ISSN: 0976-3104
SPECIAL ISSUE (RAE)
Kumavat et al.

THE IIOAB JOURNAL

ARTICLE OPEN ACCESS

EFFECT OF ALCOHOLIC AND NON-ALCOHOLIC BEVERAGES ON COLOR STABILITY, SURFACE ROUGHNESS AND FRACTURE TOUGHNESS OF RESIN COMPOSITES: AN IN VITRO STUDY

Vrishali Kumavat*, Srinidhi Surya Raghvendra, Nishant Vyavahare, Udita Khare, Pratik Kotadia

Dept. Of Conservative Dentistry and Endodontics, Sinhgad Dental College and Hospital, Pune, Maharashtra, INDIA

ABSTRACT

***Background**: Consumption of certain beverages may affect the esthetic and physical properties of the resin composite, thereby undermining the quality of restorations. Aim: To analyze the effect of four beverages (Sparkling Wine, Energy Drink, Jamun Juice and Cola drink) on color stability, surface roughness and fracture toughness of two different types of resin composites at various time intervals in vitro .**Materials and Methods**: A UDMA based composite and a Bis-GMA based composite were used. Each material was randomly divided into four subgroups of 10 samples each according to the beverages used (Sparkling Wine, Energy Drink, Jamun juice, Cola drink). The samples were immersed in each beverage for 10 minutes each day for 28 days. Color change and surface roughness measurements were noted at the baseline, 7th, 14th and 28th days. On 28th day, the samples were tested for fracture toughness using universal testing machine with a cross head speed of 0.1mm/min. The maximum load at specimen failure is recorded. **Results**: The maximum discolouration took place in UDMA based composite when immersed in energy drink (p<0.05) and the maximum change took place in the Bis-GMA based composite and results were statistically significant (p<0.05) in Cola drink for surface roughness and fracture toughness. **Conclusion:** UDMA based composites had highest discolouration in energy drink while Bis GMA based composites had more alterations in surface roughness and fracture toughness when immersed in Cola drink.*

Received on: 16th-March-2016
Revised on: 29th-March-2016
Accepted on: 4th-April-2016
Published on: 13th– June-2016

KEY WORDS

Beverages; color change; resin composite; surface roughness; fracture toughness; time

***Corresponding author: Email:** doc301287@gmail.com; **Tel:** +91 8446379773

INTRODUCTION

Esthetic failure is one of the most common reasons for the replacement of tooth colored restorations. Color changes in resin composites occur from intrinsic and extrinsic factors. Intrinsic factors involve chemical changes in the material whereas extrinsic factors like adsorption or absorption of stains pose a major problem for esthetic restorations. Surface roughness is one of the reasons for exterior discoloration [1]. Consumption of certain beverages may affect the esthetic and physical properties of the resin composite, thereby, undermining the quality of restorations [2]. The chemicals in them can lead to wear and surface degradation of composite restorations, resulting in external pigmentations. Due to its low pH, ethanol can produce erosion and also act as a plasticizer of the polymer matrix [3-4]. The effect of alcohol on the wear resistance of resin composites has not been studied extensively. Fracture toughness is an intrinsic characteristic of a material describing its resistance to crack propagation. The lower the fracture toughness, higher is the clinical probability of restoration failure under load. This is because fracture toughness defines the critical intensity level at which catastrophic failure occurs due to a micro-defect. Water sorption by a resin composite is dependent on the matrix resin, the filler and the properties of the interface between the matrix and filler [5]. The greater the resin content, the more the water that is absorbed [6]. It has been shown [7] that water sorption weakens the matrix and leaches the fillers into the aqueous media which can result in filler/matrix cracking and hydrolytic degradation of the filler surface [3]. It causes softening of the composite by penetration into the matrix followed by leaching out of unreacted monomer, degradation and leaching of filler components [8]. A number of different mechanical properties of resin composites have been described in various studies using different tests. However, limited information is available on the effect of different beverages on the fracture toughness of resin based composites. The aim of the study is to analyze the effect of four alcoholic and non-alcoholic beverages (Sparkling Wine, Jamun juice, Energy drink, and Cola drink) on the color stability, surface roughness and fracture toughness of two different types of resin composites (Bis-GMA and UDMA)at different time intervals in vitro.

MATERIALS AND METHODS

Forty six disk shaped samples (10 mm×2 mm) were prepared for each material using a Teflon mould [9]. The samples were cured as per the manufacturer's instructions. Forty samples were randomly divided into two groups;

- Group 1: Bis-GMA based composite {Tetric N-Ceram (Ivoclar Vivadent, Schaan; Liechtenstein)} A1 shade
- Group 2: UDMA based composite (G – aenial, GC, Tokyo, Japan), A2 shade. Six samples were kept as controls.

Each disk was polished using the Super-Snap polishing system (Shofu Inc, Kyoto, Japan). All the samples were stored at 37°C in distilled water for 24 hours for rehydration and completion of polymerization [10]. After 24 hours of storage, each material was randomly divided into four subgroups of 10 samples each, according to the beverages used.

- Group 1A and 1B: Sparkling wine (RiO fizzy wine)
- Group 2A and 2B: Jamun juice (Paper Boat Jamun Kala khatta, Hector Beverages Pvt Ltd)
- Group 3A and 3B: Energy drink (Red Bull GmbH)
- Group 4A and 4B: Cola drink (Thums Up, The Coca-Cola Company)

Fig: 1. Samples immersed in four different beverages

The samples were blotted dry using tissue paper and the baseline readings were obtained for Surface Roughness (Ra) and Color Change (ΔE) for each group. Surface roughness was measured using a Profilometer, Hommel Tester T500 (Hommelwerke GmbH) The diamond stylus tip of 4 µm radius was placed at the extremity of the disk shaped sample and it traversed the surface of the disk to trace a 10mm course, providing the first measurement of Ra in micrometers. Two additional measurements were taken by rotating the disk to 90° and the mean Ra was obtained from the three values [11]. Color change was measured using a Spectrophotometer, Spectrolino (Gretag Macbeth AG, Germany). The color was assessed using the CIEL*a*b* measuring system. The color measurements were performed at the center of the resin composite disks and repeated thrice. The ΔE values were obtained for each sample and the mean of the values was calculated [12].

After baseline readings, the samples were immersed in the respective beverages **[Figure–1]**. The immersion regimen followed was as follows: The samples in each group were immersed in the respective beverage for 10 minutes every day. For the remaining part of the day, the samples were kept immersed in distilled water. This regimen was followed for 28 days. Surface roughness and color measurements were checked on the seventh, fourteenth and twenty eighth days. The control samples were placed in distilled water only. Fracture toughness was measured after twenty eight days. Pre crack was made on the samples using diamond disk under water

THE IIOAB JOURNAL
ISSN: 0976-3104

coolant till 5mm i.e, half of the disk **[Figure –2a]**. Two holes were made at equal distance with No. 2 round carbide bur as shown in figure. The specimens were secured in universal testing machine using guide pins placed through specimens holes **[Figure– 2b]**. Tensile loading was applied at a crosshead speed of 0.1 mm/min; the maximum load at specimen failure was recorded in MPa.

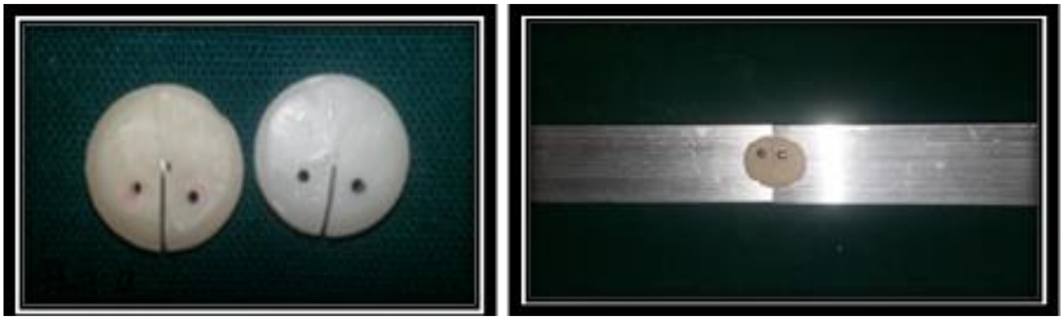

Fig: 2 (a). Pre crack was made on the samples using diamond disk; (b) Sample attached to jig

For statistical analysis, unpaired t test was done to compare the color difference, surface roughness and fracture toughness scores of two different composite materials at different time intervals in different media. Post Hoc Tukey's test was done to compare the effect individually. P value was set at 0.05.

RESULTS

When color changes between two resin composites was considered, the maximum discolouration took place in UDMA based composite as compared to Bis-GMA and results were statistically significant(p<0.05) on 28th day of immersion in energy drink. However, with other drinks, results were not statistically significant. When discoloration in different beverages was considered, maximum discoloration took place in Energy drink > Cola drink > Jamun Juice > Sparkling Wine **[Figure-3].**

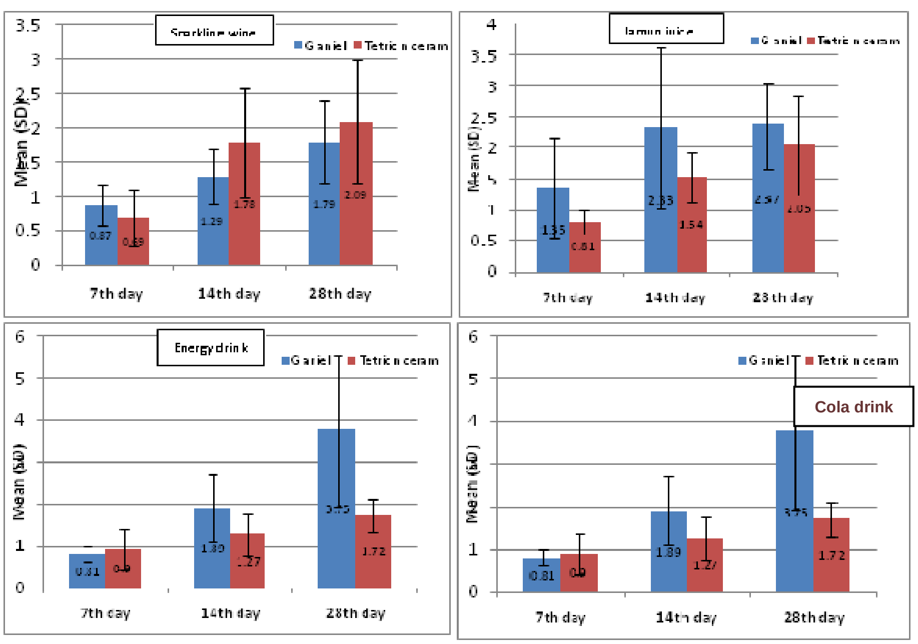

Fig:3. Comparison of Delta E in resin composite in different beverages over time

THE IIOAB JOURNAL
ISSN: 0976-3104

When surface roughness between two resin composites was considered at the 14th day, the maximum change took place in the Bis-GMA based composite and results were statistically significant ($p<0.05$) in Cola drink. When surface roughness in different beverages was considered, maximum roughness took place in Cola drink > Jamun Juice > Energy drink > Sparkling Wine **[Figure-4].**

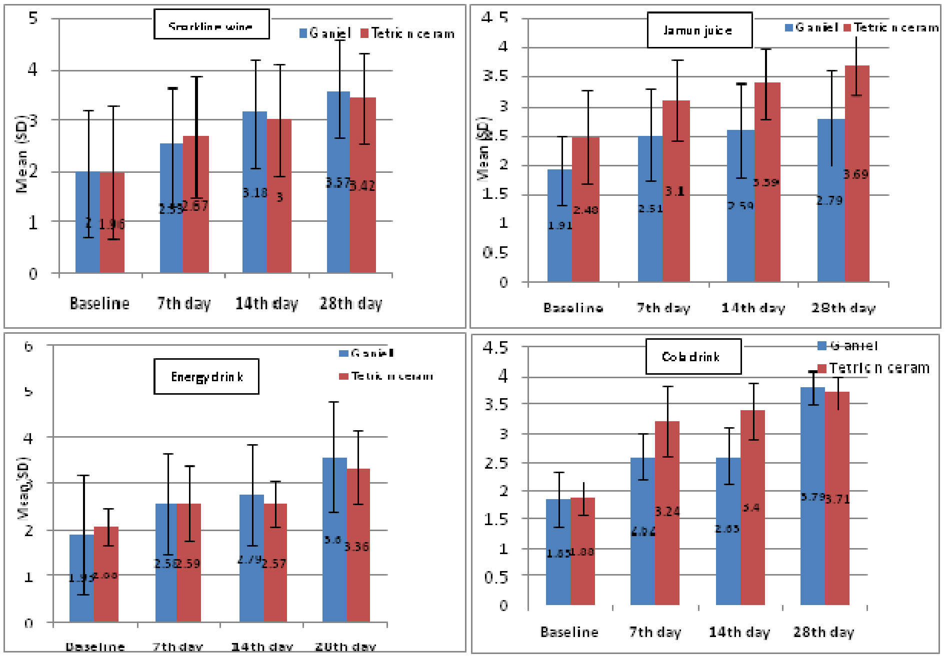

Fig: 4. Comparison of Ra in resin composite in different beverages over time

When facture toughness between two resin composites was considered on 28th day, the minimum fracture toughness was seen in the Bis-GMA based composite and results were highly statistically significant ($p<0.001$) in Cola drink. In other drinks, Bis GMA based composites had higher fracture toughness values as compared with UDMA based composites, but the difference was not statistically significant ($p<0.05$). Fracture toughness of different beverages was considered, Cola drink < Jamun Juice < Energy drink <Sparkling Wine **[Figure-5].**

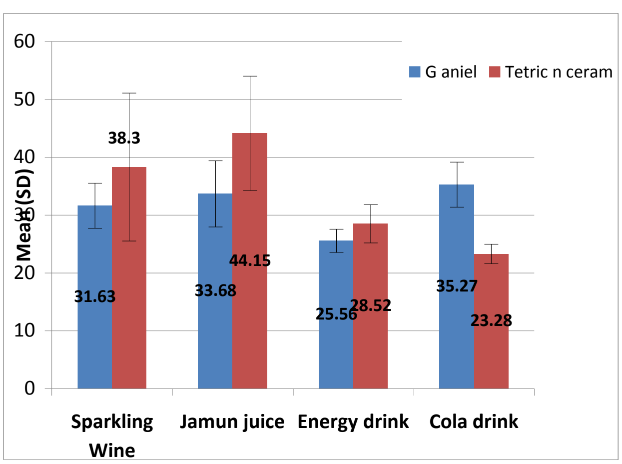

Fig: 5. Comparison of fracture toughness in resin composite in different beverages over time

ISSN: 0976-3104

DISCUSSION

The present study was conducted on two resin composites; one, a Bis GMA based and the other a UDMA based composite. G – aenial, a new UDMA based resin composite, has not been researched on its degradation under acidic conditions, fracture toughness and color stability. In this study, surface roughness assessment was chosen because surface micromorphology would affect the staining susceptibility. The CIEL*a*b* system for measuring the chromaticity was chosen to record color differences, because it is well suited for the determination of small color differences [13]. CIE (Commission Internationale de l'Eclairage) Lab* system was established in 1976 and as International standard for color measurement in 1978. It consists of a three-dimensional color coordinate system by which every color may be identified. Of the three variables, L* is defined as the attribute by which a perceived color is judged to be equivalent to one of a series of grays ranging from black (0) to white (100). a* is defined as the difference in "a" between a specimen and a standard reference color.; if "a" is positive, there is more redness than greenness, if "a" is negative, there is more greenness than redness. b* is defined as the difference in "b" between a specimen and a standard reference color; if "b" is positive, there is more yellowness than blueness; if "b" is negative, there is more blueness than yellowness.

Commonly consumed alcoholic (Sparkling wine) and non-alcoholic beverages (Energy drink, Jamun juice and Cola drink) were used as the test media in this study, to evaluate the discoloration of resin composites in an in vitro setting. Among the alcoholic beverages, previous studies have evaluated the effect of red wine and cola drinks on the discoloration of a resin composite [13-15]. During consumption, food or drink comes in brief contact with the tooth surfaces before it is washed away by saliva. In previous studies, substrates usually contacted acidic foodstuff for a prolonged period of time. Here, the immersion regimen selected was to immerse each sample in the respective beverage for ten minutes each day. For the remaining part of the day, the samples were kept in distilled water to mimic the neutralizing effect of saliva. The measurement of color change and surface roughness was made at different time intervals (baseline, 7th, 14th, 28th days) to see the relationship of time on surface degradation.

According to the results of this study, both materials became stained and rougher after they were subjected to the immersion regimen. This can be ascribed to the capability of acid media to soften resin based restorative materials. In this study, UDMA based resin composite showed significantly more discoloration than Bis GMA based resin composite. Staining of resins by fluid pigments and beverages is caused by adsorption or absorption (the uptake of substances into or through tissues) of colorants by resins. According to Sham et al, [16] chemical discoloration is caused due to the oxidation of the polymer matrix or oxidation of unreacted double bonds in the residual monomers and the subsequent formation of degradation products from water diffusion. Filler loading plays important role in composite discoloration as well as with the material's strength [17-18]. The filler loading by weight of spectrum G – aenial is 73% where as that of Tetric N-Ceram is 76%. This might be the reason that in this study the spectrum of G – aenial had ΔE greater than Tetric N-Ceram. Some studies [19-20] have shown that heavier filler loading has a significant impact on the mechanical properties with the highly filled composites being the strongest while others [21] concluded that filler content has no role in fracture behavior. Time was found to be a critical factor for the color stability of tooth colored restorative materials. In this study, results showed that as the immersion time increased, the color changes became more intense. This result was similar to that reported by Abu-Bakr et al [22].

Values of ΔE^* greater than or equal to 3.3 are visually perceptible and clinically unacceptable to 50% of the trained observers [23]. In this study, ΔE^* of UDMA based composites in the Energy drink group crossed the 3.3 level at 28th day, whereas other groups were below 2 (28th day).

When different beverages were compared, Cola drink had more surface degradation. All the beverages used in the study were acidic with Cola being the most acidic (pH=1.57)>Jamun juice (pH=2.82)>Energy drink (pH=3.37)> Sparkling wine (pH=3.5). Lower pH was seen to increase the erosion in polymers and negatively affect the wear resistance of composite materials [24-25].Thus, the higher degradation that took place in Cola drink could be attributed to its lower pH. More surface roughness change in Cola drink is supported by an earlier study, in which cola caused a significant increase in surface roughness than sugar cane spirit (alcoholic graduation 39.00% v/v) [13].

CONCLUSION

Both type of resin composites exhibited increased staining and surface roughness change, over time, on selective exposure to alcoholic and non-alcoholic beverages. Cola drink, among all three beverages, had more surface roughness and the most change in fracture toughness. Energy drink, among all three beverages, had more discolourations.

FINANCIAL DISCLOSURE

None

ACKNOWLEDGEMENT

Mr. Suraj Boyar, Lecturer, Metallurgy Dept., Sinhgad College Of Engineering, Pune.; Mr. Samiappan Appachi (Director), Spectra Colourtech India Pvt. Ltd., Mumbai.; Mr. Ashok Bhagat, Praj Laboratories, Pune. Mr. Sachin Baad, Dental Technician, Sinhgad Dental College and Hospital, Pune.

CONFLICT OF INTERESTS

None

REFERENCES

[1] Lu H, Roeder LB, Lei L, Powers JM.[2005] Effect of surface roughness on stain resistance of Dental resin composites. *J Esthet Restor Dent*, 17:102–109.
[2] Dietschi D, Campanile G, Holz J, Meyer JM.[1994] Comparison of the color stability of ten new-generation composites: An in vitro study. *Dent Mater*, 10:353–362.
[3] Sarret DC, Coletti, Peluso AR.[2000] The effect of alcoholic beverages on composite wear. *Dent Mater*; 16:62–67.
[4] Ferracane JL, Marker VA.[1994] Solvent degradation and reduced fracture toughness in aged composites. *J Dent Res*, 92:257–261.
[5] Asaoka K, Hirano S.[2003] Diffusion coefficient of water through dental composite resin. *Biomaterials*, 24: 975–979.
[6] Santos C, Clarke RL, Braden M, Guitian F, Davy KW.[2002] Water absorption characteristics of dental composites incorporating hydroxyapatite filler. *Biomaterials*, 23: 1897–1904.
[7] Söderholm KJ, Mukherjee R, Longmate J.[1996] Filler leachability of composites stored in distilled water or artificial saliva. *J Dent Res*, 75: 1692–1699.
[8] Söderholm KJ. Leaking of fillers in dental composites.[1983] *J Dent Res*, 62: 126–130.
[9] Turkun LS, Turkun M.[2004] The effect of one-step polishing system on the surface roughness of three esthetic resin composite materials. *Oper Dent*, 29:203–211.
[10] Topcu FT, Sahinkesen G, Yamanel K, Erdemir U, Oktay EA, Ersahan S.[2009] Influence of different drinks on the colour stability of dental resin composites. *Eur J Dent*,3:50–56.
[11] Badra VV, Faraoni JJ, Ramos RP, Palma-Dibb RG.[2005] Influence of different beverages on the microhardness and surface roughness of resin composites. *Oper Dent*, 30:213-219.
[12] Ergucu Z, Turkun S, Aladag A.[2008] Color stability of nanocomposites polished with one-step systems. *Oper Dent*,33:413-420.
[13] Guler AU, Yilmaz F, Kulunk T, Guler E, Kurt S.[2005] Effects of different drinks on stainability of resin composite provisional restorative materials. *J Prosthet Dent*, 94:118–124.
[14] Patel SB, Gordan VV, Barrett AA, Shen C.[2004] The effect of surface finishing and storage solutions on the color stability of resin based composites. *J Am Dent Assoc*, 135:587–594.
[15] Bagheri R, Burrow MF, Tyas M.[2005] Influence of food simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials. *J Dent*, 33:389-398.
[16] Sham AS, Chu FC, Chai J, Chow TW.[2004] Color stability of provisional prosthodontic materials. *J Prosthet Dent*, 91:447–452
[17] Rastelli AN, Jacomassi DP, Faloni AP, Queiroz TP, Rojas SS, Bernardi MI et.al.[2012] The filler content of the dental composite resins and their influence on different properties. *Microsc Res Tech*,75:758–765
[18] Kim KH, Ong JL, Okuno O.[2002] The effect of filler loading and morphology on the mechanical properties of contemporary composites. *J Prosthet Dent*, 87: 642–649.
[19] Watanabe H, Khera SC, Vargas MA, Qian F.[2008] Fracture toughness comparison of six resin composites. *Dent Mater*, 24: 418–425.
[20] Ferracane JL.[2011] Resin composite--state of the art. *Dent Mater*, 27: 29–38.
[21] Rodrigues SA Jr, Scherrer SS, Ferracane JL, Della Bona A.[2008] Microstructural characterization and fracture behaviour of a microhybrid and a nanofill composite. *Dent Mater*, 24: 1281–1288.
[22] Abu Bakr N, Han L, Okamoto A, Iwaku M.[2000] Color stability of compomer after immersion in various media. *J Esthet Restor Dent*, 12:258–263
[23] Ruyter IE, Nilner K, Moller B.[1987] Color stability of dental composite resin materials for crown and bridge veneers. *Dent Mater*,3:246–251.
[24] Chadwick RG, McCabe JF, Walls AW, Storer R.[1990] The effect of storage media upon the surface microhardness and abrasion resistance of three composites. *Dent Mater*, 6:123–128
[25] Ortengren U, Andersson F, Elgh U, Terse Lius B, Karisson S.[2001] Influence of pH and storage time on the sorption and solubility behaviour of three composite resin materials. *J Dent*, 29:35–41

THE IIOAB JOURNAL
ISSN: 0976-3104

ABOUT AUTHORS

Vrishali Kumavat: *Post graduate student, Dept. Of Conservative Dentistry and Endodontics, Sinhgad Dental College and Hospital, Pune, Maharashtra, India.*

Srinidhi Surya Raghvendra, *MDS, Professor and Head, Dept. of Conservative dentistry and Endodontics, Sinhgad Dental College and Hospital, Pune, Maharashtra, India.*

Nishant Vyavahare, *MDS, Lecturer, Dept. Of Conservative Dentistry and Endodontics, Sinhgad Dental College and Hospital, Pune, Maharashtra, India.*

Udita Khare: *Post graduate student, Dept. Of Conservative Dentistry and Endodontics, Sinhgad Dental College and Hospital, Pune, Maharashtra, India*

Pratik Kotadia: *Post graduate student, Dept. Of Conservative Dentistry and Endodontics, Sinhgad Dental College and Hospital, Pune, Maharashtra, India*