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Original Research

Effects of various beverages on hardness, roughness and solubility of esthetic restorative materials

[1]Dr. Parul Verma, [2]Dr. Shivangi Gupta

[1]Reader, Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences, Sehora, Jammu;
[2]Reader, Department of Periodontics and Implantology, MMCDSR, Deemed to be University, Mullana, Ambala

ABSTRACT:
Background: An increase in consumption of aerated beverages has presented an increase in the wearing of teeth and an increase in the usage of esthetic restoration materials. This study aimed to evaluate surface microhardness of these materials following surface treatment with beverages in *in-vitro* condition. **Material and Methods**: The initial surface microhardness of 5 restorative materials: GC Fuji II LC, GC Fuji IX, Nano Glass ionomer, Resin, and Nanocomposite were recorded. All materials were exposed to selected acidic beverages daily and once weekly in a month. The final surface microhardness was recorded following experimentation. Statistical analysis was performed using the student t-test and ANOVA. **Results**: Inter-group comparisons were made among groups and statistical significance (p<.05) was noted following treatment with beverages. **Conclusion:** The surface microhardness, roughness, and solubility values of esthetic restoration materials were found to reduce following repeated beverage exposures.
Keywords: esthetic, roughness, solubility, restorative.

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Corresponding address: Dr. Parul Verma, Reader, Department of Conservative Dentistry and Endodontics Institute of Dental Sciences, Sehora, Jammu

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INTRODUCTION

Restoration of teeth is done for various reasons which include- dental caries, trauma, abrasion, erosion along with developmental or congenital anomalies. [1] Esthetic restorations are considered when these restorative materials are used for repairing tooth structure with material that closely resembles the color of natural teeth. [2]

The acidic sources resulting in erosion process affecting both the tooth structure and restorative materials may be-a) either of intrinsic nature, for example, gastric reflux and eating disorders such as bulimia and anorexia nervosa, and b) of extrinsic nature, for example, soft drinks, few fruits as well as fruit juices. Besides affecting teeth, it also reduces the clinical performance and durability of esthetic dental restorative materials. Various mechanisms which result in deterioration along with subsequent, degradation of a variety of restorative materials are complex due to myriad conditions existing within the oral microenvironment. [3]

Materials that are used as fillers must-have features such as long-term durability and the longevity of restorations depend upon a variety of factors like-resistance to wear, the durability of both the tooth and restorative interface, and the extent of mechanical preparation of tooth required. [4]

A variety of esthetic restorative materials that are presently available include- glass ionomer cement, resin-modified glass ionomer cement, compomer, and resin composites. [2] Each of these materials has distinct advantages as well as disadvantages that may be considered during the process of selecting appropriate materials. [1]

Dental composites contain a resin-based oligomeric matrix such as bisphenol-a-glycidyl methacrylate (BisGMA) or Urethane dimethacrylate (UDMA) and silane-treated inorganic fillers such as silicon dioxide. [5]

Composites are the treatment of choice for sealing enamel as well as minimizing progressive structural loss due to erosive acidic exposure. [1] The main advantages of using composites are- a) esthetics and b) higher bond strength with the tooth structure. Although, the success rate of composites is dependent upon the technique of application.

Glass ionomer cements (GIC) are based upon chemical reactions between silicate glass powder and poly-alkenoic acid. These restorative materials are specifically indicated in the treatment of erosive as well as carious lesions in low stress-bearing areas. Hence, modifications in these restorative materials have been introduced like- Resin modified Glass Ionomer Cement, Dual- and tri-cured Glass Ionomer Cement, and metal-reinforced Glass Ionomer Cement. [6]

Resin-modified Glass Ionomer Cement is a light-cured combination of glass ionomer cement along with the composite resin. This chemical composition significantly causes improvement in mechanical properties of Glass Ionomer Cement. [7, 8]

Studies have shown that acidic foods and beverages result in the degradation of the restorative material surface. [9] Degradation of restoration surface of resinous restorative materials is closely dependent upon the composition of the matrix, contents, distribution of fillers material, and effects of silane surface treatment. The contents of fillers show a correlation with restoration color, polymerization depth, stability, compressive strengths along stiffness of composite restorative material. [10]

Thus, this study was conducted to analyze the effects of various beverages on the hardness, roughness, and solubility of esthetic restorative materials.

MATERIALS AND METHODS

a) Restorative materials used and Beverages tested:

Five tooth-colored esthetic restorative materials: a) Group I: GC Fuji II LC Improved (A2, GC Corporation, Tokyo, Japan), b) Group II: Fuji IX (GC High Strength Posterior Restorative, GC Corporation, Tokyo, Japan), c) Group III: KetacTM N100 (3M ESPE, USA), d) Group IV: Filtek Z350 universal restorative Composite (3M ESPE, USA) and e) Group V: Ceram XTM Nanoceramic restorative (Dentsply, Mono M6) were selected for this study. All restorative materials underwent manipulation as per the manufacturer's instructions and were then placed within rectangle-shaped recesses manufactured from customized acrylic moulds (3 mm wide, 4 mm long, and 2 mm depth). Light cure composite materials used underwent polymerization using a curing light on the surface of a glass slide whereas the chemical cures restorative materials were allowed to set at normal room temperature for 10 minutes. After completion of polymerization or setting, these materials were carefully taken out from their respective moulds (n = 60, in each group). Each group specimens were then equally distributed in subgroups 1(Beverage 1) and 2 (Beverage 2).

The selected aerated beverages that were used for testing these specimens included- 2 Coca-Cola beverages that had pH = 2.5 and 2.98, respectively which were measured by making use of a pH meter.

SPECIMEN CONDITIONING

All the test specimens were thoroughly cleaned in distilled water using an ultrasonic cleaner for one minute for removing any particles of debris. Before testing, all experimental specimens were first stored in distilled water for 7 days.

MEASUREMENT OF SURFACE MICROHARDNESS

All prepared specimens were dried using blotting paper and were repositioned within the prepared blocks of acrylic by positioning in the center underneath the indenter of a digital Knoop micro-hardness tester for estimating the initial surface micro-hardness value which was measured in Knoop hardness number. A load of 50 gf was then applied using the indenter with dwell time lasting for up to 10 seconds. Initial Surface microhardness was determined by performing up to five indentations of each prepared specimen sample for purpose of standardization. Mean initial surface microhardness values for all restorative material samples were calculated. Samples whose mean surface microhardness values ranged between 10 % of the total mean value were then included in the study.

PERCENTAGE SURFACE MICRO-HARDNESS CALCULATION WAS DONE AS PER THE FORMULA

% Microhardness Surface Hardness = 100 X Surface Microhardness b- Surface Microhardness f divided by Surface Microhardness b

Where 'b' stands for baseline value and ‘f’ stands for final.

EXPERIMENTAL DESIGN

A total of three cycles of 5-minute immersion of all test restorative specimens in both the beverages in half the quantity (n=30 for each beverage)) for a storage time of 5 minutes in the artificial saliva in between were followed. This process was repeated once every week for a month. All the test specimens were followed by rinsing in normal saline solution before as well as after each period designated for immersion. All of these esthetic restoration study samples were followed by storage in de-ionized water in air-tight plastic containers/jars at room temperature. After 1 month duration of experimental conditioning, the final values of surface microhardness and consequent solubility of prepared specimens were then, recorded in terms of Knoop Hardness Number values. Surface roughness was tested using a Profilometer and values (Ra) were recorded in μm.

STATISTICAL ANALYSIS
Collected values pertaining to KHN were then subjected to statistical analysis (SPSS version 22.00) at a 5 % significance level. Statistical tools used were student's T-test and One-way ANOVA were employed for inter-group comparisons.

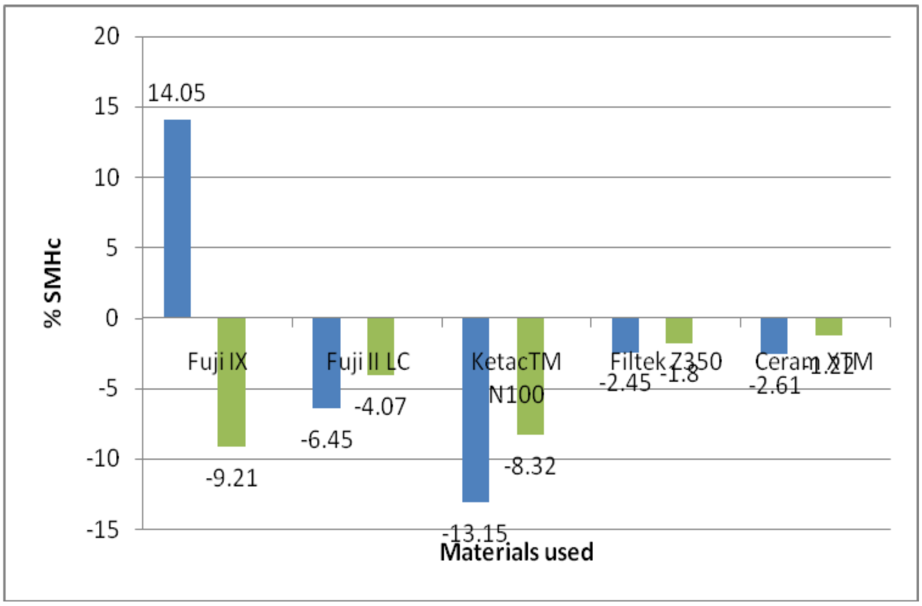
RESULTS
Inter-comparisons of KHN values among the 5 restorative materials between Group 1 and 2 showed an increased SHM reduction with the samples treated with initial mean surface microhardness to their final values of all groups using the paired student t-test. A high statistical difference (*p*<.0005) was observed between all the groups when treated with both beverages (Tables 1).

Table 1: Result of surface treatment of all restorative materials used in the study

		Fuji IX	Fuji II LC	KetacTM N100	Filtek Z350	Ceram XTM
Beverage 1	**Initial SMH**	41.8 ± 2.85	47.6 ± 2.34	35.32 ± 3.5	75.03 ± 2.1	82.42 ± 0.18
	Final SMH	36.8 ± 1.45	40 ± 1.75	30.21 ± 1.17	67.56 ± 0.45	72.11 ± 0.31)
	%SMHC	14.05	- 6.45	-13.15	-2.45	-2.61
Beverage 2	**Final SMH**	32.12 ± 2.1	41.2 ± 1.47	31.25 ± 2.02	69.35 ± 1.9	72.5 ± 2.34
	%SMHC	-9.21	-4.07	-8.32	-1.8	-1.22

The high statistical difference observed in these groups explains the increased loss of surface microhardness of restorative blocks following repeated and prolonged exposure to beverages of low pH. Group 1 showed a maximum increase in surface roughness as compared to other groups and was found to be statistically significant (P=0.02). these results indicate that conventional glass ionomer cement is most soluble in acidic beverages.

Graph 1



DISCUSSION
The clinical success of any dental restorative substance is directly correlated with its longevity and extended continuity. These qualities are strongly influenced by either both intrinsic characteristics or properties of these materials as well as the oral environmental conditions towards which they are continuously exposed. [11]

An ideal dental restorative material must offer a long-term result. This is dependent upon the inherent properties of the concerned material and largely upon the external environment existing within the oral cavity. In addition, there are several other aspects, for example decreased pH which is the result of intake created by acidic beverages and food materials which may adversely affect both physical as well as mechanical characteristics of these restorative materials. [12]

Moyin et al in 2020 analyzed the effects of acidic drink on the microhardness using a Vickers diamond indenter of esthetic restorative materials such as nanohybrid ormocer-based composite, glasiosite compomer, and glasiosite compomer. Study results showed that nanohybrid ormocer-based composite demonstrated the finest behavior both preceding and the following dipping an acidic beverage. [13]

Vaidya et al in 2020 evaluated surface roughness of three esthetic flowable restorative materials following exposure to various sports and energy drinks along with few alcoholic beverages. Flowable composites demonstrated minimal roughness values of surface tested while flowable compomers demonstrated the maximum amount of surface roughness values in experimental test conditions. On evaluating the erosive potentials of tested solutions, the surface roughness values were found to be higher than sports and/or energy drinks as compared to alcoholic beverages. [14]

Shalan et al in 2019 in their comparative study on color changes in glass ionomer cement and compomers showed that Glass ionomer cement sub-groups demonstrated greater susceptibility to surface discoloration than compomer. Significant alteration ($P < 0.001$) in color was seen in the non-brushed glass ionomer cement sub-group which was immersed in cola drink. [15]

BinMahfooz et al in 2019 analyzed the flexural strengths and micro-hardness of three provisional composite restorative dental materials- a) Temphase™, b) Protemp™ and c) CAD Temp® mono-color after immersion in three types of caffeinated drinks: a) Arabic coffee, b) American black coffee and c) Cappuccino. It was noted that all of these beverages resulted in a significant reduction in flexural strength of composite provisional restoration materials which were investigated in this study. All of the tested beverages were shown to significantly reduce the microhardness values of Temphase™ material. [16]

Saba et al in 2017 reported a significant decrease in micro-hardness values of both hybrid and Feldspathic substances following repeated immersion in coffee. Microhardness values of hybrid material were measured before or after immersing in different beverages or solutions were significantly lower than those of Feldspathic material used. A significant negative correlation was seen to exist between color changes and the percentage of change in micro-hardness of both materials. [17]

Borah et al in 2017 compared the microhardness of nanocomposites- Shofu Beautifil II and Estelite α-supranano by exposing them to two beverages, Coca-Cola and Tropicana orange juice. They observed a reduction in the hardness of both the nano-composites with the beverage, Coca-Cola demonstrating a higher reduction in surface hardness between these two materials with a P value less than 0.05. on comparing both the materials, Shofu Beautifil II demonstrated a higher reduction in surface microhardness when compared to Estelite α-supranano. [18]

Xavier et al in 2016 in their comparative analysis showed loss of surface microhardness of GC Fuji II Light Cure, GC Fuji IX, Nano Glass ionomer cement, Resin, and Nanocomposites after exposure to acidic beverages. The maximum loss of surface hardness was reported from nanocomposite material (P-value < 0.005). [19]

Fatima et al in 2012 in their study on effects of various tetra-pack juices over micro-hardness of different direct tooth-colored restorative materials reported that exposure to these juices caused a significant reduction in hardness of both resin-modified glass ionomer cement and composite ($p < 0.05$). More decrease in hardness qualities was reported in resin-modified glass ionomer cement than composite ($p < 0.00$). No statistically significant difference was noted between the effects of packed apple and orange juices. [20]

CONCLUSION

Although newly available dental restorative substances mainly fulfill esthetic requirements of indicated patients, however, the deleterious effects of routinely consumed acidic and carbonated drinks affect their overall durability and chronicity which is required for further studies and research. The present *in-vitro* study strongly recommends that keeping in mind, resistance for degradation, the material of choice should be resin composites while undertaking the restoration of teeth that are affected by acidic erosion. Though, the dentist's decision and appropriately selected patients must also be taken into consideration.

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