ORIGINAL ARTICLE

Effect of Commonly Consumed Beverages on Microhardness of Two Types of Composites

Dipti Barve[1], Pranav N Dave[2], Meenal N Gulve[3], Mohammed AK Meera Sahib[4], Fariha Naz[5], Saquib A Shahabe[6]

Abstract

Objective: The objective of the present *in vitro* study was to assess the influence of commonly consumed beverages on the microhardness of microhybrid and nanofilled composite resins.

Materials and methods: Two hundred and forty cylindrical specimens were produced using circular aluminum molds of an internal diameter of 10 mm and a thickness of 2 mm, 120 samples each from microhybrid composite (Filtek Z250, 3M, ESPE, USA) and nanofilled composite (filtek Z250, 3M, ESPE, USA). They were divided into 4 subgroups of 30 specimens each. These specimens were immersed in distilled water, tea, coffee, and cola drink, respectively. Microhardness was calculated using Vickers microhardness tester (MMT-X7 Matsuzawa, Japan). Data were statistically analyzed using paired *t*-test and one-way analysis of variance (ANOVA) using Tukey's correction was used for multiple subgroup comparison.

Results: Microhardness of both the composites reduced after immersing in different beverages compared to water. Nanofilled composites showed more change in microhardness than microhybrid composite. Cola caused a significant reduction in microhardness followed by coffee, tea, and water.

Conclusion: The beverages used have negative effects on the hardness of both the type of composites. The surface microhardness of nanofilled composite is significantly reduced when immersed in carbonated beverages like cola.

Keywords: Coffee, Cola drink, Composites, Microhardness, Tea.

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Introduction

Dental composites are one of the most widely used esthetic restorative materials. Since their introduction in the 1960s, they have undergone a lot of evolution that resulted in the development of their different types.[1] The presently available composites differ in their composition through a difference in organic chemistry and size, type, and a loading volume of filler particles. Many initial drawbacks of composites have been overcome through continuous research.[1] Because of improved physical and mechanical properties, their durability is said to be increased in both anterior and posterior restorations.[2]

The most desirable properties of any restorative material are to withstand forces and any chemical challenges encountered in the oral environment. Only if these challenges are successfully met, the restoration will be able to serve for longer periods.[3] There is a change in the pH of the oral cavity after the intake of different types of foods and beverages. In the case of natural tooth structure, there is demineralization or erosion when there is a drop in oral pH values. It can be anticipated that dental restorative materials are also prone to erosive attacks by low oral pH readings, this leads to the degradation of the composite surface integrity.[4]

So, exposure to dental restorative materials to food, acids, and enzymes can cause softening because of chemical degradation which may compromise the physiochemical properties of the materials.[5] The current experiment was aimed to assess the impact of different beverages on the microhardness of microhybrid and nanocomposite materials.

Materials and Methods

Two hundred and forty cylindrical specimens were prepared using circular aluminum molds of an internal diameter of 10 mm and a thickness of 2 mm, 120 each from microhybrid composite (filtek Z250, 3M, ESPE, USA) and nanofilled composite (filtek Z250, 3M, ESPE, USA) (Fig. 1). The mold was positioned on a glass slab into which the composite was inserted in increments using a plastic instrument. Flash was removed, and the material was made blush with the top of the mold surface. A glass slide of 1 mm thickness was kept onto the mold and the specimen disk was light-cured using curing light (Spectrum; Dentsply Inc., Milford, DE 19960, USA) for 40 seconds. Aluminum oxide disks were used to finish and polish the specimens (Sof-Lex, 3M ESPE, St. Paul, MN, USA) as per the

[1]Department of Conservative Dentistry and Endodontics, SMBT Institute of Dental Sciences and Research, Nashik, Maharashtra, India

[2]Department of Paediatric and Preventive Dentistry, SMBT Institute of Dental Sciences and Research, Nashik, Maharashtra, India

[3]Department of Conservative Dentistry and Endodontics, MGV's Karmaveer Bhausaheb Hiray Dental College and Hospital, Nashik, Maharashtra, India

[4,5]Department of Restorative Dental Science, King Khalid University, Abha, Kingdom of Saudi Arabia

[6]Department of Periodontics and Community Dental Sciences, King Khalid University, Abha, Asir, Kingdom of Saudi Arabia

Corresponding Author: Dipti Barve, Department of Conservative Dentistry and Endodontics, SMBT Institute of Dental Sciences and Research, Nashik, Maharashtra, India, Phone: +91 9021729622, e-mail: barve.dipti@gmail.com

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manufacturer's instructions (Fig. 1). Procedures were employed by a single operator for all the samples for standardization.

After polishing, the composite cylindrical specimens were stored for 24 hours in distilled water for post-irradiation curing and then each group was distributed into 4 subgroups of 30 samples each (Fig. 2). After taking baseline readings for microhardness, the specimens were immersed in the beverages which were replaced daily, for a period of 15 days.

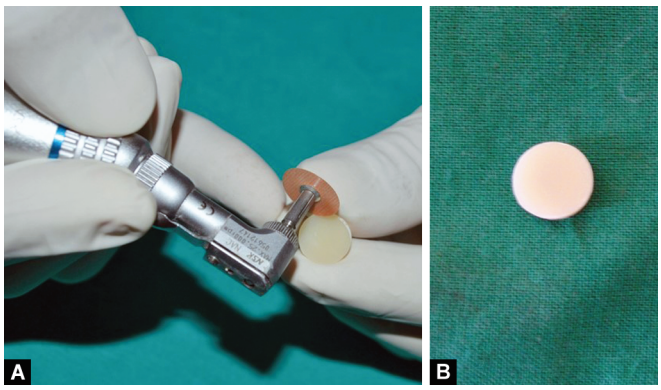
Group IA—30 samples of microhybrid composite immersed in tea.

Group IB—30 samples of microhybrid composite immersed in coffee.

Group IC—30 samples of microhybrid composite immersed in cola drink.

Group ID—30 samples of microhybrid composite immersed in distilled water (control group).

Group IIA—30 samples of nanofilled composite immersed in tea.



Figs 1A and B: (A) Microhybrid and (B) nanofilled composite samples immersed in different test media

Group IIB—30 samples of nanofilled composite immersed in coffee.

Group IIC—30 samples of nanofilled composite immersed in cola drink.

Group IID—30 samples of nanofilled composite immersed in distilled water (control group).

Microhardness Testing

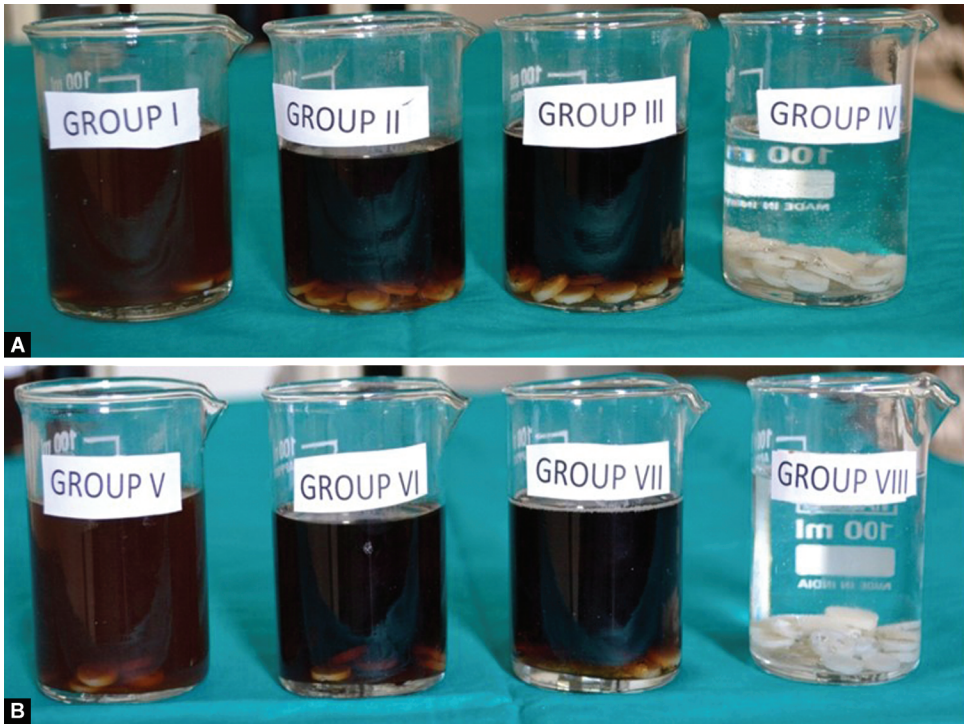
Before immersion in beverages, a baseline reading was taken for all the specimens in the designated group. Microhardness measurement (v1) of each specimen was recorded using a Vickers indenter (Fig. 3), with a load of 50 g for 20 seconds. After 15 days of immersion in solutions, specimens were taken out and blotted dry with absorbent paper and microhardness measurements were performed again (Fig. 4). These measurements were designated v2.

Statistical Analysis

Data were analyzed by SPSS version 18 (SPSS, Chicago, IL, USA). A paired *t*-test was applied for comparison of microhardness within each group after immersion in beverages. A p value of <0.05 was contemplated to be statistically significant. Also within the material statistical comparison of the change in microhardness was carried out. p values were calculated by one-way analysis of variance (ANOVA) using Tukey's correction for multiple group comparisons. A p value of <0.05 was contemplated to be statistically significant.

Results

The mean and standard deviation in microhardness values of the two restorative materials before and after immersion into distilled water and other beverages are calibrated (Table 1). For microhybrid and nanofilled composite, microhardness significantly reduced in all the groups after the exposure to the beverage (Fig. 5). For percentage change in microhardness, it was not significantly



Figs 2A and B: (A) Preparation of standardized composite specimen; (B) Prepared specimen of 10 mm diameter and 2 mm thickness

different between two materials in water, tea, and coffee. Percentage change in microhardness was significantly higher in nanofilled composite compared to microhybrid composite in cola drink (Table 2 and Fig. 6).

Relative percentage change in microhardness is calculated using the following formula:

$$\frac{\text{Microhardness Before} - \text{Microhardness After}}{\text{Microhardness Before}} \times 100$$

All the hypotheses were formulated using two-tailed alternatives against each null hypothesis.

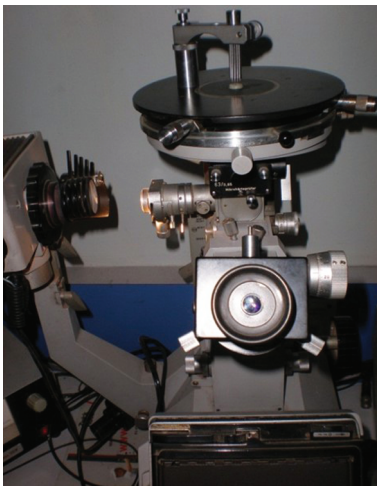


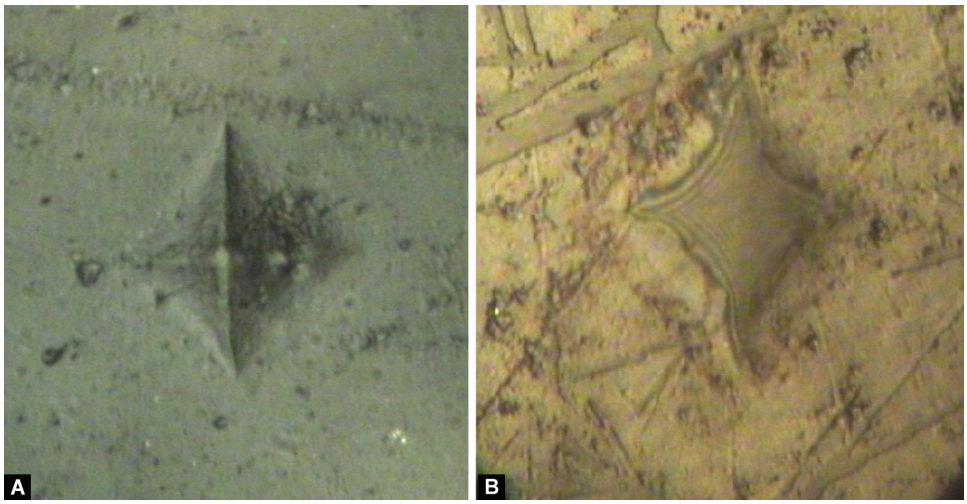
Fig. 3: Image of Vickers microhardness testing machine with specimen

Discussion

The long-term performance of esthetic dental materials is determined by their durability and color stability. The longevity of dental composite restorations is mainly based on their resistance against degradation of those results from disclosure to food, plaque acids, and enzymes that can cause softening of the composite material. The objective of the present study was to assess the effect of commonly used beverages viz. tea, coffee, and cola on the surface microhardness and stability of the color to two types of composite resins. Distilled water was chosen as a control in accordance with studies performed by Ertaş et al., Fontes et al., and Yanikoğlu.[6–8]

The size of specimens prepared was 10 mm in diameter and 2 mm in thickness, as this was the most common size for specimens as reported by Ergücü and Türkün.[9] The specimens were cured for 40 seconds as per the manufacturer's instruction.[10,11] Finishing and polishing procedure is a very important factor that affects the surface quality of composite dental restoration. Soflex provides the smoothest surface finish for composites.[12] Therefore, in this study, the surface of resin composite specimens was finished and polished with coarse, medium, fine, and superfine polishing and finishing disks as recommended by the manufacturer.

The hardness of materials before and after immersion in beverages was tested using the Vickers hardness test. Compared to Brinell or Rockwell machines, the Vickers machine is more accurate and costly.[13–15] The results in this study revealed that the surface microhardness of composite resins is decreased by immersing them in all the beverages. The decline in the surface microhardness for both microhybrid and nanocomposite was greatest with specimens immersed in cola followed by coffee, tea, and the least decrease



Figs 4A and B: Image of indentation under a microscope at baseline (A) and after immersion for 5 days (B)

Table 1: Comparison of microhardness within each group after immersion in beverages

	Material I (n = 120) (microhybrid)			*Material II (n = 120) (nanofilled)*		
Beverage	*Before (mean ± SD)*	*After (mean ± SD)*	*p value*	*Before (mean ± SD)*	*After (mean ± SD)*	*p value*
Water (control) (*n* = 30)	76.1 ± 3.0	74.6 ± 3.2	0.001*	65.2 ± 3.3	63.4 ± 3.5	0.001*
Tea (*n* = 30)	76.7 ± 2.5	74.2 ± 2.9	0.001*	68.1 ± 7.0	65.6 ± 7.4	0.011*
Coffee (*n* = 30)	77.4 ± 2.3	74.1 ± 2.6	0.001*	67.7 ± 3.1	64.7 ± 4.0	0.009*
Cola drink (*n* = 30)	75.4 ± 2.4	67.7 ± 3.2	0.001*	67.6 ± 2.4	58.1 ± 4.4	0.001*

n = number of samples
*Indicates statistically significant

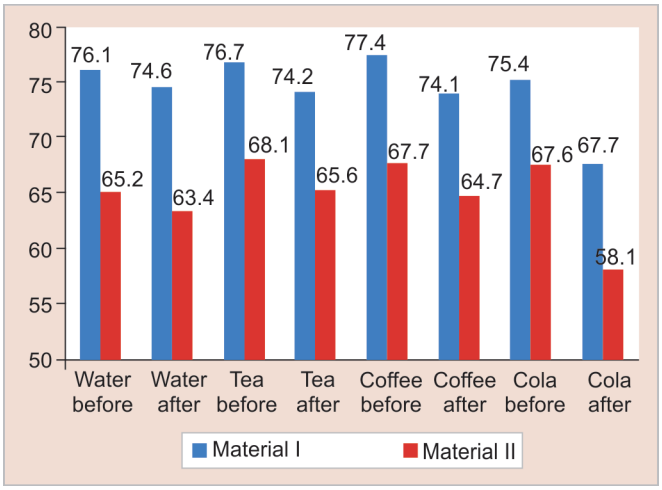


Fig. 5: Comparison of microhardness of each material within each group

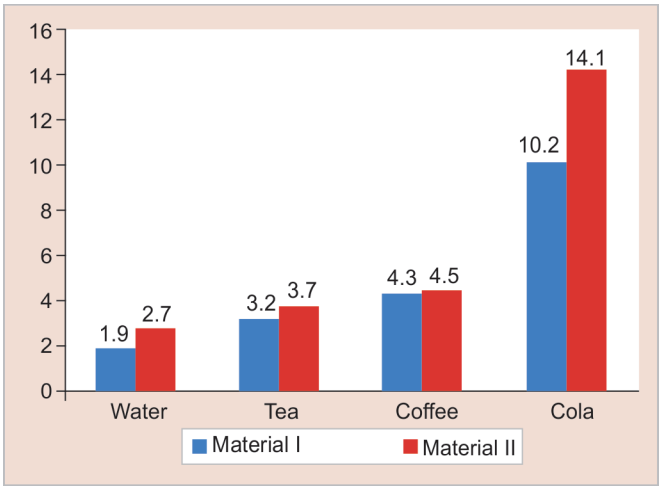


Fig. 6: The distribution of change in microhardness between two materials in each beverage type

Table 2: Between-group distribution of change in microhardness and change in color (as measured by delta E) between two materials in each beverage type

	Material I (n = 60) (microhybrid composite)				*Material II (n = 60) (nanofilled composite)*			
	Water (control)	*Tea*	*Coffee*	*Cola drink*	*Water (control)*	*Tea*	*Coffee*	*Cola drink*
% Change in microhardness	1.9 ± 1.2	3.2 ± 2.1	4.3 ± 1.9	10.2 ± 2.6	2.7 ± 1.9	3.7 ± 2.2	4.5 ± 2.0	14.1 ± 4.3

Values are the mean standard deviation of microhardness. *p* value by independent sample "*t*" test. *p* value <0.05 is considered to be statistically significant. * denotes significant

was seen in the specimens immersed in distilled water which was the control group.

The composite resins show high solubility in beverages with low pH and that solubility results in surface erosion and disintegration, which will affect the hardness of the resins.[16] The pH of the solutions used in this study were approximate; distilled water: 7, coffee: 5 to 6, tea: 5 to 6, cola: 1 to 3. Hence, the decrease in microhardness was proportional to pH with the highest decrease in solution with minimum pH values.

In the present study, the percentage change in microhardness is significantly higher in nanofilled compared to microhybrid in cola drink. The polymer matrix composition of the nanofilled composite resin used in this study is Bis-GMA, UDMA, TEGDMA, and Bis-EMA resins.[11] Previous studies have established that Bis-GMA, TEGDMA, Bis-EMA, and copolymer are very prone to softening by chemicals.[17,18] The polymer network created by TEGDMA is denser compared to Bis-GMA, UDMA, and Bis-EMA resins, which, however, is the most flexible, and water absorption is higher. The polymer network formation for Bis-GMA is more rigid and water absorption less than TEGDMA.[19] Both the composites used in this study consisted of both Bis-GMA. The presence of TEGDMA in nanofilled composite might be the factor responsible for the high water absorption.

The two main mechanisms of polymer degradation have been explained; one by hydrolysis which is passive and the other by enzymatic reactions which are active, among them the passive hydrolysis of polymer being the most important. Increased water absorption by nanocomposite might be responsible for its hydrolytic degradation and decrease in surface hardness after immersion in different solutions. This was in accordance with the study done by Almeida et al. who described that the absorption values of nanofilled composites were much higher than those of hybrid composites.[20] They attributed this to the presence of nanoclusters in the nanofilled composites.

Secondary causes of a decrease in the surface microhardness of the composites after exposure to the beverages could be the sustained loss of silica after degradation of the matrix, splitting of the matrix–filler interface, and subsurface damage. The decrease in hardness is due to the internal disintegration of the silane coupling agent and the siliceous filler particles.[21] The water contains hydroxyl ions which attack the siloxane bond to break them into silanol groups leading to the degradation of the filler surface.[22]

The findings of the present experiment validate with other studies that suggested some food substances cause softening and accelerated wear of resin composites.[23–26] Limitation of the present study is the continuous immersion in the beverages for 15 days. The *in vivo* conditions are different from the *in vitro* conditions due to the presence of saliva. Hence, more *in vivo* studies should be carried out to confirm the findings of the present study.

Conclusion

The results of the present study provided information on the microhardness of microhybrid and nanofilled composites and the staining potential of some drinks commonly consumed in daily life. The results of the present study exhibited that nanofilled composite did not present superior microhardness against these beverages.

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