INTERNATIONAL JOURNAL OF CURRENT MEDICAL AND PHARMACEUTICAL RESEARCH

IJCMPR

Available Online at http://www.journalcmpr.com

RESEARCH ARTICLE

EFFECT OF FINISHING PROCEDURES AND BEVERAGES ON THE COLOR STABILITY OF DIRECT COMPOSITE ESTHETIC RESTORATIVE MATERIAL-AN IN VITRO STUDY

[1]Raghunath Patil, [2] Ruta Jadhav, [3]Sounyala Rayannavar and [4]Vinuta Hiremath

K.L.E. V.K. Institute of dental sciences, JNMC campus, Belagavi (590010), Karnataka

ARTICLE INFO

Article History:

Received 15th October, 2016
Received in revised form 7th November, 2016
Accepted 16th December, 2016
Published online 28th January, 2017

Key words:

Color stability, composite resin, surface roughness, nanohybrid

ABSTRACT

Aim: Evaluation of the effect of composite polishing systems and the type of storage solutions on color stability of resin-based direct composite at various time intervals in vitro.

Methods and Material: Forty discs were prepared using methacrylate-based nanofilled composite and polished with one of the two groups: aluminum oxide discs (Super-Snap) and diamond impregnated polishing wheels (Compomaster). Profilometric analysis and SEM observations were performed for determining the surface roughness. Samples were then sub-grouped (n=10) and immersed in beverages (distilled water, coffee, cola, orange juice) for 10 minutes each day. Color coefficients (CIE L*a*b*) were measured by a spectrophotometer before and after the immersions; after 24 hrs, 36 hrs and one week.

Statistical analysis: The results were compared among the four groups by two-way analysis of variance and Tukey's t-test ($p \leq 0.05$). Regression analysis was carried out to test if any correlation existed between color change and surface roughness.

Results: Significant correlation was found between the effects of surface roughness and color change of composite resins. Super-Snap system resulted in the best surface finish and lowest degree of color change. Highest level of mean color change was observed in coffee solution ($P < 0.05$) followed by cola and orange juice with maximum staining shown after one week.

Conclusions: Composite resin tested showed an acceptable color change after immersion in different beverages.

INTRODUCTION

Dental esthetics has become a rewarding discipline in dentistry, as patients have begun to demand for high esthetic value anterior restorations for improving and personalizing their smile. This exigency has led to the gradual introduction of improved direct esthetic restorative materials for obtaining better color stability, clinically acceptable surface smoothness of restorations and greater wear resistance.[1]

One of the most common clinical problems associated with these direct esthetic materials like composite resins is their discoloration.[2] The colour change of composite resins is multifactorial and dependent on extrinsic and intrinsic factors, which includes absorption or adsorption of colorants in the beverages (such as coffee, fruit juices, nicotine, mouth rinses), changes in the matrix/filler interface, poor oral hygiene, inadequate polishing technique, surface texture and surface integrity.[3]

Repair or replacement of these discoloured restorations is time-consuming and costly process for both patient and dentist.[3, 4] A smooth composite resin restoration is crucial for achieving good esthetic quality and long-term success, as rough surface is a major reason for plaque accumulation and esthetic failure of restoration.[2]

To achieve clinically acceptable surface smoothness of composite restorations, the manufacturers have introduced new 'nanofill' esthetic resin restorations. Nanofilled composites have the polish of a microfill and the strength of hybrids. They can be polished to the highest lustre and smoothest surface because of the nanoparticle sized fillers.[5] Surface roughness, colour stability and degradation under acidic conditions of the nanofilled composites are yet to be known and proven. With the goal of achieving a smooth surface composite restoration in fewer steps, various polishing tools have been used, ranging from fine and superfine diamond burs, abrasive disks, diamond and silicon impregnated soft rubber cups. The variety of polishing systems available should be evaluated to verify which polishing system yields the best polish effect on esthetic compositerestorations.[6]

While making a choice of direct esthetic composite material, property of colour stability is often ignored over other physical and mechanical properties. An ideal anterior esthetic composite restorative material should exhibit adequate esthetics as a function of colour stability in addition to adequate surface characteristics and biocompatibility.

Consumption of certain beverages has been reported to alter the esthetics and physical properties of resin composites affecting the clinical success of the restorations. Various studies have investigated the effect of different beverages on the colour stability of direct resin composites.[7, 8] However; researchers have not considered the effect of various polishing techniques on the colour stability of these restorations by determining its effect. Therefore, the aim of the study was twofold: (1) to evaluate the surface finish of a nanohybrid direct resin composite restorative material by two polishing systems, super-snap disc system and composite polishing kit system, (2) to evaluate the colour stability of direct composite esthetic restorative material following immersion in common beverages after 24 hours, 36 hours and one week period.The null hypotheses were that there would be no difference in the surface roughness between the two polishing systems when used on the same composite and no effect of beverages on the colour stability of direct composite esthetic restorative material.

METHODS AND MATERIAL

Preparation of specimens

Commercial resin composite, IPS Empress Direct (Ivoclar Vivadent) of a single standardized shade A2, two polishing systems (Super Snap, Compomaster) and three commonly consumed beverages (Table no.1) were selected for the study. A total of 40 disc-shaped specimens (n = 20 per polishing system) with the diameter of 17 mm, corresponding to the spectrophotometer sample compartment size and thickness of 1mm as required by ISO international standard #7491:2000.5 were prepared in a teflon mould. All samples were prepared as per the manufacturer's instructions.[9] Mylar strips were placed over each surface of the uncured composite to prohibit oxygen inhibition and 2 kg load was placed on the mould for 30 seconds to extrude the excess material.[6] Polymerization of the light-curing materials was performed with the use of a curing light (Curing Light XL 3000; 3M ESPE, St. Paul, Minn) on top of the specimens, through the Mylar strip, for 40 seconds.[10] The intensity of the polymerizing light was 400 mW/cm^2 and the diameter of the light tip was 1 cm.[7] Immediately after the light-curing cycle, the specimens were taken from the mould and immersed in deionized water at 37°C for 7 days in the dark. Following the storage period, one side of each specimen was finished with a 16-fluted carbide finishing bur (Brassler, Savannah, GA, USA) to simulate a clinical finishing procedure.[6] Twenty specimens were randomly assigned to each of the two polishing systems (group A and group B). Same operator performed finishing and polishing in a standardized way. Each polisher was used only once, and a slow-speed handpiece (5,000 rpm), with a contact pressure of 1.0 N monitored by a digital balance (AT200, Mettler) underneath the specimen, was used for polishing.[10] Twenty samples from each group were polished using one of the following two polishing systems (Figure no.1)

The Super-Snap Rainbow Technique Kit (Shofu)-group A; contained disks of four different grits. In this study, the last two grits; fine (green, 20-µm aluminum oxide–particle impregnated disk) and superfine (red, 7µm aluminium oxide–particle-impregnated disk) were each used for 30 seconds on each specimen surface (total polishing time 60 seconds) without water spray.[10]

Compomaster (No. 13S, Shofu)-group B; composed of 6-µm diamond-particles and 25-µm zirconium particles - impregnated rubber points, used for 30 seconds each without water spray.[10]

Table 1 Immersion solutions used in the study used.

Beverage		Composition	Brand
Group 1 (control)	Distilled water	20ml stored at 37°	-
Group 2	Cola	As supplied	Coca-Cola, Coca-Cola Company
Group 3	Coffee	(3 g/100 mL water) at 55°	Nescafe, Nestle
Group 4	Orange juice	Water, concentrated orange juice, natural orange flavouring substances	Tropicana, Pepsico, India

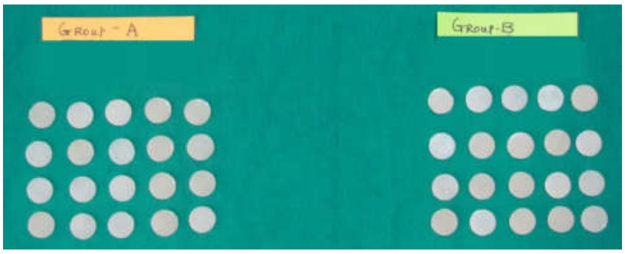


Figure-1 Composite resin samples after finishing and polishing with Super-Snap (group A) and Compomaster (group B) polishing systems.

Surface roughness analysis

After completion of polishing procedures, the specimens were rinsed with tap water, cleaned in an ultrasonic cleaner for 3 minutes, and air dried.[6] Surface roughness (Ra, µm) was measured with a surface profilometer (surtonic S128, Mumbai, Maharashtra), using a tracing length of 2mm and a cut-off value of 0.25mm to maximize filtration of surface waviness. Five tracings at different locations on each specimen were recorded. Surface microphotographs were taken using scanning electron microscope (JEOL, Japan; SM-6390, IIT Bombay).

Baseline color assessment

All specimens were immersed in distilled water at 37°C for 24 hours, then the baseline CIE values of all specimens were determined using a spectrophotometer (Shimadzu UV-3101PC, Shimadzu Scientific Instruments).[3] The color measurement process was standardized by accurate positioning of specimens using a custom jig.[3,11] All measurements were repeated twice, and means for the L, a, and b values were calculated.

Color assessment after immersion in solutions

The specimens of each group were then divided into four subgroups according to the immersion solutions (n=5). Group 1 was immersed in distilled water at 37°C for the entire week (control group). Group 2 was immersed in 100 mL of cola at room temperature for 10 minutes then washed with tap water and stored in distilled water until the next treatment. Group 3 was immersed in freshly prepared coffee at 55°C for 10 minutes every day, then washed and stored as described for group 2. Group 4 was immersed in orange juice following the same method used with group 2. All the specimens were subjected to their respective regimens for 24 hours (t1), 36 hours (t2), 7 successive days (t3). A color measurement was carried out for t1, t2, t3 study periods. The CIE values were measured for each specimen. ΔL, Δa, and Δb were determined, and the total color change (ΔE) was calculated using the formula.[12]

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

Statistical analysis

Two-way analysis of variance (ANOVA) was used to evaluate the data from profilometric and spectrophotometric experiments using statistical software (SPSS for Windows, version 19.0; SPSS Inc.). The means were then compared by Tukey's test (a = 0.05). t-test and paired t-test were used to analyse data at a significance level of <0.05. Regression analysis was used to examine the correlation between surface roughness and colour stability (a = 0.01).

RESULTS

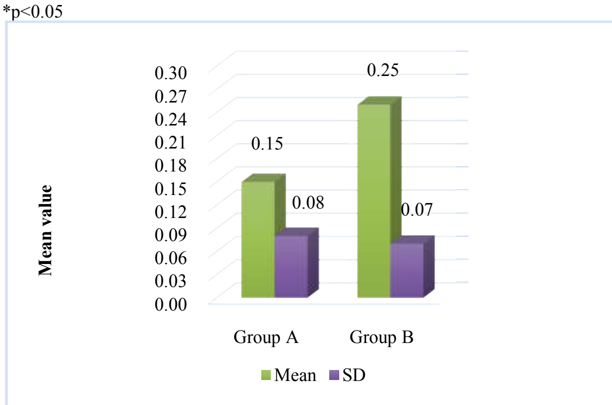
There were three variables in this study: two polishing systems, four immersion solutions, and three time intervals. The interaction between these three variables produced statistically significant results in surface roughness (P<0.001; F=12.879) and colour change (P<0.001; F=53.581).

The mean values and standard deviations of surface roughness (Ra, µm) for group A and group B are listed in the (Table-2). Statistically significant change took place in the overall surface roughness for group B- Compomaster as compared to group A- Super-Snap disks (Graph-1). Super-Snap consistently showed the lowest Ra value for the tested resin composite as compared to Compomaster.

Table-2 Comparison of group A and B with Ra values by t tests.

Group	n	Mean	SD	SE	t-value	p-value
Group A	19	0.15	0.08	0.02	-4.4486	0.0001*
Group B	19	0.25	0.07	0.02		

*p<0.05



Graph-1 Comparison of group A (Super-Snap) and group B (Compomaster) with mean Ra values.

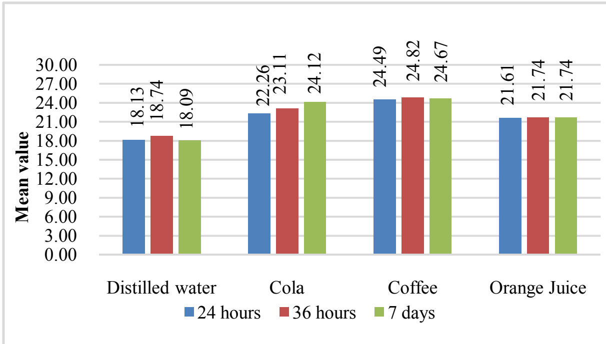
Table no.3 shows the overall means and standard deviation of ΔE for specimens in each immersion solution for three time periods:24 hours (t1), 36 hours (t2) and 7 days (t3). Discoloration (ΔE, L*a*b*) of the specimen was seen to be less with the use of Super-Snap system for all test samples, as compared to Compomaster system. When discoloration in different beverages was considered, maximum discoloration took place in coffee > cola> orange juice and minimum in distilled water. While for different time periods, ΔE was significantly higher for t3 followed by t2 and t1 (Graph-.2).

Two-way ANOVA tests were performed for L*, a* and b* separately and correlated with the experimental group and time.

Table-3 Mean ΔE for tested composite resin in each beverage for group A and group B at 24 hours (t1), 36 hours (t2) and one week (t3).

Beverages	n	24 hours		36 hours		7 days	
		Mean	SD	Mean	SD	Mean	SD
Distilled water (control A)	05	18.12	1.37	18.22	1.61	18.30	1.29
Distilled water (control B)	05	18.14	1.43	18.27	1.32	18.88	1.35
Cola (group A)	05	21.80	1.20	22.79	2.08	23.94	0.71
Cola (group B)	05	22.72	0.97	23.44	1.44	24.30	1.64
Coffee (group A)	05	23.98	1.19	24.32	0.89	24.32	2.01
Coffee (group B)	05	25.00	0.86	25.32	0.94	25.02	0.60
Orange Juice (group A)	05	21.04	1.25	21.60	0.54	21.04	1.72
Orange Juice (group B)	05	21.18	1.86	21.88	0.82	21.44	0.72

SD = Standard Deviation



Graph-2 Comparison of immersion periods;24 hour (t1), 36 hours (t2) and one week (t3) with color changes in four groups (distilled water, cola, coffee and orange Juice).

SEM pictures are presented (Figure- 2 and 3) for visual comparison of surface texture after polishing. Polished surfaces with the Super-Snap systems were smoother compared to those with the Compomaster.

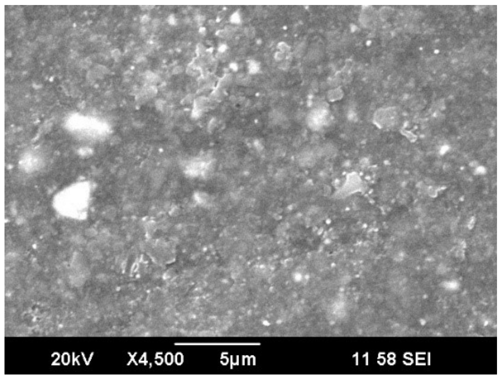


Figure-2 Scanning electron micrograph image of the surface after polishing with Super Snap polishing system.

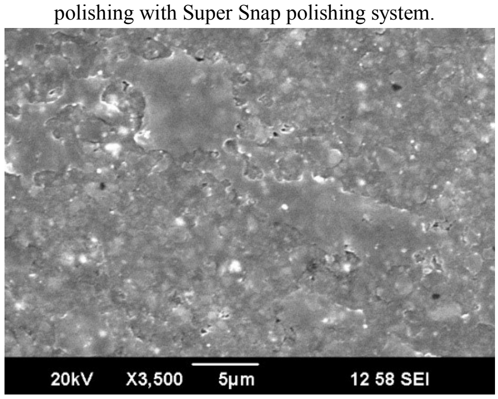


Figure-3 Scanning electron micrograph image of the surface after polishing with Compomaster polishing system.

DISCUSSION

Esthetics of direct composite restorations is dependent on proper finishing and polishing techniques.[13, 14] The surface roughness associated with improper finishing can result into discoloration of restorations and consequently compromised esthetics.[15] In the present study, surface roughness of methacrylate-based nanohybrid composite resin has been assessed after using different polishing systems because the surface micromorphology of composite resins is known to affect the colour stability or staining susceptibility.[7] To evaluate the discoloration of direct resin composites, determination of effect of commonly consumed beverages such as coffee, cola and orange juice on resins was carried out in an in vitro setting.[17] CIE L*a*b* system was chosen for measuring the chromaticity as it is well suited for the determination of small colour differences.[12] Measurement of colour change and surface roughness were made at different time intervals (baseline, after 24 hours, 36 hours, seven days) to see the effect of time on surface degradation. Low periods of immersion like 7 days are sufficient to produce staining and colour changes to composite resins.[5, 17] In previous studies, substrates have been tested after immersion in different beverages for a prolonged period. However, clinically food or drink comes only for a brief contact with the tooth surfaces before it is washed away by saliva. Thus, the new regimen selected in this study was to immerse each sample in the respective beverage for ten minutes each day and transfer them to distilled water for the remaining part of the day to mimic the neutralizing effect of saliva.[5]

On basis of the results, the hypotheses set as the premise of this study should be accepted. Colour stability of the composite resin materials is related to the polishing procedures. Significant differences were found in Ra ($P<.0.01$) and ΔE values ($P<.0.01$) among the groups. The two polishing systems used in the study produced different levels of polishing and staining when immersed in different solutions after three time intervals. Super-Snap system demonstrated to be more effective (minimum Ra value) in obtaining a smoother surface as compared to Compomaster system. The surface roughness of the restoration is determined by the mechanical properties of the resin composites as well as the flexibility, hardness, and grit size of the polishing material.[18] Setcos *et al*.[19] in a similar study reported lowest Ra values obtained with aluminum oxide abrasive disc group as compared to the groups polished with polishing wheels. Compomaster is a point-shaped abrasive that contains 6-µm diamond and 25-µm zirconium particles, respectively. Whereas, Super-Snap uses polishing discs with finer grits of abrasives; 20-µm (green, fine) and 7-µm (red, superfine) aluminum oxide particles, resulting in smoother and finer composite surface. Also, ability to produce a smooth surface with the use of the aluminum oxide discs depends on their cutting filler particles and matrix resin equally.[15] The fact that for any finishing system to be effective for composite resins, the abrasive particles must be relatively harder than the filler particles to not leave the filler particles protruding behind from the surface.[20] The aluminum oxide particles have a significantly higher level of hardness than most of the composite resin filler materials used in formulations.[21] Thus, aluminum oxide abrasive discs (Super-Snap system) produced smoother surfaces than polishing wheels. The present results corroborate with those found by. Lu *et al*[22], T¨urk¨un *et al*[23] and Venturini *et al*[24], who reported that aluminum oxide flexible discs are superior to other polishing aids in generating a smother resin surface. From the SEM photographs (Fig.no.1 and 3) of the polished surfaces, relatively smoother surfaces with small scratches and pitting were observed for the Super-Snap groups.

Concerning ΔE value, a decrease in ΔE value was observed for composite resin in relation to the polishing procedures. Highest values were observed for samples polished with Compomaster polishing (group B) followed by Super Snap system (group A). The ΔE values observed in this study revealed that the lower the roughness after polishing, the greater the resistance to staining of the composite resins.[17] Different polishing methods influence resistance to discoloration of direct composite resin restorations.[25] Roughened surface increases random reflections at the surface, which leads to increased opacity and a dull appearance.[26]Coffee was observed to be the most staining solution in the study followed by cola. Least change was seen with orange juice and no significant change observed for distilled water. Studies by Ardu *et al* [27] and Domingos *et al* [28] have reported ΔE values greater than 15, and as high as 32–39 after immersion in coffee for a prolonged period. Coffee stains by both adsorption and absorption of its colorants onto/into the organic phase of resin composites. Color change caused by colorant absorption into resin matrix has greater clinical significance as it is refractory to mechanical cleaning and may signify a need for replacement of restorations.[29, 12] Kolbeck[30] studied the discoloration of restorative resin composites and veneers using UV irradiation and storage in red wine. He concluded that optimal polishing of composites processed chair side is essential for the prevention of discoloration. Very limited studies have reported the effects of polishing or surface roughness on the L*a*b* color parameters of direct resin composites.[20]

The chemical properties can also influence discoloration of the resin composites as staining is directly related to the resin phase of composites.[2] Resin composite used in this study is Urethane dimethacrylate (UDMA) based, multi-filled composite with higher filler content. Urethane dimethacrylate (UDMA) is more stain resistant than bis-GMA.[31] This may have accounted for low viscosity and low water absorption of urethane dimethacrylate and its successful polymerization with visible light resulting into good color stability.[32, 33] Bayne and Taylor[34] stated that increasing the filler content of composite resins improves the physical, chemical and mechanical properties such as color stability, water absorption and wear resistance. Pearson[8] showed a correlation between both the tested parameters; smoother the surface, more resistant the material to staining.

Present study showed maximum color change after one week (t3) of immersion period. As the immersion time increased, the color changes became more intense, attributed to low pH of beverages leading to increased surface roughness.[35] Chan *et al*[36] investigated the staining potential of different resin composites and the greatest amount of discoloration occurred during the first week, which agrees to the results obtained in the present study.

As with any in vitro experimental models, this study has its limitations, such as the lack of consideration for the roles of saliva and oral microbes. Clinically, composite resin restorations have an irregular shape with convex and concave surfaces, whereas study specimens had flat surfaces. However, there is limited published information as to how storage conditions reflect the clinical situation and this study allows us to assess the color stability of composite resins better than the existing experimental models. Information obtained from this study should prove valuable for clinicians in selecting the best materials for esthetic restorations for their patients and realize patient's control of dietary habits.[29]

CONCLUSION

The results of this in vitro surface roughness and staining study showed that the effect of interaction of resin composites, various beverages, and time depended on a multitude of factors following are the conclusions drawn from the study:

- The methacrylate-based nanohybrid composite resin polished with aluminum oxide abrasive discs exhibited lower surface roughness and relatively better color stability when compared to composite resins polished with diamond impregnated polishing wheels.
- Coffee, among the three beverages caused the highest discoloration.

Resincomposites polished with both the systems exhibited maximum staining after one week of selective exposure to beverages.

Acknowledgement

We wish to thank the administration and ethics committee of the K.L.E. V.K. Institute of dental sciences, JNMC campus, Belagavi, Karnataka for permitting us to undertake these cases. We also would like to acknowledge Prof. G. N. Jadhav, IIT Bombay for providing with valuable support during the period of the study.

References

1. Cynthia Nunes, Anand F Farias, Taru Rao, Sajni Rai. A dental spectroscopic study to evaluate the effects of health drinks on the color stability of anterior restorative materials: An in vitro study. *Univ Res J Dent* 2012;2:97-10.
2. Taskinsel E, Ozel E, Ozturk E. Effects of sports beverages and polishing systems on color stability of different resin composites. *J Conserv Dent* 2014;17:325-9
3. Ayad NM. Susceptibility of restorative materials to staining by common beverages: an in vitro study. *Eur J Esthet Dent*. 2007;2(2):236-47.
4. Reddy PS, Tejaswi KL, Shetty S, Annapoorna BM, Pujari SC, Thippeswamy. Effects of commonly consumed beverages on surface roughness and color stability of the nano, microhybrid and hybrid composite resins: an in vitro study. *J Contemp Dent Pract*. 2013;14(4):718-23.
5. Bansal, Kshitij, Shashi Rashmi Acharya, and Vidya Saraswathi. Effect of alcoholic and non-alcoholic beverages on color stability and surface roughness of resin composites: An in vitro study. *J Conserv Dent*. 2012; 15(3): 283–288.
6. Da Costa J1, Ferracane J, Paravina RD, Mazur RF, Roeder L. The effect of different polishing systems on surface roughness and gloss of various resin composites. *J Esthet Restor Dent*. 2007;19(4):214-24.
7. Abu-Bakr N, Han L, Okamoto A, Iwako M. Color stability of compomer after immersion in various media. *J Esthet Dent* 2000; 12:258–63.
8. Fay RM, Walker CS, Powers JM. Color stability of hybrid ionomers after immersion in stains. *Amer J Dent* 1998;11: 71–72.
9. International Organization for Standardization. ISO 7491:2000 (E), Dental Materials – Determination of color stability. [cited 2003 Nov 22]. Available from: http://www. webstore.ansi.org.
10. Watanabe, Tamayo, Masashi Miyazaki, and B. Keith Moore. Influence of polishing instruments on the surface texture of resin composites. *Quintessence Int.* 2006;37(1):61-7.
11. Samra, A Bührer,L C Delgado, CP Borges. Color stability evaluation of aesthetic restorative materials. *Braz. oral res.* 2008:22(3).
12. Topcu, Fulya Toksoy, Kivanc Yamanel, Ugur Erdemir, Elif Aybala Oktay, Seyda Ersahana. Influence of different drinks on the colour stability of dental resin composites. *Eur J Dent*. 2009 Jan; 3(1): 50–56.
13. Korkmaz Y1, Ozel E, Attar N, Aksoy G.The influence of one-step polishing systems on the surface roughness and microhardness of nanocomposites. *Oper Dent*. 2008;33(1):44-50.
14. Ergücü Z1, Türkün LS.Surface roughness of novel resin composites polished with one-step systems. *Oper Dent*. 2007;32(2):185-92.
15. Reis AF1, Giannini M, Lovadino JR, Ambrosano GM. Effects of various finishing systems on the surface roughness and staining susceptibility of packable composite resins. *Dent Mater*.2003;19(1):12-8.
16. Guler AU1, Kurt S, Kulunk T. Effects of various finishing procedures on the staining of provisional restorative materials. *J Prosthet Dent*. 2005 May;93(5):453-8.
17. VL Schmitt, RM Puppin-Rontani, FS Naufel, F Nahsan, 3 MA Sinhoreti et al. Effect of the Polishing Procedures on Color Stability and Surface Roughness of Composite Resins. *ISRN Dent*. 2011:11.
18. Stanford WB, Fan PL, Wozniak WT, Stanford JW. Effect of finishing on color and gloss of composites with different fillers. *J Am Dent Assoc* (1985):110; 211-13.
19. Setcos JC, Tarim B, Suzuki S. Surface finish produced on resin composites by new polishing systems. *Quintessence Int* 1999; 30:169-73.
20. Sarac D1, Sarac YS, Kulunk S, Ural C, Kulunk T. The effect of polishing techniques on the surface roughness and color change of composite resins. *J Prosthet Dent*. 2006;96(1):33-40.
21. da Costa JB, Goncalves F, Ferracane JL. Comparison of two-step versus four-step composite finishing/polishing disc systems: evaluation of a new two-step composite polishing disc system. *Oper Dent.* 2011;36(2):205-12.
22. Lu H, Roeder LB, Powers JM. Effect of polishing systems on the surface roughness of microhybrid composites. *J Esthet Restor Dent.* 2003;15(5):297-303.
23. Türkün LS1, Türkün M. The effect of one-step polishing system on the surface roughness of three esthetic resin composite materials. *Oper Dent*. 2004;29(2):203-11.

24. Venturini D, Cenci MS, Demarco FF, Camacho GB, Powers JM. Effect of polishing techniques and time on surface roughness, hardness and microleakage of resin composite restorations. *Oper Dent.* 2006;31(1):11-7.
25. Heintze SD, Forjanic M, Rousson V.Surface roughness and gloss of dental materials as a function of force and polishing time in vitro. *Dent Mater*.2006;22(2):146-65.
26. Hosoya Y, Shiraishi T, Odatsu T, Nagafuji J, Kotaku M, Miyazaki M Et al. Effects of polishing on surface roughness, gloss, and color of resin composites. *J Oral Sci*. 2011;53(3):283-91.
27. Ardu S, Braut V, Gutemberg D, Krejci I, Dietschi D, Feilzer AJ. A long-term laboratory test on staining susceptibility of esthetic composite resin materials. *Quintessence Int*. 2010;41(8):695-702.
28. Domingos P. Garcia P, Oliveira A, Palma-Dibb RG. Composite resin color stability: influence of light sources and immersion media. *J. Appl. Oral* Sci.2011;19(3).
29. Ren YF, Feng L, Serban D, Malmstrom HS. Effects of common beverage colorants on color stability of dental composite resins: the utility of a thermocycling stain challenge model in vitro. *J Dent*. 2012;40:48-56.
30. 30. J.K. Subramanya and S. Muttagi. In vitro color change of three dental veneering resins in tea, coffee and tamarind extracts. *J Dent (Tehran)*. 2011;8(3):138–45.
31. Khokhar ZA, Razzoog ME, Yaman P. Color stability of restorative resins. Quintessence Int. 1991; 22:733-7.
32. Douglas WH, Craig RG. Resistance to extrinsic stains by hydrophobic composite resin systems. *J Dent Res* 1982; 61:41-3.
33. Khan Z, von Fraunhofer JA, Razavi R. The staining characteristics, transverse strength and micro hardness of a visible light cured denture base material. *J Prosthet Dent* 1987; 57:384-6
34. Sturdevant. The art and science of operative dentistry.3rd. ed. St. Louis: Mosby p. 20687.
35. Hotwani K, Thosar N, Baliga S. Comparative in vitro assessment of color stability of hybrid esthetic restorative materials against various children's beverages. *J Conserv Dent* 2014;17:70-4.
36. Ruyter IE, Nilner K, Moller B. Color stability of dental composite resin materials for crown and bridge veneers. *Dent Mater*. 1987;3(5):246-51.