

EVALUATION OF SPECTROPHOTOMETER ANALYSIS OF BULK-FILL COMPOSITES IN VARIOUS DAILY USED BEVERAGES

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Abstract:

The visible color alterations in esthetic materials can also be ascribed to the proprietary differences in chemistry that may affect the polymerization, water sorption, and consequently the color stability of the material. In addition, the obvious effect of colorants in beverages and foods leads to extrinsic discoloration of composites. Thus, for suitable performance, longevity and good clinical success of esthetic restorations, the material of choice should present adequate inherent characteristics. The discoloration of tooth-colored, resin-based materials may be caused by intrinsic or extrinsic factors. Visual or instrumental techniques can be used to evaluate discoloration. The use of instrumental methods like spectrophotometers and colorimeters to quantify tooth color could potentially eliminate the subjective aspects of color assessment. Hence based on above findings the present study was planned for evaluation of spectrophotometer analysis of bulk-fill composites on various daily used beverages.

The present study was planned in Department of Conservative Dentistry and Endodontics, Buddha Institute of Dental Sciences and Hospital, Patna, Bihar. The color of composite resins can be determined by varying methods, including visual assessment and instrumental measurement by a spectrophotometer.

According to the Spectrophotometer results of this study, material tested became changes in color after immersion in the beverages. The data generated from the present study concludes that all the beverages used in this study changes in color in the material tested. Coca-Cola causes more color changes than other beverages in the material tested. The total changes of color after 1, and 7 days of composite immersion in coca cola were higher than the clinically acceptable threshold, and they are comparable to the color changes observed with coffee, tea, orange juice and beer, which are known as strong staining agents.

Keywords: Spectrophotometer Analysis, Bulk-Fill Composites, Beverages, esthetic materials, color change, etc.

Introduction:

Dental composite resins (better referred to as "resin-based composites" or simply "filled resins") are types of synthetic resins that are used in dentistry as restorative material or adhesives. Dental composite resins have certain properties that will benefit patients according to the patient's cavity. It has a micro-mechanical retention property that makes composite more effective for filling small cavities where amalgam fillings are not as effective and could therefore fall out (due to the macro-mechanical retention property of amalgam). Synthetic resins evolved as restorative materials since they were insoluble, of good tooth-like appearance, insensitive

to dehydration, easy to manipulate and reasonably inexpensive. Composite resins are most commonly composed of Bis-GMA and other dimethacrylate monomers (TEGMA, UDMA, HDDMA), a filler material such as silica and in most current applications, a photoinitiator. Dimethylglyoxime is also commonly added to achieve certain physical properties such as flow-ability. Further tailoring of physical properties is achieved by formulating unique concentrations of each constituent.[1]

Many studies have compared the longevity of resin-based composite restorations to the longevity of silver-mercury amalgam restorations. Depending on the skill of the dentist, patient characteristics and the

type and location of damage, composite restorations can have similar longevity to amalgam restorations. (See Longevity and clinical performance.) In comparison to amalgam, the appearance of resin-based composite restorations is far superior.

Traditionally resin-based composites set by a chemical setting reaction through polymerization between two pastes. One paste containing an activator (not a tertiary amine, as these cause discolouration) and the other containing an initiator (benzoyl peroxide).[2] To overcome the disadvantages of this method, such as a short working time, light-curing resin composites were introduced in the 1970s.[3] The first light-curing units used ultra-violet light to set the material, however this method had a limited curing depth and was a high risk to patients and clinicians.[3] Therefore, UV light-curing units were later replaced by visible light-curing systems which used Camphorquinone as a light source and overcame the issues produced by the UV light-curing units.

In the late 1960s, composite resins were introduced as an alternative to silicates and unfulfilled resins, which were frequently used by clinicians at the time. Composite resins displayed superior qualities, in that they had better mechanical properties than silicates and unfulfilled resins. Composite resins were also seen to be beneficial in that the resin would be presented in paste form and, with convenient pressure or bulk insertion technique, would facilitate clinical handling. The faults with composite resins at this time were that they had poor appearance, poor marginal adaptation, difficulties with polishing, difficulty with adhesion to the tooth surface, and occasionally, loss of anatomical form.[4]

In 1978, various microfilled systems were introduced into the European market.[5] These composite resins were appealing, in that they were capable of having an extremely smooth surface when finished. These microfilled composite resins also showed a better clinical colour stability and higher resistance to wear than conventional composites, which favoured their tooth tissue-like appearance as well as clinical effectiveness. However, further research showed a progressive weakness in the material over time, leading to micro-cracks and step-like material loss around the composite margin. In 1981, microfilled composites were improved remarkably with regard to marginal retention and adaptation. It was decided, after further research, that this type of composite

could be used for most restorations provided the acid etch technique was used and a bonding agent was applied.[4]

Hybrid composites were introduced in the 1980s and are more commonly known as resin-modified glass ionomer cements (RMGICs). The material consists of a powder containing a radio-opaque fluoroaluminosilicate glass and a photoactive liquid contained in a dark bottle or capsule.[2] The material was introduced, as resin composites on their own were not suitable for Class II cavities.[4] RMGICs can be used instead. This mixture of resin and glass ionomer allows the material to be set by light activation (resin), allowing a longer working time. It also has the benefit of the glass ionomer component releasing fluoride and has superior adhesive properties.[2] RMGICs are now recommended over traditional GICs for basing cavities.[5] There is a great difference between the early and new hybrid composites.[4]

Initially, resin-based composite restorations in dentistry were very prone to leakage and breakage due to weak compressive strength. In the 1990s and 2000s, such composites were greatly improved and have a compression strength sufficient for use in posterior teeth.

Today's composite resins have low polymerization shrinkage and low coefficients of thermal shrinkage, which allows them to be placed in bulk while maintaining good adaptation to cavity walls. The placement of composite requires meticulous attention to procedure or it may fail prematurely. The tooth must be kept perfectly dry during placement or the resin will likely fail to adhere to the tooth. Composites are placed while still in a soft, dough-like state, but when exposed to light of a certain blue wavelength (typically 470 nm) [6], they polymerize and harden into the solid filling (for more information, see Light activated resin). It is challenging to harden all of the composite, since the light often does not penetrate more than 2–3 mm into the composite. If too thick an amount of composite is placed in the tooth, the composite will remain partially soft, and this soft unpolymerized composite could ultimately lead to leaching of free monomers with potential toxicity and/or leakage of the bonded joint leading to recurring dental pathology. The dentist should place composite in a deep filling in numerous increments, curing each 2–3 mm section fully before adding the next. In addition,

the clinician must be careful to adjust the bite of the composite filling, which can be tricky to do. If the filling is too high, even by a subtle amount, that could lead to chewing sensitivity on the tooth. A properly placed composite is comfortable, of good appearance, strong and durable, and could last 10 years or more.[7]

The most desirable finish surface for a composite resin can be provided by aluminum oxide disks. Classically, Class III composite preparations were required to have retention points placed entirely in dentin. A syringe was used for placing composite resin because the possibility of trapping air in a restoration was minimized. Modern techniques vary, but conventional wisdom states that because there have been great increases in bonding strength due to the use of dentin primers in the late 1990s, physical retention is not needed except for the most extreme of cases. Primers allow the dentin's collagen fibers to be "sandwiched" into the resin, resulting in a superior physical and chemical bond of the filling to the tooth. Indeed, composite usage was highly controversial in the dental field until primer technology was standardized in the mid to late 1990s. The enamel margin of a composite resin preparation should be beveled in order to improve the appearance and expose the ends of the enamel rods for acid attack. The correct technique of enamel etching prior to placement of a composite resin restoration includes etching with 30%-50% phosphoric acid and rinsing thoroughly with water and drying with air only. In preparing a cavity for restoration with composite resin combined with an acid etch technique, all enamel cavosurface angles should be obtuse angles. Contraindications for composite include varnish and zinc oxide-eugenol. Composite resins for Class II restorations were not indicated because of excessive occlusal wear in the 1980s and early 1990s. Modern bonding techniques and the increasing unpopularity of amalgam filling material have made composites more attractive for Class II restorations. Opinions vary, but composite is regarded as having adequate longevity and wear characteristics to be used for permanent Class II restorations. Whether composite materials last as long or has the leakage and sensitivity properties when compared to Class II amalgam restorations was described as a matter of debate in 2008.[8]

As with other composite materials, a dental composite typically consists of a resin-based oligomer

matrix, such as a bisphenol A-glycidyl methacrylate (BISGMA), urethane dimethacrylate (UDMA) or semi-crystalline polyceramide (PEX), and an inorganic filler such as silicon dioxide (silica). Without a filler the resin wears easily, exhibits high shrinkage and is exothermic. Compositions vary widely, with proprietary mixes of resins forming the matrix, as well as engineered filler glasses and glass ceramics. The filler gives the composite greater strength, wear resistance, decreased polymerisation shrinkage, improved translucency, fluorescence and colour, and a reduced exothermic reaction on polymerisation. It also however causes the resin composite to become more brittle with an increased elastic modulus.[9] Glass fillers are found in multiple different compositions allowing an improvement on the optical and mechanical properties of the material. Ceramic fillers include zirconia-silica and zirconium oxide.

Matrices such as BisHPPP and BBP, contained in the universal adhesive BisGMA, have been demonstrated to increase the cariogenicity of bacteria leading to the occurrence of secondary caries at the composite-dentin interface. BisHPPP and BBP cause an increase of glycosyltransferase in *S. mutans* bacteria, which results in increased production of sticky glucans that allow *S. mutans*' adherence to the tooth. This results in a cariogenic biofilms at the interface of composite and tooth. The cariogenic activity of bacteria increases with concentration of the matrix materials. BisHPPP has furthermore been shown to regulate bacterial genes, making bacteria more cariogenic, thus compromising the longevity of composite restorations. Researchers are highlighting the need for new composite materials to be developed which eliminate the cariogenic products currently contained in composite resin and universal adhesives.[10]

A coupling agent such as silane is used to enhance the bond between these two components. An initiator package (such as: camphorquinone (CQ), phenylpropanedione (PPD) or lucirin (TPO)) begins the polymerization reaction of the resins when blue light is applied. Various additives can control the rate of reaction.

The search for optimal esthetic smile is increasingly present in dental office. This increased demand for cosmetic procedure may be slightly influenced by media. [11] Resin composites are one of the most popular material in esthetic dentistry because of their excellent esthetic properties, adequate strength and their ability to be bonded to dentin or enamel [12]

allowing their use in both anterior and posterior restorations. [13-14] Restorative materials are constantly subjected to thermal challenges in oral environment. [15] Such challenges if significant, can have unfavourable effects on the material such as on the margins of the restoration and the tooth structure. Consumption of certain beverages and a wide range of physical and chemical conditions in the mouth, including temperature variation, masticatory forces, and chemicals from food may effect the esthetic and physical properties such as microhardness, surface roughness and color stability of the resin composite, thereby, undermining the quality of restorations. [16] Currently the behaviour of nanohybrid composite material over temperature change of beverages is relatively unknown. [6] However, in support of this current study, a number of studies have shown that coffee, tea, grape juice and black cola had a significant staining effect on optical properties of resin-based restorative materials. [17-18] The temperature change of oral cavity and dietary substrates are also associated with discolouration to resin based materials. Long-term immersion of resin composite in a high temperature solution can induce changes in the material properties, which ultimately may lead to discolouration. [17] This prolonged exposure to heat may degrade organic matrices to promote pigmentation. [18]

The visible color alterations in esthetic materials can also be ascribed to the proprietary differences in chemistry that may affect the polymerization, water sorption, and consequently the color stability of the material. In addition, the obvious effect of colorants in beverages and foods leads to extrinsic discoloration of composites. Thus, for suitable performance, longevity and good clinical success of esthetic restorations, the material of choice should present adequate inherent characteristics. The discoloration of tooth-colored, resin-based materials may be caused by intrinsic or extrinsic factors. Visual or instrumental techniques can be used to evaluate discoloration. The use of instrumental methods like spectrophotometers and colorimeters to quantify tooth color could potentially eliminate the subjective aspects of color assessment. Hence based on above findings the present study was planned for evaluation of spectrophotometer analysis of bulk-fill composites on various daily used beverages.

Methodology:

The present study was planned in Department of Conservative Dentistry and Endodontics, Buddha Institute of Dental Sciences and Hospital, Patna, Bihar. The color of composite resins can be determined by varying methods, including visual assessment and instrumental measurement by a spectrophotometer.

The specimen of universal shade (IVB) bulk fill resin Tetric-N-ceram composite material (IvoclarVivadent). The cylindrical samples were prepared in the metal ring mould (10 mm internal diameter and 4 mm height). Composite were filled in each specimen according to manufacturer's instructions and Polyester strip was placed on a glass slab and Teflon matrix. After filling a mould to excess, the material surface was covered with another polyester strip and glass slide and compressed with a device (500gm) for 20sec. To further compress the material and removal of the excessive material. All the specimens were light cured using LED curing light (Blue phase C8, IvoclarVivadent, Astria), in accordance to manufacturer instruction. The polymerisation of specimens was carried at 4 quadrants on each top and bottom side against the strip and glass plate and then for another similar amount for irradiation but without the glass plates. The curing tip was positioned to perpendicular to specimens surface. The power output density used was 1000mW/cm. [19] Then all specimens were finished with a series of different grid abrasive finishing disc (Shofu Super Snap Dental India Private Limited, New Delhi, India) in a sequence of decreasing abrasiveness with intermittent movement, under constant water cooling. Polishing procedure was kept to minimum time 10s for each step to avoid microcrack formation. Total sixty specimens was randomly divided into six groups comprised of 1 control group & 5 experimental groups.

Groups	Sample Details	Preparation
Group A	Tea Solution	Specimens were stored in 37°C tea for preparation of tea solution. 3 gm of tea was prepared in 50ml boiling water and added to 50ml of boiled milk the tea was freshly prepared daily prior to each test period.
Group B	Coca Cola	Specimens were stored in 37°C cola carbonated soft drink. The lids of the container tightly closed to prevent escape of carbonic gas in order to

		maintain an acceptable label of carbonic gas a new bottle used everyday. Samples were immersed in 100ml of coca cola solution.
Group C	Coffee Solution	Specimens were stored in 37°C coffee for preparation of coffee solution. 1.5gm of coffee was prepared in 50ml boiling water and added to 50ml of boiled milk. The coffee was freshly prepared daily prior to each test period.
Group D	Distilled Water	Specimens were stored 100ml distilled water and the solution was changed daily. Distilled water was used as a control and to investigate intrinsic color changes in the restorative material.
Group E	Orange Juice	Specimens were stored in 37°C orange juice. The lids of the container tightly closed to prevent change in pH of orange juice in order to maintain an acceptable label of pH a new bottle used everyday. Samples were immersed in 100ml of orange juice.
Group F	Beer	Specimens were stored in 37°C BEER. The lids of the container tightly closed to prevent escape of carbonic gas in order to maintain an acceptable label of carbonic gas a new bottle used everyday. Samples were immersed in 100ml of beer solution

All the patients were informed consents. The aim and the objective of the present study were conveyed to them. Approval of the institutional ethical committee was taken prior to conduct of this study.

Results & Discussion:

Discoloration can be evaluated visually and by instrumental techniques (spectrophotometer and colorimeter). [20] Color evaluation by visual comparison has been shown to be unreliable as a result of inconsistencies in color perception specification among observers. Since instrumental measurements eliminate the subjective interpretation of visual color comparison, colorimeters and spectrophotometers have been most commonly used to measure color change in dental materials. [21] Spectrophotometers have been shown to be more accurate in measuring the color change than colorimeters as spectrophotometers contain monochromators and photodiodes that measure the reflectance curve of a product's color every 10 nm or less. [22]

Table 1: Color Stability at Initial, 1 day and 7 days after Immersion

Groups	Sample Details	Initial: Pre Immersion	1 days: After Immersion	7 days: After Immersion
Group A	Tea Solution	0.139 ± 0.007	0.199 ± 0.02	0.211 ± 0.003
Group B	Coca Cola	0.138 ± 0.002	0.210 ± 0.01	0.215 ± 0.008
Group C	Coffee Solution	0.139 ± 0.002	0.202 ± 0.01	0.212 ± 0.001
Group D	Distilled Water	0.136 ± 0.005	0.189 ± 0.05	0.206 ± 0.008
Group E	Orange Juice	0.134 ± 0.004	0.178 ± 0.06	0.195 ± 0.007
Group F	Beer	0.137 ± 0.004	0.179 ± 0.02	0.189 ± 0.003

Consumption of certain beverages such as coffee, soft drinks, alcoholic beverages, and even water may affect the esthetic and physical properties (micro hardness, surface roughness, and translucency) of the composites due to the degradation of the resin matrix thereby undermining the quality of restoration. [23] Different mechanisms of polymer degradation have been demonstrated, such as hydrolytic, chemical and chemicomechanical. Different definitions for degradation have been given; however it has been described by Gopferich (1996) as a „chain scission process during which polymer chains are cleaved to form oligomers and finally monomers“. Gopferich stated that the intrusion of water into the polymer bulk activates the chemical polymer degradation which leads to the creation of oligomers and monomers. [24]

Nano composites are a type of composite in which the primary filler size is in the nm range while the secondary filler clusters are in the µm range. Thus, this material has a better polishability and improved retention of the polish and gloss compared to microhybrid composites. [25] Salivary enzymes, pH changes, organic solvents, and the ionic composition of food, beverages, or saliva may influence the surface quality of composite resins. [26]

Excessive water sorption could reduce the longevity of composites by expanding and plasticizing the resin matrix, hydrolyzing the silane coupling agent, and producing microcracks formations. This permits penetration of staining solutions.[27] Some studies have reported high surface roughness of composites even after finishing, due to irregularly arranged

inorganic filler particles, which could result in easier staining over time.[28] Although developments in filler technology have led to significant improvements regarding filler size, low wear, and high resistance against degradation of resin materials.

However, one of the studies has shown that the highly glazed surface of porcelain restorations when subjected to repeated exposure of carbonated beverages can lead to roughened and etched surface texture.[29] The simplest way to assess this surface texture visually is by using a scanning electron microscope. Discoloration of porcelain may be endogenous or exogenous. Chemical instability of the material may lead to endogenous color change. The exogenous staining may occur due to the adsorption or absorption of stains from different food products. Finishing and polishing procedures may also influence surface smoothness and color stability. In this study, the porcelain group shows some color changes and also it is not known, whether it is the glaze layer which undergoes disruption due to acidic solution and cause retention of stains or these are absorbed within the body of this porcelain, and this is similar to a study conducted by Chandni Jain et al. The exact behavior of the porcelain, the color change, and change in surface roughness can be probably be explained in an in vivo study. [30]

Staining susceptibility of resin-based materials might be attributed to their degree of water sorption and hydrophilicity of matrix resin, that is, if the resin composite can absorb water, it can also absorb other fluids like tea and coffee.[31] The glass filler particles will not absorb water into the bulk of the material; however, can absorb water onto the surface. In the literature, hydrophobic materials like resin composites are believed to exhibit greater stain resistance and color stability than hydrophilic materials like glass ionomer cements and compomers. [32] The results of the current study also add support to this conclusion. It is reported that most of the water sorption with resinbased materials was observed during the first week. Chan et al. [33] investigated the staining potential of coffee, tea, cola, and soy sauce on two different resin composites and reported that staining after 1 week of immersion differed significantly from all succeeding weeks, and the greatest amount of discoloration occurred during the first week, which is in agreement to the results obtained in the present study.

The visible color alterations in esthetic materials can also be ascribed to the proprietary differences in chemistry that may affect the polymerization, water sorption, and consequently the color stability of the material. In addition, the obvious effect of colorants in beverages and foods leads to extrinsic discoloration of composites. Thus, for suitable performance, longevity and good clinical success of esthetic restorations, the material of choice should present adequate inherent characteristics. However, the property of color stability of esthetic dental materials is often ignored over other physical and mechanical properties while making a choice. The ideal composite resin formulations that may permit an optimal esthetic outcome without compromising the mechanical properties essential for a suitable functional outcome are nevertheless under exploration. It is imperative that an ideal anterior restorative material should exhibit adequate esthetics as a function of color stability in addition to other properties such as strength and biocompatibility and at the same time aid in prevention of secondary caries formation.

It is difficult to extrapolate the results of this study to in vivo conditions. However, the results of this study can give an insight into how nanohybrid resin composites may behave when exposed to different temperature of beverages, thus affecting the clinician's choice of material and the patient's control of dietary habits.

Conclusion:

According to the Spectrophotometer results of this study, material tested became changes in color after immersion in the beverages. The data generated from the present study concludes that all the beverages used in this study changes in color in the material tested. Coca-Cola causes more color changes than other beverages in the material tested. The total changes of color after 1, and 7 days of composite immersion in coca cola were higher than the clinically acceptable threshold, and they are comparable to the color changes observed with coffee, tea, orange juice and beer, which are known as strong staining agents.

References:

1. Robert G. Craig, Dieter Welker, Josef Rothaut, Klaus Georg Krumbholz, Klaus-Peter Stefan, Klaus Dermann, Hans-Joachim Rehberg, Gertraute Franz, Klaus Martin Lehmann, Matthias Borchert (2006). "Dental Materials". Ullmann's Encyclopedia of Industrial

- Chemistry. Weinheim: Wiley-VCH. doi:10.1002/14356007.a08_251.pub2.
2. Van Noort, Richard; Barbour, Michele (2013). *Introduction to Dental Materials* (4 ed.). Elsevier Ltd. pp. 104–105.
 3. Baratieri, LN; Araujo Jr, EM; Monteiro Jr, S (2005). *Composite Restorations in Anterior Teeth: Fundamentals and Possibilities*. Brazil: Quintessence Editoria. pp. 257–258.
 4. Vanherle, Guido; Smith, Dennis C (1985). *Posterior Composite Resin Dental Restorative Materials*. The Netherlands: Peter Szule Publishing Co. pp. 28–29.
 5. Lynch, Christopher D (2008). *Successful Posterior Composites*. London: Quintessence Publishing Co. Ltd. p. 4.
 6. Rueggeberg, Frederick (2011). "State-of-the-art: Dental Photocuring - A review". *Dental Materials*. 27 (1): 39–52. doi:10.1016/j.dental.2010.10.021. PMID 21122903.
 7. Kubo, Shisei (2011-02-01). "Longevity of resin composite restorations". *Japanese Dental Science Review*. 47 (1): 43–55. doi:10.1016/j.jdsr.2010.05.002. ISSN 1882-7616.
 8. Shenoy, A. (2008). "Is it the end of the road for dental amalgam? A critical review". *Journal of Conservative Dentistry* (open access). 11 (3): 99–107. doi:10.4103/0972-0707.45247. PMC 2813106. PMID 20142895.
 9. Bonsor, Steven (2012). *Applied Dental Materials*. Churchill Livingstone. p. 71.
 10. Sadeghinejad, Lida; Cvitkovitch, Dennis G; Siqueira, Walter L.; Merritt, Justin; Santerre, J Paul; Finer, Yoav (2017-02-01). "Mechanistic, Genomic and Proteomic Study on the Effects of BisGMA-derived Biodegradation Product on Cariogenic Bacteria". *Dental Materials*. 33 (2): 175–190. doi:10.1016/j.dental.2016.11.007. PMC 5253116. PMID 27919444.
 11. Rodrigo PIROLO1, Rafael Francisco Lia MONDELLI2, Gisele Maria CORRER, Carla Castiglia GONZAGA, AdilsonYoshioFURUSE, Effect of coffee and a cola-based soft drink on the color stability of bleached bovine incisors considering the time elapsed after bleaching, *J Appl Oral Sci*. 2014;22(6):534-40
 12. Brunson WD, Bayne SC, Sturdevant JR, Roberson TM, Wilder AD, Taylor DF. Three year clinical evaluation of a self cured posterior composite resin. *Dent Mater* 1989;5:127-32.
 13. Erta E, Güler AU, Yücel AC, Köprülü H, Güler E. Color stability of resin composites after immersion in different drinks. *Dent Mater* 2006;25:371-76.
 14. Hickel R, Heidemann D, Staehle HJ, Minnig P, Wilson NH. Direct composite restorations: extended use in anterior and posterior situations. *Clin Oral Investig* 2004;8:43-44.
 15. Sidhu SK1, Carrick TE, McCabe JF. Temperature mediated coefficient of dimensional change of dental tooth-colored restorative materials. *Dent Mater* 2004;20:435-40.
 16. Kshitij Bansal, Shashi Rashmi Acharya, 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;15:283–88.
 17. Domingos PA, Garcia PP, Oliveira AL, Palma-Dibb RG. Composite resin colorstability: influence of light sources and immersion media. *JAppl Oral Sci*. 2011;19:204-11.
 18. Garcia ER, Santos PAD, Campos JADB, Dibb RGP. Influence of Surface Sealant on the Translucency of Composite Resin: Effect of Immersion Time and Immersion Media. *Mat Res*. 2008;11:193-7.
 19. Ayad NM. Susceptibility of restorative materials to staining by common beverages: an in vitro study. *Eur J Esthet Dent* 2007 Summer;2(2):236-47.
 20. Okubo SR, Kanawati A, Richards MW, Childress S. Evaluation of visual and instrument shade matching. *J Prosthet Dent* 1998;80:642-8.
 21. Guler AU, Yilmaz F, Kulunk T, Guler E, Kurt S. Effects of different drinks on stainability of resin composite provisional restorative materials. *J Prosthet Dent* 2005;94:118-24.
 22. Brewer JD, Wee A, Seghi R. Advances in color matching. *Dent Clin North Am* 2004;48:v, 341-58.
 23. D.Y. Papadogiannis, R.S. Lakes, Y. Papadogiannis, G. Palaghias, M. Helvatjoglu-Antoniades. The effect of temperature on the viscoelastic properties of nano-hybrid composites. *Dent Mater* 2008;24:257-66.
 24. Wu W, McKinney JE. Influence of chemicals on wear of dental composites. *J Dent Res* 1982;61:1180-3.
 25. Kitchens M, Owens BM. Effect of carbonated beverages, coffee, sports and high energy drinks, and bottled water on the in vitro erosion characteristics of dental enamel. *J Clin Pediatr Dent* 2007;31:153-9.
 26. Dos Santos PA, Garcia PP, De Oliveira AL, Chinelatti MA, Palma-Dibb RG. Chemical and morphological features of dental composite resin: Influence of light curing units and immersion media. *Microsc Res Tech* 2010;73:176-81.
 27. Ferracane JL, Marker VA. Solvent degradation and reduced fracture toughness in aged composites. *J Dent Res* 1992;71:13-9.
 28. Guler AU, Kurt S, Kulunk T. Effects of various finishing procedures on the staining of provisional restorative materials. *J Prosthet Dent* 2005;93:453-8.
 29. Kamala KR, Annapurni H. Evaluation of surface roughness of glazed and polished ceramic surface on exposure to fluoride gel, bleaching agent and aerated drink: An in vitro study. *J Indian Prosthodont Soc* 2006;6:128-32.
 30. Toledano M, Osorio R, Osorio E, Fuentes V, Prati C, Garcia Godoy F, et al. Sorption and solubility of resin

based restorative dental materials. J Dent 2003;31:43-50.

31. 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.
32. Mutlu-Sagesen L, Ergün G, Ozkan Y, Semiz M. Color stability of a dental composite after immersion in various media. Dent Mater J 2005;24:382-90.
33. Chan KC, Fuller JL, Hormati AA. The ability of foods to stain two composite resins. J Prosthet Dent 1980;43:542-5.