Evaluating the possibility of re-polishing and in-office bleaching in removing the stains induced by common beverages on direct composite resin: a comparative *in vitro* study

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N Jain[1], A Kumari[2], HL Usha[3], N Meena[4], D Mehta[5], A Gupta[6]

ABSTRACT

Aim: Discolouration of direct composite resin restoration poses a significant aesthetic problem. This study compares the staining capacities of various beverages on direct composite materials, and compares the stain removing abilities of in-office bleaching using 38% Hydrogen Peroxide (Opalescence Boost) and re-polishing with Sof-Lex polishing system (3M ESPE).

Materials & Methods: 180 composite resin specimens were prepared, incubated and immersed in six staining solutions: tea, tea with sugar, coffee, coffee with sugar, Coca-Cola and water (control) for seven days. 90 randomly selected samples were then bleached and the remaining 90 were re-polished. Colour measurements were made with a spectrophotometer, just before immersion, after one, three, five and seven days, and after bleaching and polishing procedures.

Results: Coffee with sugar solution showed the maximum staining effect. Bleaching and re-polishing were found equally effective with no statistically significant differences observed.

Conclusion: The presence of sugar in coffee and tea solutions increases the stainability of direct composite resin. Most of the staining observed on resin composites is superficial and can be partially removed by re-polishing or bleaching procedures.

Clinical Significance: Sugar in beverages increases the staining of direct composites. Bleaching and re-polishing are equally effective in removing stains from discoloured direct composite resins.

Keywords: bleaching; composites; cosmetics; dental material; laboratory research; veneers

1. **N Jain:** Department of Conservative Dentistry & Endodontics. Hitkarini Dental College & Hospital, Jabalpur, India.
2. **A Kumari:** Department of Conservative Dentistry & Endodontics. V.S. Dental College & Hospital, Bangalore, India.
3. **HL Usha:** Department of Conservative Dentistry & Endodontics. V.S. Dental College & Hospital, Bangalore, India.
4. **N Meena:** Department of Conservative Dentistry & Endodontics. V.S. Dental College & Hospital, Bangalore, India.
5. **D Mehta:** Department of Conservative Dentistry & Endodontics. V.S. Dental College & Hospital, Bangalore, India.
6. **A Gupta:** Department of Orthodontia. Hitkarini Dental College & Hospital, Jabalpur, India.

Corresponding author

N Jain:
Department of Conservative Dentistry & Endodontics, Hitkarni Dental College & Hospital, Dumna Hills, Airport Road, Jabalpur, India.
Tel: +91 942 439 2599. E-mail: niharika.dr@gmail.com

INTRODUCTION

Over the past two to three decades, the dental profession has witnessed a shift from restorative to elective cosmetic procedures.[1] One of the main reasons that patients seek aesthetic dental treatment is a real or perceived discolouration of anterior teeth. Discoloured teeth can be treated with various restorative techniques such as direct composite veneers, porcelain veneers, ceramic crowns or even vital tooth bleaching.[2] Resin composite veneers remain the treatment of choice in most cases for discoloured anterior teeth because of their excellent aesthetic properties and cost effectiveness. However, a major disadvantage is the discolouration occurring after prolonged exposure to the oral environment. Unacceptable colour match is a primary reason for replacement of composite resin restorations.[3]

The staining of resin-based materials by coloured solutions such as coffee, tea, and other beverages,[4-6] and colour stability after aging in different solutions[7-8] have been reported. Studies have also shown that the inclusion of sugar into these beverages increases the colour difference as compared with the effect of beverages without sugar. Various methods such as bleaching, re-polishing and replacement of existing stained restorations have been suggested to remove the discolouration to re-establish the aesthetics of these restorations. Re-polishing appears to be the most

popular and well reported method,[9] even for highly stained composites, but the process removes material from the restoration surface.[2] Bleaching procedures may therefore appear to be a non-destructive method of solving the problem. There are scant reports of how bleaching agents affect stained resin composite restorations.

This study evaluated the effects of re-polishing and bleaching on dental composite resin specimens which had been artificially stained with commercially available cola, and with coffee and tea solutions, either with no added sugar or containing a standardized amount of sugar. The CIELAB colour technique was utilised for the evaluations.

METHODS AND MATERIALS

180 resin composite specimen discs (Amelogen Plus A2 shade microhybrid composite resin, Ultradent, South Jordan, USA) were prepared with a height of 2.5mm and diameter of 6mm and were roughened with silicon carbide paper. These specimens were then polished dry using Soflex discdiscs (3M ESPE, Dental Products) in a slow speed handpiece with coarse, medium, fine and ultrafine discdiscs, each grit being used for 30 seconds. The specimens were then incubated at 37ºC for 24 hours before baseline measurements were taken. The composition and manufacturers of the products included in the study are shown in Table 1.

Six solutions were prepared and the sample specimens randomly divided into six groups.

Group I: Tea without sugar
The tea solution was prepared by immersing 5 tea bags (Brooke Bond Tea, 5*2.6 gm) into 500 ml of boiling water for 10 minutes.

Group II: Tea with sugar
Tea solution was prepared as in Group I, and then 16 grams of white sugar (Parry's refined white sugar) was added for every 500 ml.

Group III: Coffee without sugar
15 gram of coffee (Nescafe Classic) was dissolved in 500 ml of boiling water, and filtered through a filter paper after 10 minutes of stirring.

Group IV: Coffee with sugar
The coffee solution was prepared as in Group III, and the 16 gram of white sugar was added for every 500 ml.

Group V: Coca Cola
Coca Cola solution stored at 37ºC

Group VI: Water
Solution of tap water at 37° C, which served as a control.

For each Group the specimens were divided into lots of six, the discs placed vertically on special holders and then immersed in 20 cc of the staining solution in glass containers at 37ºC +/- 1ºC. The assembly was kept in the dark for seven days. The solutions were not agitated. At the end of one week, 90 of the samples which had been immersed in the staining solutions were randomly selected and subjected to bleaching (38% Hydrogen Peroxide, Opalescence Boost, Ultradent, USA) for one hour continuously. The remaining 90 specimens were re-polished for 30 seconds with the polishing system used earlier. Colour measurements were made just before immersion (baseline): after 1 day (T1); after 3 days (T2); after 5 days (T3); after 7 days (T4); after the bleaching procedure (T5) and after the polishing procedure (T6). Before each measurement, the specimens were cleaned ultrasonically in distilled water for 1 minute and dried with air spray.

The colour and colour difference of each specimen were measured by a spectrophotometer (X-rite spectrophotometer, X-Rite Inc, USA) (Figure 2). The measuring characteristics

Table 1: Products and manufacturers included in the study

Amelogen Plus	Shade: A2 Filler size/content: 0.7µm, 76% by weight Matrix composition: Bis-GMA Manufacturer: Ultradent Product, South Jordan,UT, USA
Opalescence Boost	Content: 38% hydrogen peroxide Manufacturer: Ultradent Product, South Jordan,UT, USA
Soflex polishing system	Content: Aluminium oxide polishing disc-discs Manufacturer: 3M/ESPE Dental Products, St. Paul, MN, USA
Brooke Bond tea bags	Manufacturer: Hindustan Unilever Limited, India
Nescafe classic, Instant coffee	Manufacturer: Nestle USA Inc. Glendale, CA, USA
White sugar	Manufacturer: E.I.D-Parry Ltd., India
Coca-Cola	Manufacturer: The Coca-Cola Company, Atlanta, GA, USA

Table 2: Mean Delta E Values recorded in the different groups in different groups irrespective of the days.

Group	Mean	SD§	Median	Min.	Max.
Group 1	2.31	0.67	2.33	0.83	4.04
Group 2	2.54	0.94	2.42	0.61	5.00
Group 3	2.60	0.89	2.62	0.68	5.10
Group 4	2.87	1.27	2.65	0.95	9.44
Group 5	1.13	0.44	1.17	0.16	2.30
Group 6	0.81	0.44	0.72	0.11	2.62

§ Denotes Standard Deviation

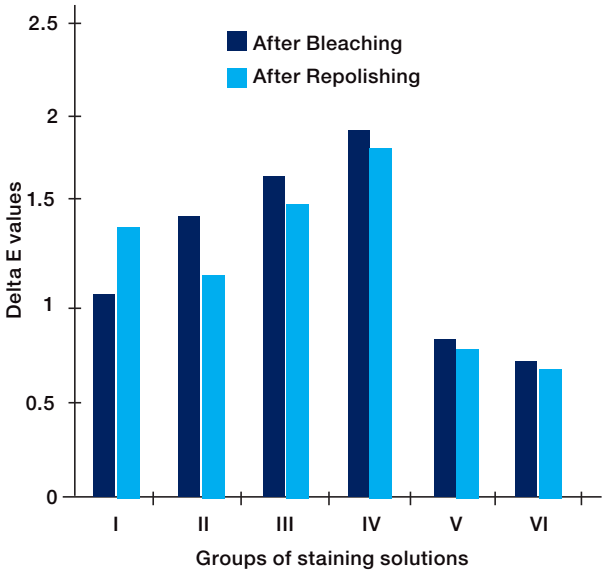

Figure 1: Comparison of Delta E values for the different groups of specimens after bleaching and re-polishing procedures.

of the spectrophotometer were standard illuminant D65, illuminating geometry d/8° and standard observer 10°. Before each measurement session, the colourimeter was calibrated according to the manufacturer's recommendations by using the supplied white calibration standard. The discs were mounted at 90° relative to the light source. Colour measurements were made under daylight conditions and at the same time of the day. Values were recorded in the Commission International de l'Eclairage (CIELAB) colour system.

L*, a*,and b* values of each specimen before immersion (baseline) and after all procedures were measured six times by placing each specimen on the measuring head. The values of Δ L*, Δ a*, and Δ b* after six measurements were automatically calculated by the colourimeter and were recorded. Resistance to staining effects is expressed in Δ E* units and was calculated from the mean Δ L*, Δ a*, and Δ b* values for each specimen with the following formula:
ΔE*=[(L0-Ll)2+(a0-al)2+(b0-bl)2]1/2

The colour changes observed between the different staining media during the study were tabulated and subjected to analysis of variance (ANOVA) and a multiple comparison test with a p value set at 0.05.

RESULTS

The Group Four specimens immersed in coffee with sugar showed the maximum colour change, followed in deceasing order by Group 3, Group 2, Group 1 and Group 5. Least colour change was observed in specimens in Group 6. Table 2 shows mean, standard deviation and range (min. and max.) of Δ E values of prepared resin composite specimens in different groups irrespective of the days. The difference in mean Δ E Values between the groups were found to be statistically significant (P<0.001). Multiple comparison of the ΔE values of all the specimens immersed in the different staining solutions was carried out using the Bonferroni test.

It was observed that the specimens immersed in tea with sugar solution (Group II) showed more colour change than specimens immersed in tea solution (Group I), and similarly specimens immersed in coffee with sugar solution (Group IV) showed more colour change than specimens immersed in coffee solution (Group III).

Comparison of the mean delta E values revealed a statistically significant difference in the reduction of those values from day 7 to "after re-polishing" (P<0.001) and from day 7 to "after bleaching (P<0.001) in all the groups, except in Group VI, where neither procedure was effective in significantly reducing the water stains (Table 3). The reductions in mean delta E values between "after re-polishing" and "after bleaching" were found to be statistically insignificant (P<0.05) in all the Groups (Figure 1), suggesting that re-polishing and bleaching were equally capable of reducing all stains from the resin composite.

DISCUSSION

Colour stability is critical for the aesthetics of permanent restorative materials. This study the effect of common beverages on the colour stability of microhybrid composite resin and the effect of in-office bleaching and re-polishing in removing these stains. The tea and coffee solutions were prepared in accord with the studies done by Guler and colleagues[10] and Turkun and colleagues.[2] If is accepted that the average amount of time for the consumption of a cup of beverage is 15 minutes and that the average coffee drinker consumes 3.2 cups per day, and the tea drinker 4-8 cups per day, then exposure to the solutions for a full 24 hours reasonably simulates the consumption of those drinks over one month.[2] Hence sampling at 1, 3, 5 and 7 days reflects exposure over some years. This provides a suitable test for the composite resins which might become stained after a few years of being placed in the mouth.

Colour evaluation was performed using a colourimeter

Table 3: Comparison of Delta E values after 7 days with delta E values after re-polishing and bleaching

Groups	Time interval	Mean	SD§	Mean difference	t	P value
Group I	Day 7	2.67	0.5			
	After re-polishing	1.42	0.36	1.247	7.505	<0.001*
	After bleaching	1.07	0.37	1.599	12.160	<0.001*
Group II	Day 7	3.24	0.99			
	After re-polishing	1.49	0.40	1.755	5.427	<0.001*
	After bleaching	1.18	0.37	2.063	9.198	<0.001*
Group III	Day 7	3.32	0.85			
	After re-polishing	1.69	0.43	1.631	6.089	<0.001*
	After bleaching	1.54	0.32	1.777	7.716	<0.001*
Group IV	Day 7	3.55	1.81			
	After re-polishing	1.94	0.47	1.611	3.255	0.006*
	After bleaching	1.83	0.51	1.717	3.811	0.002*
Group V	Day 7	1.36	0.43			
	After re-polishing	0.83	0.33	0.527	3.927	0.002*
	After bleaching	0.78	0.31	0.579	4.053	0.001*
Group VI	Day 7	1.01	0.64			
	After re-polishing	0.73	0.34	0.282	1.562	0.141
	After bleaching	0.68	0.28	0.334	1.663	0.119

*Denotes significant difference

using Commission Internationale de l'Eclairge (CIE) L*a*b colour system which is well suited for the determination of small colour differences.[11] This system is related to the colour perception of the human eye for three coordinates for lightness, namely white-black(L*), red-green (a*), and yellow-blue (b*).12 The human eye can usually not detect ΔE* values of < 1.5, although this value is measurable using a colour spectrophotometer. A ΔE* value of 3.7 or less is considered to be clinically acceptable according to Johnston and Kao.[2] Staining effects caused by coffee, tea, and Coca Cola were measured and expressed in ΔE* units, with the lower values indicating less staining. After immersion, staining was observed in all the specimens. The susceptibility of resin-based materials to staining may be related to resin content, resin filler type, type of resin matrix, or type of the staining agent. The higher the resin content of a material, the less is its resistance to photolysis, photo-oxidation and water sorption, thus rendering it more susceptible to staining.[13] On the other hand, higher monomer conversion indicates a low amount of unreacted monomer, lower solubility and higher colour stability. The Amelogen Plus microhybrid composite used in the present study is a Bis-GMA material which is about 76% filled by weight with a maximum particle size of 0.7 µm. Therefore, the staining susceptibility of this composite could be attributed primarily to the degree of conversion and the related water sorption values.

All the specimens immersed in the staining solutions, except those exposed to water, showed colour differences which were perceptible. Specimens immersed in coffee with sugar solution showed maximum colour change, followed by coffee solution, tea with sugar solution, tea and Coca-Cola. The staining ability of tea could be due to the presence of tannic acid.[14] Discolouration by tea might be due to absorption of polar colourants into the material surface and the higher discolouration by coffee might be due to both adsorption and absorption of colourants. This absorption and penetration of colourants into the organic phase of the material were probably due to compatibility of the polymer phase with the yellow colourants of coffee.[15] Cola drink does not appear to be strongly implicated in colour change of composites, despite the presence of phosphoric acid. Acids behave differently in promoting dissolution and hence in eroding the materials. In addition, the presence of phosphate ions in Coca-Cola may suppress the dissolution since these ions have been shown to reduce the dissolution rate of calcium phosphate from the tooth[3,9] When composite resins were immersed in water, the colour differences were imperceptible and clinically acceptable. This observation confirms that water sorption by itself did not alter the colour of composites to any extent. As immersion times increased, colour changes with the other media became more intense. The results were in agreement with those reported by, Yannikakis and colleagues, Chan and colleagues, and Fay and colleagues, all cited by Turkun.[2]

The reduction in mean Δ E values produced by the bleaching procedure could be attributed to the formation of very reactive per-hydroxyl free radicals which may break up large macromolecular stains into smaller stain molecules. But this chemical process is also believed to accelerate the hydrolytic degradation of composites, contributing to wear of the resin in both stress-bearing and non-stress-bearing areas.[15]

The limitation of the current study was that the storage conditions of the specimens does not mimic true oral conditions and the effect of bleaching on the structural integrity of the composite has to be studied to ascertain the long term durability of the composite restorations.

CONCLUSION

From the results of this study, it is concluded that

- Among the staining solutions used in the current study, coffee with sugar showed maximum staining of composite resin specimens, followed by coffee, tea with sugar and tea solutions resepectively. Coca-Cola and water resulted in the least staining. The presence of sugar in coffee and tea solutions increases the staining capacity.
- Most of the staining observed on resin composites is superficial and can be removed partially by re-polishing or bleaching procedures.

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