esthetic problems and may lead to the replacement of restorations. This is a very expensive and time-consuming process.^{5,6}

The colour stability of composite materials has been examined by artificial aging and by immersion in colored solutions, such as tea, coffee, and red wine.^{5,9} A number of factors, such as incomplete polymerization, water sorption, chemical reactivity, diet, oral hygiene, and surface roughness of the restoration, can influence the degree of discoloration.¹⁰ The structure of the composite resin and the characteristics of the particles have a direct impact on the surface roughness and susceptibility to extrinsic discoloration. Villita et al reported that hydrophobic materials showed better colour stability and stain resistance than hydrophilic materials.⁸

Mouthwashes are very popular oral hygiene agents. They can chemically control cariogenic biofilms and aid remineralization. Due to the rise in patients' concerns about the esthetic appearance of their teeth in recent years, the number of mouthwash products containing hydrogen peroxide has significantly increased.¹¹ Mouthwashes that include a low concentration of hydrogen peroxide and sodium hexametaphosphate can help prevent stains and fight plaque buildup.¹² Hydrogen peroxide penetrates the tooth and produces free radicals, which attack and break apart the chromophore bonds of large, long chain, dark-coloured molecules; this eventually breaks down the molecules and chromophore bonds, resulting in changes in tooth colour.²⁵ However, in some cases, hydrogen peroxide may not whiten teeth substantially due to the method of application and the length of time it is in contact with the teeth. Ganay et al examined the effects of bleaching agents on composite resin materials.^{13,14} However, there is little information available on the impact of mouthwashes on stained direct composites.

AIM AND OBJECTIVES:

The aim of this *in vitro* study was to evaluate colour changes in two stained universal composite resins immersed for different times in three hydrogen peroxide based mouthwashes compared with those immersed in a 16% carbamide peroxide bleaching gel.

*PG Student, **PG Student, ***PG Student, ****Head of the Department, *****Professor, *****Senior Lecturer

DEPARTMENT OF CONSERVATIVE DENTISTRY AND ENDODONTICS, AHMEDABAD DENTAL COLLEGE AND HOSPITAL

ADDRESS FOR AUTHOR CORROSPONDENCE : DR. KHUSHBOO SHAH, TEL: +91 9712088442

The null hypotheses were that:

1. The mouthwashes would not affect the colour stability of the composite resins,
2. The immersion time in the mouthwashes would not affect the results,
3. There would be no significant colour differences among the mouthwashes used.

MATERIALS AND METHOD:

The details of the materials used in this study are presented in Tables 1 and 2. Twenty five specimens from each universal composite resin Filtek Z350 (Z35), and Polofil Supra(PS), A2 shade, were prepared using a silicon cylindrical mould (10 mm in diameter and 2 mm in depth). Each composite resin was loaded into the mold, fixed on a glass slide, and covered with a transparent Mylar strip. Excess materials were then removed by applying pressure on another glass slide placed on the Mylar strip to obtain a flat surface. The composite resins were polymerized with a light-emitting diode (LED-D, Woodpecker) according to the manufacturer's recommended cure time. The power output of the light unit was checked using a power meter (Bluephase Meter-II, Ivoclar Vivadent, India) to maintain the light intensity at 800 mW/cm². The specimens were removed from the molds, and the top and bottom surfaces of the composites were polished with finer grit (Sof-Lex, 3M ESPE, St. Paul, MN, USA) for 10s. The polishing process was conducted using a low-speed handpiece under dry conditions. To complete the polymerization, the specimens were stored in distilled water and dark containers at 37°C for 24 hours.

The prepared composite specimens were immersed for 7 days in a tea mixture, which was prepared by brewing 3.5 g of black tea (Tata Tea Gold, Tata Tea, India) in 100 mL of boiled distilled water for 10-12 min. The specimens were then washed with running distilled water for 1 min. Twenty -five stained specimens per composite resin were then randomly divided into five different groups (n = 5) according to the immersion solution: Distilled water (DW group, negative control), Crest 3D White whitening mouthwash for 4 min daily for 56 days at 37°C (CR group), Listerine whitening mouthwash for 4 min daily for 56 days at 37°C (LS group), Colgate Optic White whitening mouthwash for 4 min daily for 56 days at 37°C (CO group), and

a positive control group, with the specimens placed in glass containers filled with bleaching gel Opalescence PF (16% carbamide peroxide) for 4 hours daily at 37°C, for 14 days (OP group). All the specimens were immersed in distilled water in dark containers at 37°C for the rest of the day. After the completion of bleaching with carbamide peroxide, the specimens were immersed in distilled water until the end of the experiment.

One trained operator used a digital spectrophotometer (VITA Easyshade Advance, Zahnfabrik, Bad Säckingen, Germany) to measure the colour of each specimen in standardized daylight against a standard white background. The spectrophotometer was calibrated according to the manufacturer's recommendations. The spectrophotometric data were recorded according to the colour system recommended by the Commission international de l'éclairage (CIELAB-CIE1976 L*a*b*). The L* scale indicates the amount of lightness in a specimen and varies from black (0) to white (100). The a* scale indicates the amount of red (+a*) and green (-a*) in the specimens, and the b* scale denotes the amount of yellow (+b*) and blue (-b*).

The colour measurements were performed at different times: Baseline (before staining the prepared composite specimens); after immersion in the tea solution; and after 7 days, 28 days,

and 56 days of whitening. The colour difference between two measurements was calculated using the following formula⁸:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{0.5} = [(L1-L0)^2 + (a1-a0)^2 + (b1-b0)^2]^{0.5}$$

Where the subscripts 0 and 1 denote the initial and final measurements, respectively.

When ΔE values are below 3.3 units, the difference is clinically acceptable.¹⁵ Colour differences in this study were calculated using baseline colour parameters at each measurement time: After staining (T0), and on the 7th (T1), 28th (T2), and 56th (T3) days of the treatment period. In the Opalescence group, the colour differences were calculated on days 7, 14 (recorded as 28 days in this study), and 56 of the treatment period.

Graph Pad Prism 7.0 was used to analyze the data. Parametric tests were used, as the data were normally distributed. After staining, the data

obtained were assessed by a paired t test. Between treatments (vs distilled water), mean colour change overtime was analysed by repeated measure two-way ANOVA. Within treatment, mean colour change at specified time was analysed by paired t test. After the whitening period, analysis of the mean ΔE values (between each mouthwashes) was performed with a two-way repeated-measure ANOVA and Tukey's multi-group comparison test at $P < 0.05$.

Table 1 - Composition of mouthwashes and bleaching gel used in this study

Brand name (code)	Manufacture	Material composition
Listerine whitening mouthwash (LS)	Johnson & Johnson Healthcare Products, Skilman, NJ, USA	Water, alcohol (8%), hydrogen peroxide, tetrapotassium pyrophosphate, pentasodium triphosphate, citric acid, poloxamer 407, flavor, sodium saccharin, sucralose
Crest 3D White Multi-Care whitening mouthwash (CR)	Procter & Gamble, Cincinnati, OH, USA	Water, 1.5% hydrogen peroxide, propylene glycol, sodium hexametaphosphate, poloxamer 407, sodium citrate, flavor, sodium saccharin, citric acid
Colgate optic white mouthwash (CO)		Water, Glycerin, Propylene Glycol, Sorbitol, Hydrogen Peroxide, Tetrapotassium Pyrophosphate, Polysorbate 20, Phosphoric Acid, Tetrasodium Pyrophosphate, Flavor, Citric Acid, Sodium Saccharin, Sucralose.
Opalescence PF 16% (OP)	Ultradent Products Inc., South Jordan, UT, USA	Glycerin, water, xylitol, carbamide peroxide, flavor, carbomer, PEG-300, sodium hydroxide, potassium nitrate, EDTA, sodium fluoride

Table 2 - Composition of composite resin materials tested in this study

Composition (code)	Resin type (Universal,A2)	Manufacture	Composition
Filtek Z350 (Z35)	Nanofilled	3M ESPE, St. Paul, MN, USA	Resin- bis-GMA,UDMA,TEGDMA and bis-EMA Filles-20nm silica filler, 4-11nm zirconia filler, and aggregated zirconia/silica cluster filler. Filler amt-63.3vol % (78.5 wt %)
Polofil Supra(PS)	Microhybrid	Voco GmbH, Germany	60% vol%(76.5wt%),inorganic fillers, microfillers (approx.. 0.05um%) and micro particle fillers (approx.0.5-2 um)

RESULTS

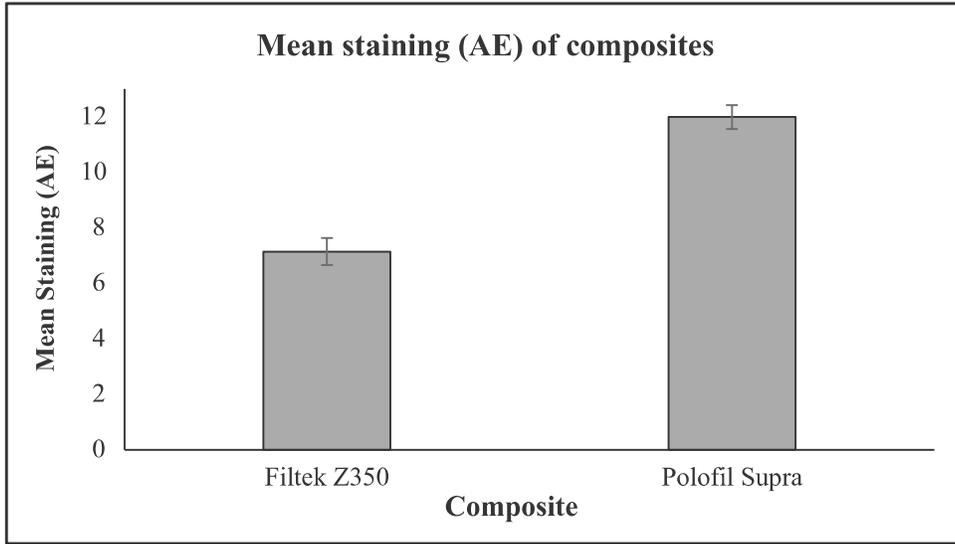
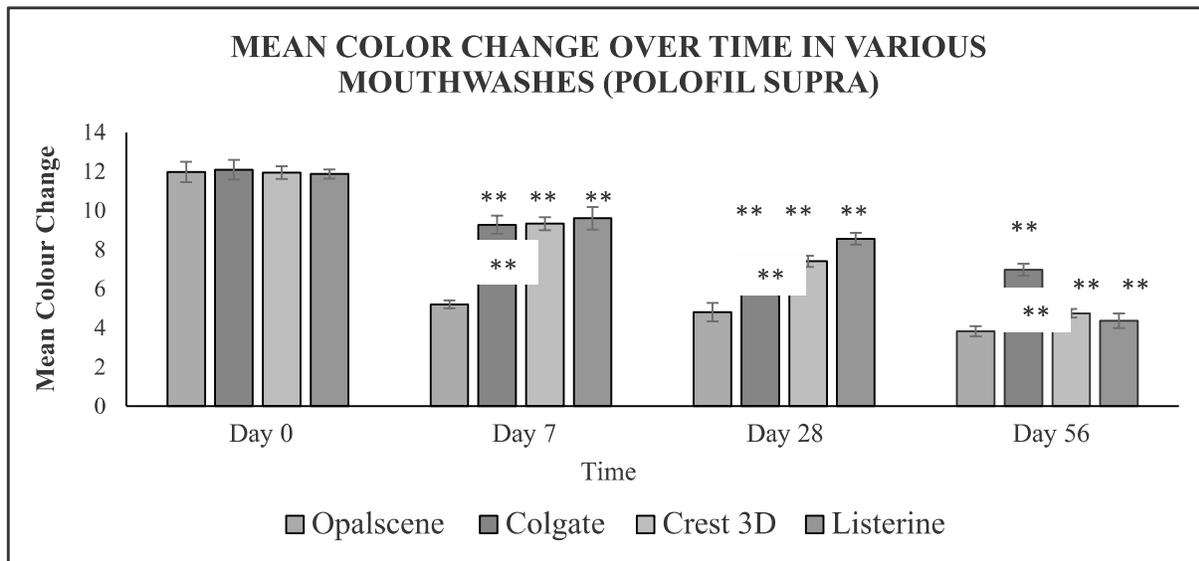


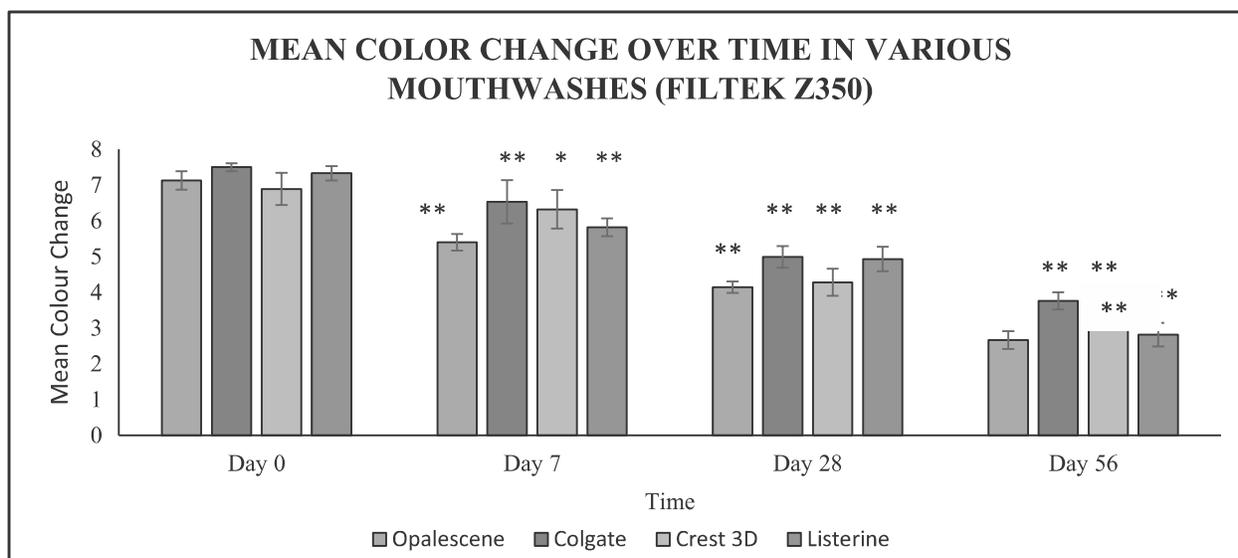
Figure 1: Mean colour changes of composites after immersion in tea solution

The colour changes (ΔE) of all the composite resins after immersion in the tea solution are represented in Figure 1. The level of staining differed significantly among the composite resin groups ($P < 0.01$) ** $p < 0.01$

Figure 2: The mean \pm standard deviations colour change over time after various mouthwashes treatment (N=5 in each treatment)



** $p < 0.01$, * $p < 0.05$ denotes statistically significant difference



** p < 0.01, * p < 0.05 denotes statistically significant difference

Table 1: The results of two way repeated measure ANOVA

FILTEK Z350				
Effect	DF	Mean Square	F	P
<i>Tests of between-treatment effects</i>				
Mouth wash	3	8.65	6.4	0.0007
Composite	3	56.5	41.83	<.0001
Mouthwash x Composite	9	0.95	0.71	0.69

In Filtek Z350 composite, the results of the repeated measure ANOVA revealed that the immersion time in the mouthwashes and mouthwash used, and the interactions among them did not significantly affected the ΔE values (p=0.69)

Table 2: The results of two-way repeated-measure ANOVA

POLOFIL SUPRA				
Effect	DF	Mean Square	F	P
<i>Tests of between-treatment effects</i>				
Mouth wash	3	24.89	132.84	<.0001
Composite	3	172.39	920.16	<.0001
Mouthwash x Composite	9	6.48	34.61	<.0001

In Polofil Supra composite, the results of the repeated measure ANOVA revealed that the immersion time in the mouthwashes and mouthwash used, and the interactions among them significantly affected the ΔE values (p=<.0001)

DISCUSSION:

This in vitro study evaluated colour changes of stained composite resin specimen treated with commercially available mouthwashes containing hydrogen peroxide. The findings of the two-way ANOVA revealed that the immersion period and the mouthwashes had a major influence on colour changes. Thus, the null hypothesis that the mouthwashes would have no effect on colour stability of stained composite resin was rejected.

The colour stability of different composite resin materials has been reported to be inconsistent.¹⁶ The staining susceptibility of a composite resin may be attributed to its resin matrix or filler type.¹⁷ Antonson et al reported that the size and composition of filler particles affect the roughness of composite resin materials,¹⁸ with smaller voids left on the surface of nanohybrid composite resins compared to other composite materials.^{19,20} The results of our study showed that the staining susceptibility of a nanohybrid composite, Filtek Z350, was significantly lower than that of the other composites.

One of the most prevalent drinks in the world is tea. Tea produced more severe staining in tooth-colored restorative materials than did cola-based beverages.^{17,22} In the present study, tea staining was preferred because tea has been proven to have a higher capacity for staining composite resins than other solutions, such as coffee or other beverages^{15,16}.

The findings of the current study demonstrated that the colour of the tea-stained Z350 specimens in the Listerine and Crest 3D groups returned to baseline after 56 days of immersion ($\Delta E < 3.3$). Only the mean ΔE values of the Z350 composite specimens bleached with the at-home bleaching gel decreased to an acceptable level after 14 days of the treatment. Villalta et al.⁸ examined the effects of bleaching systems on colour changes of nanocomposite and microhybrid resins stained with different solutions and reported that the colors of both types of composite specimens returned to the baseline. On the other hand, in a study of the effectiveness of mouthwashes in the colour recovery of a stained microhybrid composite, Harorli et al.²⁴ found that the immersion time in the mouthwash and the brand of mouthwash had a significant effect on the color recovery of the stained composite.

In the present study, Distilled Water was selected as the negative control group because water is a common component of both solid and liquid diets. Hattab FN et al demonstrated that although water helped to dissolve stains and ameliorated color changes in composite resins, it did not fully dissolve hydrophobic molecules.²³ In the present study, the level of staining of Polofil Supra composites significantly decreased with increased time when immersed in Distilled Water but that of the Z350 composites did not change, which may be attributed to various factors, such as the filler content, filler type, and water solubility.

The mouthwashes tested in this study included whitening products containing a low concentration of hydrogen peroxide (1-2%), sodium hexametaphosphate, and pyrophosphates. These products work either by bleaching or by removal and control of stains.^{12,24} The actual teeth whitening mechanism of hydrogen peroxide is not fully known, but it is thought to be the result of an oxidation reaction in which the pigment molecules are broken down.^{25,26}

Lu H et al suggested that the colour change of composite resins after the use of whitening agents was due to extrinsic cleansing of specimens, not an intrinsic colour change.⁸ In the present study, the mouthwashes were effective in removing stains from the composite resins over time. At the end of the 56-day treatment period, there were no statistically significant differences in the color change of any of the composites tested, irrespective of the type of mouthwash used. Only the Listerine mouthwash was as effective as the at-home bleaching gel in removing stains from all the composite resins tested.

Carbamide peroxide (16%) was chosen as the positive control group because home bleaching methods are commonly used in dental practice to whiten teeth.^{27,28} Home bleaching gel (10% carbamide peroxide) contains 3.5% hydrogen peroxide, and this percentage is greater than that found in the mouthwashes examined in this study.

The efficacy of whitening mouthwashes may be decreased by the fact that they are in contact with the teeth for a short period of time compared with bleaching gel for use at home. In the present study, the immersion time in the mouthwash had a significant influence on stain removal from the

composite. However, the continuous use of a mouthwash can cause side effects, such as mucosa desquamation, ulceration, inflammation, allergic reactions, and burning mouth sensation.

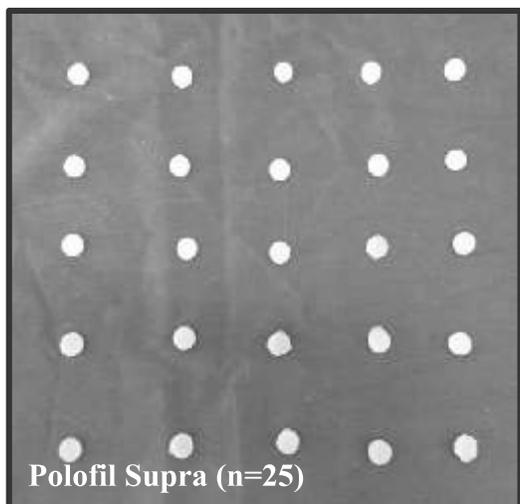
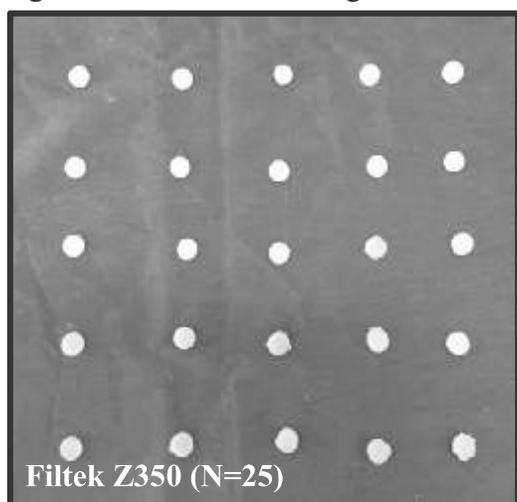
Mouthwashes have become extremely popular teeth whitening agents because of their ease of application, low cost, and wide availability. Consequently, after using whitening products, the colour of the composite resin restoration may not match that of the surrounding whitened teeth. Thus, patients should be informed that replacement of composite restorations in teeth may be required after use of whitening mouthwash, depending upon the extent of the color change.

This in vitro study evaluated the color stability of two different composite resin materials after immersion in only tea solution. The consumption of different staining substances, immersion time in staining solution, and absence of cleaning or brushing of the specimens during the study are significant factors affecting the colour stability of

composite materials.²² Therefore, additional studies should be conducted to evaluate the effect of mouthwashes in the composite materials under the oral environment and different storage conditions.

CONCLUSION:

In conclusion, immersion in a tea solution caused severe discoloration of the two composite types studied. The nanohybrid composite (Z350) showed the least discoloration, followed by the microhybrid (Polofil Supra). The discoloration of the specimens after immersion in the mouthwashes decreased significantly over time. The colour alteration (ΔE) in all the composite groups differed significantly at the time intervals evaluated compared to the Distilled Water group. Only the composites treated with the Listerine mouthwash showed a similar colour change to that of the Opalescence group. The staining of the Z350 composite treated with Crest 3D and Listerine decreased to the clinically acceptable level after the 56-day period.



Vita Easyshade Advance

REFERENCES:

1. Brunson WD, Bayne SC, Shurdevant JR, Roberson TM, Wilder AD, Taylor DF. Three-year clinical evaluation of a self-cured posterior composite resin. *Dent Mater* 1989;5:127-32.
2. Celik C, Ozgünaltay G, Attar N. Clinical evaluation of flowable resins in non-carious cervical lesions: Two-year results. *Oper Dent* 2007;32:313-21.
3. Kolbeck C, Rosentritt M, Lang R, Handel G. Discoloration of facing and restorative composites by UV-irradiation and staining food. *Dent Mater* 2006;22:63-8.
4. Sabatini C, Campillo M, Aref J. Color stability of ten resin-based restorative materials. *J Esthet Restor Dent* 2012;24:185-99.
5. Lu H, Roeder LB, Lei L, Powers JM. Effect of surface roughness on stain resistance of dental resin composites. *J Esthet Restor Dent* 2005;17:102-9.
6. Ahmed HM, Abbott PV. Discolouration potential of endodontic procedures and materials: A review. *Int Endod J* 2012;45:883-97.
7. Prodan DA, Gasparik C, Mada DC, Miclăuş V, Băciuş M, Ducea D. Influence of opacity on the color stability of a nanocomposite. *Clin Oral Investig* 2015;19:867-75.
8. Villalta P, Lu H, Okte Z, Garcia-Godoy F, Powers JM. Effects of staining and bleaching on color change of dental composite resins. *J Prosthet Dent* 2006;95:137-42.
9. Schulze KA, Marshall SJ, Gansky SA, Marshall GW. Color stability and hardness in dental composites after accelerated aging. *Dent Mater* 2003;19:612-9.
10. Dietschi D, Campanile G, Holz J, Meyer JM. Comparison of the color stability of ten new-generation composites: An in vitro study. *Dent Mater* 1994;10:353-62.
11. Maltz M. Over-the-counter preventive and therapeutic oral products. *Braz Oral Res* 2009;23(Suppl 1):4-7.
12. Lima FG, Rotta TA, Penso S, Meireles SS, Demarco FF. In vitro evaluation of the whitening effect of mouth rinses containing hydrogen peroxide. *Braz Oral Res* 2012;26:269-74.
13. Bailey SJ, Swift EJ Jr. Effects of home bleaching products on composite resins. *Quintessence Int* 1992;23:489-94.
14. Canay S, Cehreli MC. The effect of current bleaching agents on the color of light-polymerized composites in vitro. *J Prosthet Dent* 2003;89:474-8.
15. Douglas RD, Steinhauer TJ, Wee AG. Intraoral determination of the tolerance of dentists for perceptibility and acceptability of shade mismatch. *J Prosthet Dent* 2007;97:200-8.
16. ElEmbaby Ael-S. The effects of mouth rinses on the color stability of resin-based restorative materials. *J Esthet Restor Dent* 2014;26:264-71.
17. Bagheri R, Burrow MF, Tyas M. Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials. *J Dent* 2005;33:389-98.
18. Roeder LB, Tate WH, Powers JM. Effect of finishing and polishing procedures on the surface roughness of packable composites. *Oper Dent* 2000;25:534-43.
19. Antonson SA, Yazici AR, Kilinc E, Antonson DE, Hardigan PC. Comparison of different finishing/polishing systems on surface roughness and gloss of resin composites. *J Dent* 2011;39(Suppl 1):e9-17.
20. Turssi CP, Ferracane JL, Serra MC. Abrasive wear of resin composites as related to finishing and polishing procedures. *Dent Mater* 2005;21:641-8.
21. Sirin Karaarslan E, Bulbul M, Yildiz E, Secilmis A, Sari F, Usumez A. Effects of different polishing methods on color stability of resin composites after accelerated aging. *Dent Mater J* 2013;32:58-67.
22. Baruteigil Ç, Yıldız M. Intrinsic and extrinsic discoloration of dimethacrylate and silorane based composites. *J Dent* 2012;40(Suppl 1):e57-63.
23. Yew HZ, Berekally TL, Richards LC. A laboratory investigation of colour changes in two contemporary resin composites on exposure to spices. *Aust Dent J* 2013;58:468-77.

24. Harorli OT, Barutçigil C. Color recovery effect of commercial mouth rinses on a discolored composite. *J Esthet Restor Dent* 2014;26:256-63.
25. Joiner A. Tooth colour: A review of the literature. *J Dent* 2004;32(Suppl 1):3-12.
26. Hattab FN, Qudeimat MA, al-Rimawi HS. Dental discoloration: An overview. *J Esthet Dent* 1999;11:291-310.
27. Auschill TM, Hellwig E, Schmidale S, Sculean A, Arweiler NB. Efficacy, side-effects and patients' acceptance of different bleaching techniques (OTC, in-office, at-home). *Oper Dent* 2005;30:156-63.
28. Joiner A. The bleaching of teeth: A review of the literature. *J Dent* 2006;34:412-9.
29. Torres CR, Perote LC, Gutierrez NC, Pucci CR, Borges AB. Efficacy of mouth rinses and toothpaste on tooth whitening. *Oper Dent* 2013;38:57-62.
30. Goldberg M, Grootveld M, Lynch E. Undesirable and adverse effects of tooth-whitening products: A review. *Clin Oral Investig* 2010;14:1-10.
31. Hannig C, Duong S, Becker K, Brunner E, Kahler E, Attin T. Effect of bleaching on subsurface micro-hardness of composite and a polyacid modified composite. *Dent Mater* 2007;23:198-203.
32. Gerlach RW, Gibb RD, Sagel PA. A randomized clinical trial comparing a novel 5.3% hydrogen peroxide whitening strip to 10%, 15%, and 20% carbamide peroxide tray-based bleaching systems. *Compend Contin Educ Dent Suppl* 2000;29:S22-8; quiz S42-3.