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RESTORATIVE DENTAL MATERIALS;

A COMPARATIVE EVALUATION OF SURFACE MICROHARDNESS OF THREE RESTORATIVE MATERIALS WHEN EXPOSED TO ACIDIC BEVERAGES

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ABSTRACT… Introduction: Erosion is an escalating problem in all age groups. Dental erosion can be defined as painless irreversible loss of dental hard tissue due to chemical process without the involvement of microorganisms. There are several causes of erosion including acidic foods and drinks. They are not only harmful to teeth but it is one of the main causes of failure of restoration. Erosion is one of the main challenges to restorative materials. Therefore, the restorative materials used in the mouth should resist or show minimal change in these situations. A variety of restorative materials are currently recommended for erosive lesions, including resin modified glass ionomer cement, resin composite and amalgam. Each material has its own advantages and disadvantages, which are considered before selecting them as restorative materials. **Objectives:** To compare the surface micro-hardness of three restorative materials when exposed to three acidic beverages and distilled water. **Study design:** This was an experimental study. **Setting:** de'Montmorency College of dentistry in collaboration with Pakistan council of scientific and industrial research (PCSIR) Lahore. **Period:** 6 months, Nov 2014- April 2015. **Material & Methods:** Ninety six disc specimens prepared with resin modified glass ionomer, resin composite and amalgam restorative materials. The initial surface micro-hardness test was carried out at 1 day after mixing (before immersion) using micro-hardness testing machine. After base line study of micro-hardness the material specimens were subjected to one of the storage media which was comprised of cola, apple juice, orange juice and distilled water as control. Quantitative assessment of final surface micro-hardness was done at 2, 5 and 7 days after immersion. The values obtained as base line and final vickers hardness number (VHN) for each specimen were subjected to statistical analysis. **Results:** Exposure to acidic beverages decreased the surface micro-hardness of all the three restorative materials ($P<0.05$), while distal water did not affect the surface micro-hardness of any material. The resin modified GIC showed greatest reduction in surface micro-hardness as compared to Amalgam and Resin Composite. The cola produced the greatest degradation effect. **Conclusion:** Selection of restorative materials should be considered in patients with tooth surface loss, especially those with high risk for erosive conditions. In terms of materials evaluated for this study Amalgam and Resin Composite provides the greatest stability under acidic conditions.

Key words: Restorative Materials, Surface microhardness, Resin Modified Glass Ionomer, Resin Composite, Amalgam, Acidic Beverages.

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INTRODUCTION

Teeth require restoration for a variety of reasons including dental caries, trauma, abrasion, erosion, and congenital anomalies.[1] Evidence based studies have shown that the incidence of dental erosion is increasing gradually within last few years.[2,3] Various studies confirmed that exogenous or endogenous factors are responsible for dental erosion.[4,5] Exogenous factors cause dental erosion by excessive consuming of acidic beverages like fruit juices and soft drinks, while endogenous factors like exposure to gastric acid are also responsible for dental erosion.[6]

It have been confirmed experimentally that acid is the key cause of erosion thus damaging the tooth structure with no involvement of microorganisms.[3] The incidence of erosion has increased markedly

due to excessive use of beverages with acidic content.[7] Moreover advertisement of soft drinks and fruit juices have attracted the young generation predominantly towards their use.[6,8,9] Recently, soft drinks and fruit juices have also presented as healthy drinks by many sports personalities and celebrities.[10] Loss of tooth structures occurs as a result of repeated contact of acidic beverages with tooth.[11,12,13] After erosion common complications like hypersensitivity, exposure of pulp and a poor esthetic condition are common due to acidic beverages.[4] It is also noted that low pH values in the oral cavity, leads to a degradation of the surface integrity of restorative materials.[4,10,14]

As soon as the patient comes with the tooth surface damage various restorative materials can be taken into account. Materials used as restorative materials must possess long-term durability and longevity, which depends upon factors like resistance to wear, durability of the tooth/restoration interface, and the amount of tooth preparation needed.[15]

A number of restorative materials are suggested for restoration of erosive lesions, such as amalgam, resin modified glass ionomer cement, and resin composite restorative materials.[11] Every material comes with its own pones and cones, which must be taken into account before their selection.[10,11] The ability of the restorative material to resist and survive under acidic conditions must be considered while selecting restorative materials for the restoration of erosive lesions.[16]

METHODOLOGY

For this study three types of commercial restorative materials were used. These include a resin modified glass ionomer cement (Fuji II LC), resin composite (Filtek Z 250) and amalgam (Valiant phD) (Table-I).[11]

Product	Type of Material	Main Constituents	Mixing	Setting reaction	Manufacture
Fuji II LC	Resin modified glass ionomer cement.	Resin modified polyacrylic acid, ion leachable glass.	Hand mixed (3:1 p/l)	Acid-base reaction.	GC Corp., Tokyo, Japan
Filtek Z 250	Resin composite (Mini filled hybrid)	BisGMA, Zirconia/ Silica filler.	One paste	Light- activated polymerization	3M ESPE, ST.Paul.AN, USA
Valiant PhD	Amalgam (High Copper)	Silver, tin, copper, palladium, mercury.	Capsulated	Amalgamation	Dentsply Caulk, Milford, DE, USA

Table-I. Restorative materials used in this study

Mold Fabrication

Total ninety six disc specimens were prepared with resin modified glass ionomer cement, resin composite and amalgam restorative materials using Teflon mold, 10mm in diameter and 2 mm thickness (Figure-1).[7]

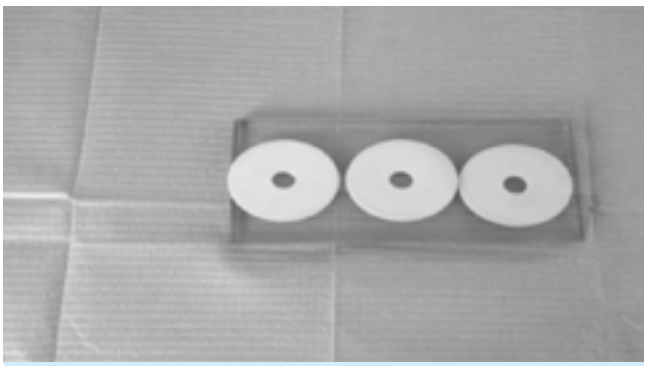

Figure-1. Teflon mold 10mm in diameter and 2mm in thickness

Specimen Preparation

The mold was placed on a transparent matrix strip and the glass slide, and then the materials were placed into the mold according to manufactures instruction. Resin Composite material was available in single component and was syringed into the mold, for resin modified glass ionomer cement powder liquid proportions were mixed and placed in mold. The filled mold was covered using a second transparent matrix and glass slide, and then light pressure was applied to remove excess material from the mold thus obtaining a smooth surface of the specimen.[3,11]

Amalgam was obtained as pre-loaded capsules and was mixed using an electrical amalgamator. For amalgam hand condensation was done by applying approximately 4 to 5 lb pressure,

followed by carving of overfilled amalgam.[17]

The Resin Composite and Resin modified GIC samples were light cured continuously through the top and bottom of the glass slide for 40 seconds using light curing unit with a light intensity of 450mW/cm2. For both the materials no finishing or polishing procedure was done. The specimens were allowed to mature in their molds in an incubator at 37 Celsius for one hour after mixing. The reason for maintain the molds in the incubator for one hour before exposure to acidic beverages is an estimated time for restorations being exposed in the oral cavity. [11]

Prepared samples (pellets) were inspected carefully and damaged samples were excluded (Figure-2).

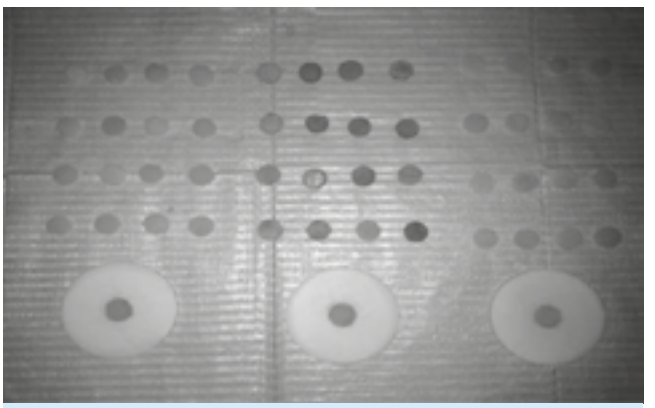

Figure-2. Pellets made from resin modified GIC, composite and amalgam restorative materials.

Grouping of the Specimens and Base Line Study of Micro-hardness

Material specimens were divided into three groups of thirty two specimens each (08 discs/treatment group). All specimens were maintained in de-ionized water until the time of testing (Figure-3).

The initial surface micro-hardness test for resin composite, resin modified glass ionomer and amalgam was carried out at 1 day after mixing (before immersion) The specimens were stabilized with the help of double sided adhesive tape and placed on the test base of the micro-hardness tester (SHIMADZU HMV- 2000) (Figure-4).

The indenter marked three indentations at different areas on the specimen using a 200 gm load for 15 seconds. Each measurement was taken automatically at a distance of 1 mm from each other (Figure-5).

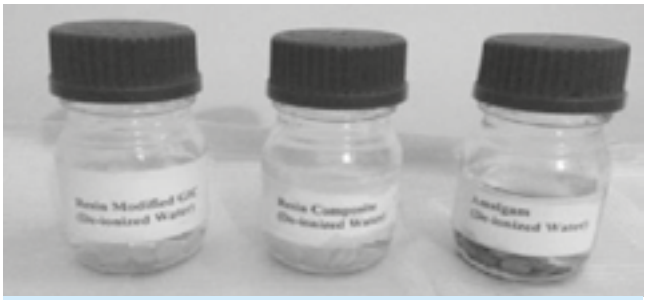

Figure-3. Material Specimens stored in De-ionized Water.

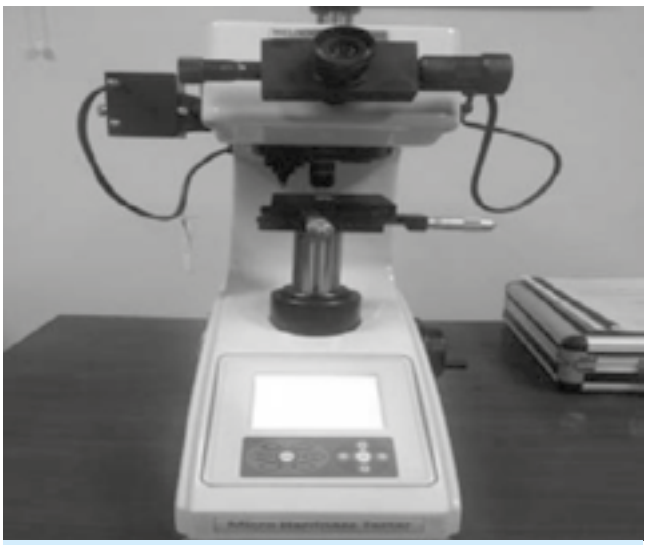

Figure-4. Microhardness Testing Machine.

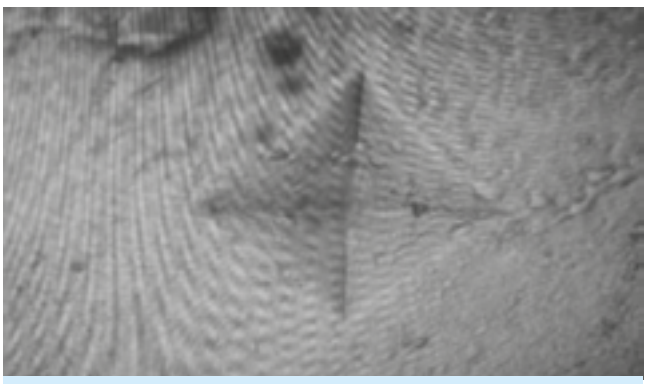

Figure-5. View of vickers microhardness indentation

The average value of the three measurements was converted into a Vickers hardness number (VHN) expressed in kg/mm^2.[13,18]

Immersion in Treatment Groups

Treatment groups was comprised of; Cola (gourmet cola), Apple juice (Nestle), Orange juice (Nestle) and distal water as control (Table-II). The specimens of each material were transferred into the storage media (Figure-6,7,8).

Solutions	Contents	pH	Manufacturer
Cola	Carbonated water, Sugar, Carbohydrate, Phosphoric acid and Caffeine.	2.5	Gourmet Lahore Pakistan Ltd.
Apple Juice	Apple juice, sugar, maleic acid, artificial flavor, permitted food colour.	3.4	Nestle Pakistan Ltd
Orange Juice	Orange juice, vitamin, citric acid, artificial flavor, permitted food colour.	4.0	Nestle Pakistan Ltd
Distal Water	Chemically pure water from which impurities, as dissolved salts and colloidal particles, have been removed.	7.9	Indus PharmaLhr Pakistan.

Table-II. Detail of Solutions used in this study

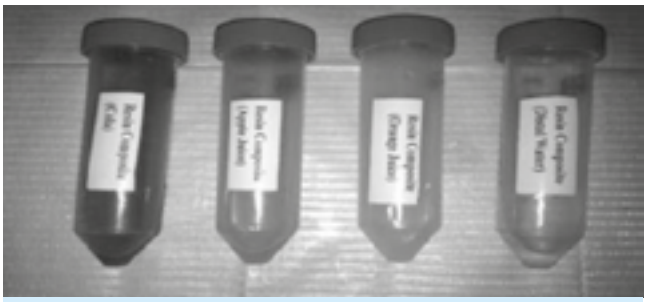

Figure-6. Resin composite specimens immersed in treatment groups for 7 days.

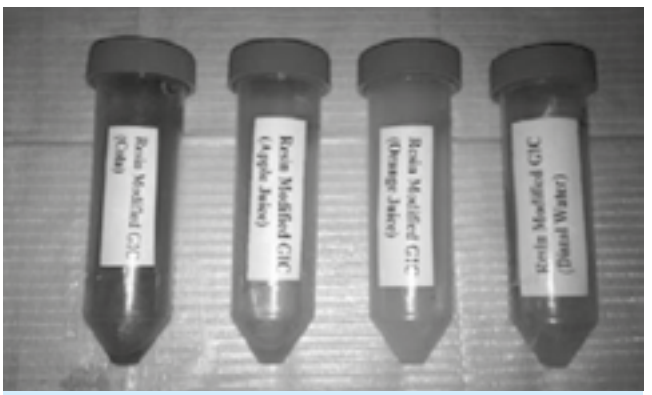

Figure-7. Resin modified GIC specimens immersed in treatment groups for 7 days

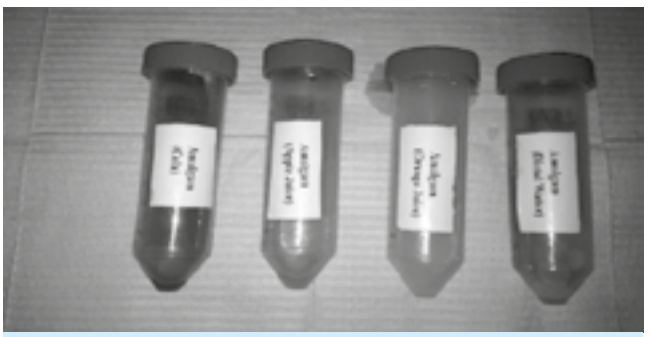

Figure-8. Amalgam specimens immersed in treatment groups for 7 days

The specimens were store in individual plastic storage pots containing 20 ml of the storage media, which was a sufficient volume to completely cover the specimens and the mold. Before and after immersion in the drink, specimens were rinsed with saline. Specimens when not exposed to the drink were stored in de-ionized water. In an attempt to maintain the actual pH level of the storage solutions they were refreshed daily throughout the experiments.[11]

Final Micro-hardness Testing

Quantitative assessment of final surface micro-hardness was done at 2, 5 and 7 days after immersion in treatment groups. These values were noted on the table as final Vickers hardness number (VHN) value of individual specimen. The obtained values as base line and final Vickers hardness number (VHN) for every specimen was statistically analyzed.[11]

Statistical Analysis

All collected data was entered and analyzed by using SPSS 18. Mean ± SD was computed for quantitative data. Analysis of variance (ANOVA) was applied to compare mean storage of media/ micro hardness value in all study groups for all materials separately. Repeated measurement ANOVA was applied to compare mean storage of media/ micro hardness value over different time period (before, after 2, 5 and 7 days). Two-Way Repeated measurement ANOVA was applied to compare mean storage of media/ micro hardness value over different time period (before, after 2, 5 and 7 days) with respect to different study groups

and materials.

A p-value ≤ 0.05 was considered significant.

RESULTS

The mean storage media / micro hardness values before one day after 2, 5 and 7 days in relation to different acidic beverages and distilled water for Glass Ionomer are shown in (Table-III).

	Mean ± S.D				p-value [b]
Groups	1 day Before	After 2 days	After 5 days	After 7 days	
Cola	48.11±6.45	35.21±1.74	28.61±2.45	26.49±1.87	0.0000
Apple Juice	45.50±4.13	41.48±1.89	37.66±2.23	35.65±0.98	0.0000
Orange Juice	48.11±6.45	41.76±1.82	37.96±1.93	36.45±1.44	0.0000
Distal water	45.50±4.13	45.28±1.29	44.33±1.38	44.21±1.19	0.599
Total	46.81±5.32	40.93±4.02	37.15±6.01	35.70±6.52	[c] 0.000
p-value [a]	0.608	0.000	0.000	0.000	

Table-III. Means comparison of storage media/microhardness vaue (kg/mm²) at different time in relation to different materials and study groups for glass ionomer

Keywords

P-value [a] = p-values are calculated using ANOVA,
P-value [b] = p-values are calculated using repeated measurement ANOVA
P-value [c] = p-values are calculated using multivariate repeated measurement ANOVA

The effect of cola, apple juice, and orange juice was significant and mean storage media / micro hardness value of glass ionomer was significantly decreased, p-value ≤ 0.05, while the mean storage media / micro hardness value of glass inomer was statistically same in distal water group, p-value > 0.05.

The mean storage media / micro hardness values before one day after 2, 5 and 7 days in relation to different acidic beverages and distilled water for Resin Composite are shown in (Table-IV).

	Mean ± S.D				p-value[b]
Groups	1 day Before	After 2 days	After 5 days	After 7 days	
Cola	96.40± 10.52	88.39±1.28	85.33 ± 1.23	84.51±0.91	0.001
Apple Juice	90.54±3.34	90.33±1.01	86.42±1.44	85.13±1.06	0.000
Orange Juice	96.40±10.52	90.76±1.18	88.35 ± 1.08	86.60±1.12	0.011
Distal water	90.54±3.34	92.89±1.30	92.24 ± 1.007	91.65±0.99	0.130
Total	93.47±7.99	90.59±1.98	88.08 ± 2.90	86.97±3.01	[c] 0.03
p-value [a]	0.235	0.000	0.000	0.000	

Table-IV. Means comparison of storage media / microhardness value (kg/mm²) at different time in relation to different materials and study groups for resin composite

Keywords

P-value [a] = p-values are calculated using ANOVA,
P-value [b] = p-values are calculated using repeated measurement ANOVA
P-value [c] = p-values are calculated using multivariate repeated measurement ANOVA

The effect of cola, apple juice, and orange juice was significant and mean storage media / micro hardness value of resin composite was significantly decreased, p-value ≤ 0.05, while the mean storage media / micro hardness value of resin composite was statistically same in distal water group, p-value > 0.05.

The mean storage media / micro hardness values before one day after 2, 5 and 7 days in relation to different acidic beverages and distilled water for Amalgam are shown in (Table-V).

Keywords

P-value [a] = p-values are calculated using ANOVA
P-value [b] = p-values are calculated using repeated measurement ANOVA

P-value [c] = p-values are calculated using multivariate repeated measurement ANOVA

The effect of cola, apple juice, and orange juice was significant and mean storage media / micro hardness value of amalgam was significantly decreased, p-value ≤ 0.05, while the mean storage media / micro hardness value of amalgam was statistically same in distal water group, p-value > 0.05.

In cola group, apple juice, orange juice and distal water groups there was significant mean difference in all there materials, with p-value ≤ 0.05. These results are summarized in (Figure-9-11).

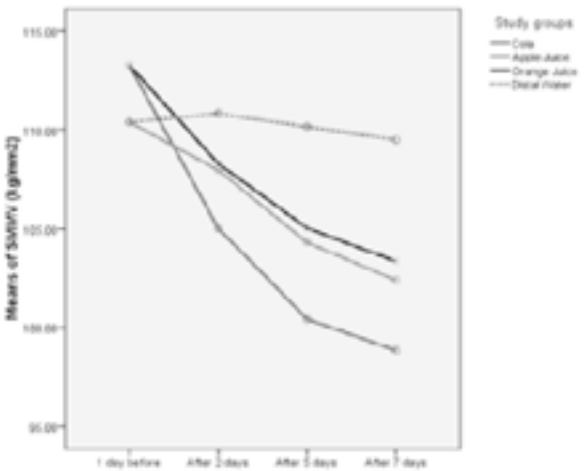

Figure-9. The effect of cola, apple juice, and orange juice can be clearly seen from the figure and mean storage media / micro hardness value of all materials significantly decreased, p-value ≤ 0.05 except distal water group.

P-value = 0.000
Keywords
SMMV=Storage Media /Microhardness value

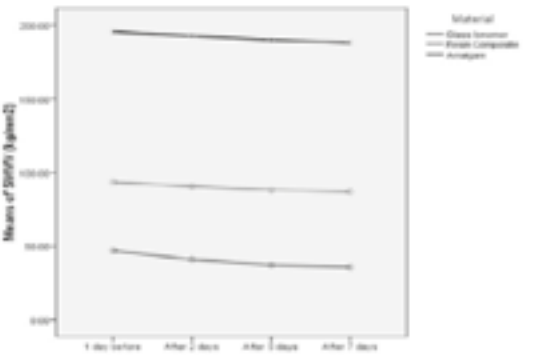

Figure-10. Comparison of mean storage media / micro hardness value of all materials are significantly decreased over 7 days when exposed to acidic beverages, p-value ≤ 0.05.

P-value = 0.000
Key words
SMMV=Storage Media /Microhardness value

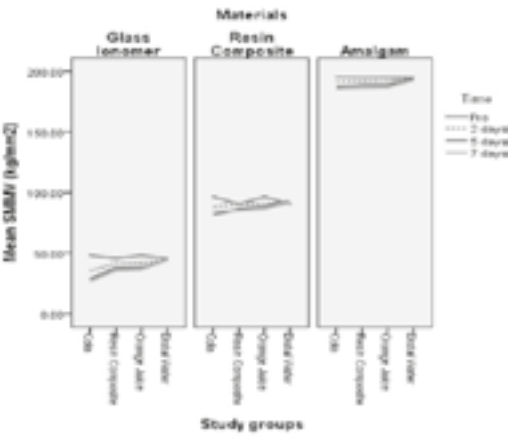

Figure-11. Comparison of mean storage media / micro hardness value of all materials are significantly decreased over a period of time, p-value ≤ 0.05 in all study groups expect distal water.

P-value = 0.000
Key words
SMMV=Storage Media/Microhardness valuess

Groups	Mean ± S.D				p-value[b]
	1 day Before	After 2 days	After 5 days	After 7 days	
Cola	195.29±5.94	191.49 ±1.93	187.32 ± 2.15	185.54 ±1.92	0.000
Apple Juice	195.15±6.55	192.14 ±1.75	188.86 ± 1.79	186.38 ±0.86	0.000
Orange Juice	195.29±5.94	192.38 ±1.82	188.82 ± 1.39	178.24 ±24.27	0.00
Distal water	195.15±6.55	194.33 ±1.56	193.87 ±1.34	192.68 ±1.39	0.539
Total	195.21 ± 5.94	192.58 ±2.00	189.72 ± 2.99	185.71 ±12.71	[c]0.01
p-value [a]	0.99	0.21	0.000	0.000	

Table-V. Means comparison of storage media / microhardness value (kg/mm²) at different time in relation to different materials and study groups for amalgam

DISCUSSION

The restorative material in the oral cavity continuously faces a number of erosive challenges both extrinsic and intrinsic, that effect the micro-hardness as well as the discoloration of teeth.[19] The exposure of restorative material to these elements as well as to changes in temperature influences the acid-base balance. Though saliva plays a role in washing away such beverages, juices and foods from the restoration material but clinical longevity demands resistant nature against such fluctuations and exposures.[6,11,20] Research has already documented the role of acid in erosion of teeth having an irreversible loss of dental hard tissue without any kind of involvement by microorganism and conducting some chemical process.[21]

Our study aimed to gather information regarding ability of the restorative materials to withstand the functional forces when they are exposed to locally produce acidic beverages in the oral cavity for different durations. Our study extended to clinical usage and is hoped to help clinicians to select materials according to patient's dietary habits.

In this study, the mean storage media / micro hardness value before one day for glass ionomer in cola group was 48.11 ± 6.445, in apple juice group the mean was 45.50 ± 4.13, in orange juice it was 48.11 ± 6.45 and in distal water group the mean storage media / micro hardness value was 45.50 ± 4.13 kg / mm^2. This mean storage media / micro hardness value reduced to a great extent after 7 days, as for glass ionomer in cola group it reduced to 26.49 ± 6.445, in apple juice group the mean was 35.65 ± 0.98, in orange juice it was 36.45 ±1.44 and in distal water group the mean storage media / micro hardness value was 44.21 ± 1.19 kg / mm^2. The effect of cola, apple juice, and orange juice was significant and mean storage media / micro hardness value of glass ionomer was significantly decreased, p-value < 0.05, while the mean storage media / micro hardness value of glass ionomer was statistically same in distal water group, p-value > 0.05.

The mean storage media / micro hardness value before one day for resin composite in cola group was 96.40 ± 10.52, in apple juice group the mean was 90.54 ± 3.34, in orange juice it was 96.40 ± 10.52 and in distal water group the mean storage media / micro hardness value was 90.54 ± 3.34 kg / mm^2. The mean storage media / micro hardness value after 7 days for resin composite in cola group was 84.51 ± 0.91, in apple juice group the mean was 85.13 ± 1.06, in orange juice it was 86.60 ± 1.12 and in distal water group the mean storage media / micro hardness value was 91.65 ± 0.99 kg / mm^2. The effect of cola, apple juice, and orange juice was significant and mean storage media / micro hardness value of resin composite was significantly decreased, p-value < 0.05, while the mean storage media / micro hardness value of glass inomer was statistically same in distal water group, p-value > 0.05. The effect of cola, apple juice, and orange juice was significant and mean storage media / micro hardness value of amalgam was significantly decreased, p-value < 0.05, in our study while the mean storage media / micro hardness value of Amalgam was statistically same in distal water group, p-value >0.05.

Study conducted by Steffen in 1996 showed significant role of chemicals present in Cola soft drink that influenced the integrity of enamel surface. This shows how the hardest known surface called "Enamel" could not be spared by the acidic nature of Cola.[22] Which makes it clear with this that the mechanical nature possessed tooth coloring materials, that are far less resistant to enamel thus are highly prone to damage by such drinks.[23]

A study published in 2012 by Fatima et al showed the effect of apple Juice, orange juice and distilled water on mean surface micro-hardness of resin modified glass ionomer cement. They showed that mean surface micro-hardness value was gradually decreased, highest before immersion and lowest after seventh day of immersion.[24]

Study by Kitchens and Owens in 2007 focused on in vitro erosion characteristics of dental enamel by adverse effects of coffee, carbonated beverages, energy and sports drinks, and bottled water. In this study it was revealed that classic Coca-Cola,

Gatorade and Red Bull with or without fluoride showed the increased post-treatment surface roughness values.[25]

Hamouda in 2011 concluded that low pH beverages aggressively attacked resin modified glass ionomer cements, while composite resins were relatively less affected. Water did not affect the hardness of the restorative materials. Reasons for the greater reduction in resin modified glass ionomer cement include selective acid attack on the poly salt matrix between the residual particles and release of fluoride from the material immersion in acidic environments.[18]

Furthermore, Hengtrakool in 2011 published the erosive effect of some different juices along with deionized water on mean surface hardness and found that acidic agents tested (citrate buffer solution, green mango juice, and pineapple juice) have cause reduction on the surface micro-hardness of restorative materials.[11]

Previous studies have compared the erosive effects of fresh juices against cola drinks. The acidic beverages were placed in contact with the restorative materials for limited periods of time.[5,27] However, in practice calculus and food debris deposited at the restoration margin can absorb chemical agents from soft drinks and juices, resulting in continuous exposure. The current study is designed to overcome the limitations of previous in vitro studies by employing a 7-day contact period to examine the effect of extended contact with acidic solutions.

The limitations of the current study include incomplete replication of the complex oral environment and disregard for the effects of saliva and thermo-cycling. While future studies may examine the in vivo effects of acidic beverages, this study at least confirms the erosive potential of certain acidic beverages, a potentially damaging factor of which the public should be aware.

CONCLUSION

The acidic beverages used in this study were able to change the surface microhardness of restorative materials. The Resin modified Glass ionomer cement showed the most significant reduction in surface micro-hardness followed by Resin Composite and Amalgam restorative materials.

Among acidic beverages Cola have the greatest effect in reducing the surface micro-hardness of restorative materials. Apple juice and orange juice have almost similar effect, whereas distal water has little to no effect on the surface micro-hardness of restorative materials.

For clinical decision making Amalgam and Resin Composite are the most appropriate materials for restoring the tooth in patients who are at greater risk for erosive conditions.

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There's something wrong with your character if "opportunity" controls your loyalty.

– Sean Simmons –

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