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Comparative Analysis of the Effect of an Aerated Energy Drink And 35% Hydrogen Peroxide on Microhardness of Nanocomposite Resin

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Abstract

Background And Objectives: The aim of this in vitro study is to evaluate the effect of 35% Hydrogen peroxide and an aerated energy drink (Red Bull) on the microhardness of nanocomposite resin.

Materials and Methods: Thirty composite resin discs (6 mm in diameter and 2 mm in height) were fabricated and they were light-cured. These samples were divided into three groups (n=10). Ten composite samples were stored in distilled water at 37℃ and served as the control group. Ten samples were exposed to 35% hydrogen peroxide bleaching gel for 6 and 42 hours (first experimental group). The remaining 10 samples were stored in aerated energy drink (Red Bull) for 6 and 42 hours. The microhardness of composite samples was measured using Vickers microhardness tester under 100 g load applied for 10 seconds before and after the immersion. The obtained data were analyzed using SPSS 16 via one-way ANOVA and post hoc test ($P \leq 0.05$).

Results: Microhardness of composite decreased at both 6 and 42 hours after immersion in distilled water (P=0.048), aerated energy drink (Red Bull) [P<0.001] and 35% hydrogen peroxide (P<0.001). Comparison of the three groups showed significant differences between the aerated energy drink (Red Bull) and 35% hydrogen peroxide groups at baseline (P=0.011), distilled water and 35% hydrogen peroxide at six hours (P=0.004), distilled water and aerated energy drink (Red Bull) at 42 hours (P=0.003) and distilled water and 35% hydrogen peroxide at 42 hours (P<0.001).

Conclusion: According to the results of this study showed decreased in the microhardness of composite

resin in all the groups distilled water, aerated energy drink (Red Bull) and 35% hydrogen peroxide.

Introduction

Recently with more awareness on esthetic , there is an increased effort towards the maintainance of natural teeth with color , surface characteristics or function .

The clinical performance of restorations depends on the type of restorative material and its mechanical properties such as wear resistance, bond strength, integrity of the interface between tooth and restoration, esthetic quality, damage and decrease hardness and roughness.

Dental composites are compounds by an organic polymerizable matrix , inorganic fillers , borosilicate , silica , and a silane-coupling agent. The organic phase (resin phase) of composite resins is constituted by monomers such as Bis-GMA (bisphenol A diglycidyl dimethacrylate) and/or UDMA (urethane dimethacrylate), co-monomers such as TEGDMA (triethylene glycol dimethacrylate) and/or Bis-EMA (ethoxylated bisphenol A glycol dimethacrylate), additives, initiator (canphoroquinone), co-initiator (dimethyl- aminobenzoic acid-ester), a polymerization inhibitor, and a photostabilizer (benzophenone). The inorganic phase is composed by fillers of different types and particle sizes . Recent advancements in the organic matrix of nano composite with compact size of particles and increased loading of filler, and have resulted in improved esthetics and mechanical properties.1

The mechanical properties of composite resins are influenced by its chemical compositions and also by the environment to which they are exposed.[2,3]

For the purpose of enhancing performance and endurance , there is an increased consumption of sports and energy drinks among the general population in recent years. 4The low pH of acidic foods and drinks causes erosive wear in these materials 5. They are exposed either intermittently or continuously to chemical agents found in saliva, food, and beverages. And such exposure can soften the resin matrix of the composite resins and cause filler constituents to leach out 6,7Hardness is defined as the resistance of a material to indentation or penetration (O'Brien, 1997). As hardness is related to a material's strength, proportional limit and its ability to abrade or to be abraded by opposing dental structures/materials (Anusavice, 1996), any chemical softening resulting from foods , beverages and bleaching agents has implications on the clinical durability of restorations.8Apart from the degradation caused by saliva, by acidic food and by beverages, bleaching procedures can potentially cause softening and increased surface roughness to resin composites, depending on the resin composite and on the bleaching agent used.With this view point , the present study was undertaken to observe the effect on microhardness of composite resin on exposure to commercially available aerated energy drink (Red bull) and 35% Hydrogen peroxide used in bleaching of vital teeth.

Materials and Methodology

Thirty composite disc were fabricated by placing composite resin (3M ESPE Filtek Z350 XT composite material) into transparent polyvinyl siloxane circular molds measuring 6 mm in diameter and 2 mm in height . The upper and lower surfaces of the mold were covered with a celluloid tape and a glass slab was placed on top of it . Pressure was applied in order for the excess material to leak out. Composite resin was light-cured for 40 seconds from each side using a LED light curing unit , according to manufacturer's instructions. The initial baseline hardness values were measured . The thirty circular discs then fabricated were randomly divided into three equal groups(n=10) based on the exposure to the experimental materials.

Group I samples were immersed in distilled water and their hardness were measured at the end of 6 and 42 hours of immersion. In group 2, 35% hydrogen peroxide gel was applied in according to the manufacturer's instructions. For this purpose, gel with 2 mm thickness for 15 minutes. The gel was then washed and reapplied for the same period of time. In the time interval between the two applications, the samples were rinsed under running water and immersed in distilled water for one minute. This procedure was repeated 42 hours later.

In group III, samples were immersed in aerated energy drink (Red bull) for 6 hours a day at 37°C and then in distilled water at 37°C for the rest of the day and the same continues for 7 days .The microhardness of samples was measured after 6 hours (one day) and 42 hours(seven days) using Vickers Microhardness Tester.

Vicker's Microhardness Tester

Vicker's microhardness tester is used for testing the initial microhardness of the composite discs The microhardness of samples was measured by applying 100 g load for 10 seconds to create three indentations at the center of the upper surface of samples. Load was applied by the indenter of the device in the form of a plus sign (+). The vertical and horizontal dimensions of the plus sign were then measured to calculate the mean hardness number according to the Vickers table. The mean value was reported as the Vickers hardness number of each sample.

Statistical Analysis

Data entry was done in Microsoft Excel. The values obtained were statistically analyzed using computer software Statistical Package for the Social Sciences (SPSS) (16.0) (SPSS Inc, Chicago, USA). The data were expressed with the mean and standard deviation. One-way analysis of variance (ANOVA) was applied for statistical analysis followed by Post hoc test was used to find the statistical significance between the groups. P value less than 0.05 ($P < 0.05$) was considered to be statistically significant at 95% confidence interval.

Results

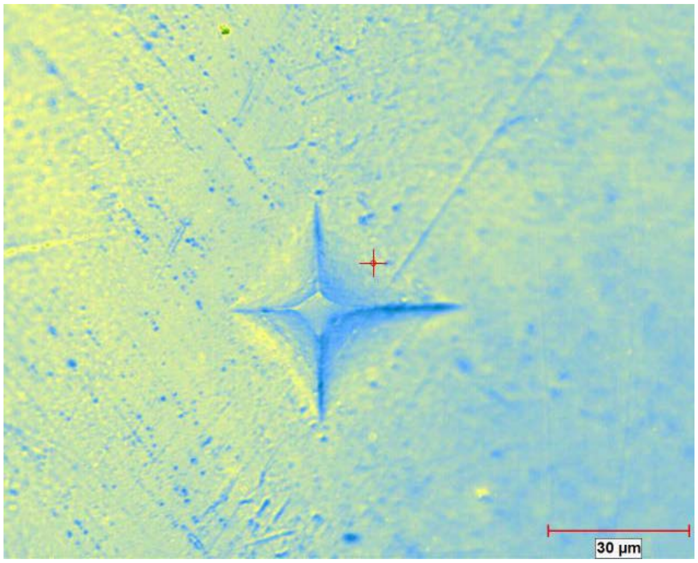
Mean and standard deviation of hardness number of samples in the three groups at baseline, six hours and 42 hours after the immersion.

GROUPS	BASELINE	6 HOURS	42 HOURS
DISTILLED WATER (GROUP- I) CONTROL GROUP	108.2±2.7	99.3±1.7	96.4±2.2
35%H2O2(GROUP – II)	98.1±1.5	81.2±2. 1	76.8±2.7
RED BULL(GROUP-III)	99.3±2.2	92.6±1.5	88.8±1.6

Table 1: shows the mean microhardness values of tested restorative materials after immersion in various media.

One-way ANOVA showed significant differences in microhardness among three immersion media ($p<0.001$) . The surface hardness values of composite materials after 6 hours, and 42 hours of storage is insignificant than the baseline surface hardness values. The comparison of hardness at baseline, 6 hours and 42 hours after the intervention shown the significant differences between the aerated energy drink (Red Bull) and 35% hydrogen peroxide groups .The average surface hardness of the materials in distilled water was significantly different from that measured for aerated energy drink (Red Bull) and 35% Hydrogen peroxide . Microhardness of composite decreased at both 6 and 42 hours after immersion in water ($P=0.048$), aerated energy drink Red Bull ($P<0.001$) and 35% hydrogen peroxide ($P<0.001$). Comparison of the three groups showed significant differences between the aerated energy drink Red Bull and 35% hydrogen peroxide groups at baseline ($P=0.011$) , distilled water and 35% hydrogen peroxide at 6 hours ($P=0.004$) , distilled water and energy drink Red bull at 42 hours (P=0.003) and distilled water and 35% hydrogen peroxide at 42 hours (P<0.001).

Microscopic view of the indentations on composite disc using Vickers Microhardness Tester.



Discussion

Surface hardness is an important mechanical property of any restorative materials , any reduction in microhardness leads to disintegration and consequently results in accumulation of dental plaque and deposition of lactic acid. Degradation of restorative materials cannot be attributed to wear alone, but involves chemical degradation as well . Invivo, these materials may either be exposed intermittently or continuously to chemical agents found in saliva , food , and beverages . Due to the exposure of restorative materials to saliva and its constituents , food and drinks , there will be washing away of resin matrix and subsequently the filler particle .9 Hence the present study was aimed to assess the microhardness of nanocomposite restorative material influenced by the solution like distilled water , aerated energy drink (Red Bull) and 35% Hydrogen peroxide

Thirty composite discs were fabricated and divided into 3 Groups (n=10) ,Group I (Distilled water) Group II (aerated energy drink- Red Bull) Group III (35% Hydrogen peroxide) .The hardness of these samples were measured before immersion and 6 hours and 42 hours after immersion. In Group II , the samples were immersed in aerated energy drink (Red Bull) for 6 hours in a day and stored in distilled water for rest of the day and the same continues for 7 days The microhardness of samples was measured after 6 hours (one day) and 42 hours(seven days) . A can of aerated energy drink (Red Bull) contains about 300 mL , assuming that in each sip, the restoration are exposed to about 30 mL of aerated energy drink (Red Bull) for approximately six seconds, drinking one can of aerated energy drink (Red Bull) equals 60 seconds of exposure. Thus, 6 hours of immersion of samples in aerated energy drink (Red Bull) corresponds to daily exposure of teeth/restorations to aerated energy drink (Red Bull) for one year; 42 hours of immersion equals seven years of frequent use of aerated energy drink (Red Bull).10

In Group III , the samples were subjected to 35% hydrogen peroxide gel applied for 15 minutes. The gel was then washed and reapplied for same period of time and then the microhardness was checked .Again the same procedure was repeated 42 hours later.

The Vicker's microhardness tester is used for the assessment of microhardness in the current study , which is in agreement with the study done by Yanikoglu et al , Medeiros et al , Okada et al , Carreiro et al , and Ateyah et al .10

The present study showed a detrimental effect in microhardness of the composite from all three groups subjected to distilled water , aerated energy (Red bull) and 35% Hydrogen peroxide .

The result revealed that there is a reduction in microhardness of all three groups after immersion period, irrespective of the solution used. The mean hardness number of composite samples decreased after 6 and 42 hours of immersion in distilled water compared to the baseline value .This result was in line with that of Yanikoglu et al, Yap et al., Ratto de moraes et al., Catelan et al., and DaneshKazemi et al. This reduction in hardness may be due to incomplete polymerization reaction of composite resin. In a study by Mottaghi et al., hardness of all composites decreased six hours after immersion in distilled water compared to the baseline value, but after 42 hours of immersion in distilled water, their hardness increased, which may be attributed to higher cross-linking reactions and completion of polymerization of resin matrix. 10

Erdemir et al states that during consumption , food or drink contacts teeth or restoration surfaces for only a short time before it is washed away by saliva. Therefore, in the present study, due to the acidity and erosive potential of aerated energy drink (Red bull) and Hydrogen peroxide , after the immersion and application of these materials the composite discs were stored in distilled water for the rest of the day to simulate the washing effect of saliva . Distilled water was selected instead of artificial saliva because the distilled water simulate the washing effect of saliva .4

In Group I when composites are immersed in distilled water, the resin matrix swells, reducing the frictional forces between polymer chains . The whole hydrolytic degradation mechanism is a diffusion rate dependent process, influenced by polymer type , filler load and the type of filler , and surface treatment of the particles . Furthermore, tensile stresses are generated at the resin-filler interfaces, straining the bonds in the inorganic component and increasing the frictional forces between filler and resin matrix, facilitating pull-out of fillers . Water sorption reduces the hoop stresses around fillers, which facilitates the plucking-out of particles. 11

In Group II , the specimens that were immersed in aerated energy drink (Red bull) demonstrated greater surface hardness reductions when compared to the specimens stored in distilled water after 6 hours and 42 hours of evaluation period.

This can be explained by Nicholson et al ,stated the fact that all of the composite materials displayed a tendency to erode under acidic conditions and the acids in these drinks promoted the release of unreacted monomers by penetrating into the resin matrix, thereby resulting in lower surface hardness values .12,13

The composition of aerated energy drink (Red Bull) contains carbonated drink , sucrose , Glucose , citric acid , taurine , sodium bicarbonate , Magnesium carbonate , caffeine , Niacinamide , Calcium panthothenate , Pyridoxine HCL and Vitamin B12 . The ph of aerated energy Red bull is 2.80 . The pH of the solutions /beverages could adversely effect the properties of esthetic restorative materials . . It has been previously reported by Valinoti et al that resin materials immersed in “low-pH drinks have a high solubility, and this solubility causes surface erosion and dissolution, negatively affecting wear, hardness, and surface integrity by softening the matrix and causing a loss of structural ions .14In addition, increased interaction between the solutions and resins, as well as the water uptake and greater erosive effect of acidic conditions on restorative materials, resulted in the decreased surface hardness values observed in the present study.4

Hardness is affected by the degree of conversion of composite resin . Some researchers have shown that bleaching agents are highly unstable and release free radicals that lead to the cleavage of polymer chains and breaking of double bonds . Hydrogen peroxide which is used as a bleaching agent for vital teeth is capable of diffusion can affect the resin filler interface causing microcracks while the filler particles remain intact . This could be responsible for reduction of microhardness. in the present study.

Nanofilled composite resin Filtek Z350 has the combination of silica nanofillers and zirconia-silica nanoclusters . Beun et al has demonstrated that this type of composite has similar mechanical properties as that of midifill composites.15 However, the high surface/volume ratio due to the presence of silica particles may increase the water sorption and lead to the destruction of polymer matrix-filler interface causing a possible drop in some mechanical characteristics .16

The mentioned mechanism and the effect of bleaching agent on the filler-matrix interface are probably responsible for the reduction of microhardness in this composite in the present study.5

The mean microhardness values of tested restorative materials after immersion in various media showed significant differences in among three immersion media ($p<0.001$) . The surface hardness values of composite materials after 6 hours, and 42 hours of storage is significant than the baseline surface hardness values. The comparison of hardness at baseline, 6 hours and 42 hours after the intervention shown the significant differences between the aerated energy drink (Red Bull) and 35% hydrogen peroxide groups . The average surface hardness of the materials in distilled water was significantly different from that measured for aerated energy drink (Red Bull) and 35% Hydrogen peroxide . Microhardness of composite resin decreased at both 6 and 42 hours after immersion in water ($P=0.048$), aerated energy drink (Red Bull) ($P<0.001$) and 35% hydrogen peroxide ($P<0.001$). Comparison of the three groups showed significant differences between the aerated energy drink (Red Bull) and 35% hydrogen peroxide groups at 6 hour and 42 hour ($P=0.011$) , distilled water and 35% hydrogen peroxide at 6 hours ($P=0.004$) , distilled water and energy drink (Red bull)at 42 hours ($P=0.003$) and distilled water and 35% hydrogen peroxide at 42 hours ($P<0.001$). Various studies showed that acids present in aerated energy drink decreased the hardness of restorative material.

Conclusion

The reduction in microhardness bringing about the loss of material may contribute to its deterioration in a clinical environment , including loss of anatomical form and discoloration. Furthermore, chemical softening may have a negative effect on wear and abrasion rates and, consequently, on the life span of a restorative material. It must be noted that the experimental conditions cannot completely replicate the oral cavity testing environment.15 However ,in the present study, microhardness of the restorative materials decreased after immersion in aerated energy , distilled water and 35% Hydrogen peroxide drink .Further studies are required with larger sample size and longer duration on different types of composites preferably in the oral environment.

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