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ORIGINAL ARTICLE

The Effect of Acidic Beverages on Hardness of Two Different Composite Filling Materials

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ABSTRACT
Introduction: Acidic beverages are widely consumed, and their erosive effects on dental materials have become a significant concern. Composite resin materials used in dental restorations are particularly vulnerable to acidic exposure, potentially leading to a reduction in their surface hardness.

Objective: This study aimed to evaluate the effect of acidic beverages, specifically Pepsi cola and orange juice, on the hardness of two types of composite filling materials: micro-filled and nano-hybrid composites.

Study setting and duration: This observational comparative cross sectional study was conducted in the department of Dental Materials at Isra Dental College, Isra University and Department of Metallurgy & Materials Engineering at Mehran University of Engineering & Technology, Jamshoro. This study was completed in six (06) months (from September 2022 to February 2023).

Methods: A total of 20 specimens, including micro-filled composite (Master Fill, Biodinamica) and nano-hybrid composite (CharmFilplus, DentKist), were prepared. Each composite type consisted of 10 samples. Specimens were immersed in Pepsi cola (pH 2.60) and Nestle orange juice (pH 3.94) for 30 minutes. Vickers micro-hardness was measured before and after immersion, applying a load of 1 kg for 15 seconds on each sample. The mean hardness values and their differences were analyzed using paired t-tests, with a significance level of 0.05.

Results: Both composite types showed significant reductions in hardness after immersion in acidic beverages. For micro-filled composites, the mean hardness decreased from 57.18 ± 0.48 VHN to 48.42 ± 0.74 VHN in Pepsi cola (mean difference = 8.76, $p < 0.05$) and from 57.02 ± 1.22 VHN to 52.04 ± 1.29 VHN in orange juice (mean difference = 4.98, $p < 0.05$). Nano-hybrid composites showed a hardness reduction from 63.38 ± 1.87 VHN to 54.20 ± 1.10 VHN in Pepsi cola (mean difference = 9.18, $p < 0.05$) and from 63.48 ± 3.19 VHN to 59.40 ± 1.33 VHN in orange juice (mean difference = 4.08, $p < 0.05$). Comparison between composites showed nano-hybrid composites exhibited greater hardness than micro-filled composites in both acidic media.

Conclusion: Acidic beverages such as Pepsi cola and orange juice significantly reduce the hardness of both micro-filled and nano-hybrid composite materials. Nano-hybrid composites retained a higher hardness level than micro-filled composites under acidic conditions, suggesting they may be more suitable for dental restorations exposed to acidic environments. Further research could explore alternative materials with improved resistance to acidic erosion for enhanced dental restoration durability.

Keywords: Composite Resins, Acidic Beverages, Tooth Erosion, Dental Materials, Microhardness.

INTRODUCTION
Advance living styles, urbanization, habits of taking diets along with more intakes of soft drinks, juices and alcoholic beverages plays a major role in the erosive effects on natural teeth as well as on filling materials because these beverages and juices are acidic in nature[1]. Wearing of tooth surface loss is abundantly increasing problem nowadays. Fizzy drinks and the juices are very popular as thirst quenchers in new generation and this routine of taking drinks and juices carried many years which become the main cause of erosion of teeth and restorative materials[2].

The type of dental materials especially the synthetic resins which are used for restoration and also as adhesive material are known as Dental composite[3]. These are evolved as restorative materials because of prominent characteristics like insolubility, better aesthetics, and easy manipulation, less expensive and free from dehydration[4]. The most common composition of composite resins are Bis-GMA and other dimethacrylate monomers (TEGMA, UDMA, HDDMA), fillers of variable sizes in many of recent formulations and photo-initiator[5-6]. Dental composites are classified according to three key factors: consistency, filler composition, and clinical application. Based on consistency, composites are divided into packable and flowable types. By filler composition, they are categorized as macro-filled, micro-filled, or hybrid composites. In terms of clinical application, they are specified for either anterior or posterior use[7].

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Micro-filled dental composite overcome some drawbacks like surface roughness and less-translucency related with macro-filled and tiny particle composite by the use of colloidal silica particles as the inorganic fillers[8]. The size of the fillers is about 0.04 micrometer. This measurement is about 200 to 300 times less than the average filler size of macro-filled dental composite and even one tenth of the wave length of visible light[8]. The idea of this entails the reinforcement of the resin with the help of fillers, now the micro-filled composites presents smooth surface which is similarly achieved by unfilled direct filling acrylic resins while the mechanical properties are considered low for application in regions of high occlusal forces[9].

Nano-hybrid composites are very much famous among dental practitioners because of their better color appearance and wear properties, high polish ability, and convenient handling properties. Nowadays such composites are known as universal composites due to their easy manipulation and beautiful appearance characteristics which enable them to be placed in anterior teeth. The mixing of micro structure and nano-clusters scattered with micro sized particles provides to nano-hybrid much better wear characteristics[10]. Bigger sub-micron sized glass particles or silica particles in the variety of 0.4 µm individual and nano-sized particles 0.05 µm. The three different types of filler particles used in nano-composites are pre-polymerized, finely milled and agglomerated nano-clusters.[11] The physical and mechanical properties of the nano-hybrid composites like fracture toughness and compressive strengths are almost same or more than the other hybrid composites like micro hybrids and micro-filled composites. The mechanical properties of nano-hybrid composites having grade of superiority for molars and pre molar restorations because of their surface hardness and their marvelous appearance characteristics and inherent toughness make them useable for anterior build up[12].

The study conducted by Wongkhantee in 2006 on effect of acidic food and drinks on surface hardness of enamel, dentine and tooth-colored filling material (dental composite) demonstrated erosive effect[13], but were limited in methodology for longer duration of test which is practically less applicable because natural teeth or the dental restoration faces environmental change for short duration but repeatedly or frequently and did not accurately reflect the in vivo situation.[28] Furthermore, the results of other study conducted in 2013 by Ugur Erdemir and co-workers were also conflicting, with some studies reporting changes in surface micro-hardness while others did not[14]. The beverages tested in previous studies included natural orange juices, apple juices, and cola soft drinks, all of which were harmful to restorative materials. The previous studies showed that cola soft drink and orange juice significantly reduces surface hardness of enamel, dentine, micro-filled composite and resin modified glass-inomer. Hence the purpose of this study is to evaluate the effect of acidic behavior of beverages (Pepsi cola and orange juice) on hardness of micro-filled and nano-hybrid composites through quantitative approach in our local setting.

METHODS

Study setting: The present study was conducted in the department of Dental Materials at Isra Dental College, Isra University and Department of Metallurgy & Materials Engineering at Mehran University of Engineering & Technology, Jamshoro.

Duration of study: This study was completed in six (06) months, from September 2022 to February 2023.

Study Design: It was an observational comparative cross sectional study.

Protocol: Twenty samples of two different composite materials, Micro-filled composite (master fill, biodinamica) and Nano-hybrid composite (CharmFilplusTM, DentKist) were used while Nestle orange juice, nectar and Pepsi cola were used as acidic beverage. Two experimental groups were made; Micro-filled composite (master fill, biodinamica) and Nano-hybrid composite (CharmFilplus™, DentKist) material treated with Nestle Orange juice and Pepsi cola.

Twenty specimens of Micro-filled (master fill™, biodinamica) and Nano-hybrid composite (CharmFilplus™, DentKist), ten of each composite material were used for hardness test. Specimen was in disc form, 12 mm in diameter and 2.5 mm in thickness. Micro-filled and Nano-hybrid dental composite were tested. Nestle orange juice having pH 3.94 and Pepsi cola having pH 2.60 were used as acidic agents. Specimens were immersed for 30 minutes each in acidic beverages Nestle orange juice and Pepsi cola. Before immersion and after immersion Vickers micro-hardness was compared.

Specimen preparation: Acrylic mount and disc of 12 mm in diameter and 2.5 mm in thickness were used. Ten samples of every composite resin were made. Restorative material was placed in between two glass slides then applied light pressure over both slides, measure the thickness of disk with the help of digital caliper. After achieving the required thickness of disc, the specimen were cured by the help of Halogen light source of wave length 470 nm from both sides incremental increase in thickness and curing is preferred. The both glass slides had smooth and plane surfaces. This procedure was able to provide a smooth surface on each specimen. The specimens were ready to place over the mounts after completion of curing. Grinding or abrasion of samples were not performed.

The samples were immersed within two different glass pots filled with 100 ml of Nestle orange juice and Pepsi cola at room temperature for 30 minutes. After their removal from the acidic beverages the samples were rinsed with distilled water.

Micro-hardness testing: Vickers micro-hardness testing machine was used for measuring the micro-hardness of both composite resins, Micro-filled (master fill™, biodinamica) and Nano-hybrid composite (CharmFilplus™, DentKist), the maximum load applied on each specimen was 1kg for 15 seconds by the calibrated speed of 50. Indentation repeated at different corners of each of the sample on both statuses before immersion in acidic beverages as base line values and after immersion in acidic beverages to getting mean value for minimizing the chances error. The diagonals of indentations D_1 and D_2 both were measured with method of microscopy to evaluate the change in hardness.

Statistical analysis: Statistical package for social sciences (SPSS-20) was used to analyze data. Relevant descriptive statistics Mean and Standard Deviation were computed for quantitative variables, (hardness of micro-filled and nano-hybrid in orange juice and Pepsi cola before and after immersion). Paired samples t-test applied to assess Mean difference between the hardness of micro-filled and nano-filled composite before and after immersion in acidic beverages with 95% confidence interval and 0.05 level of significant.

RESULTS

Twenty samples of two different composite materials, micro-filled composite (master fill™, biodinamica) and nano-hybrid composite (CharmFilplus™, DentKist) were made each. Out of which 10 samples of micro-filled were used to test the hardness before and after immersion in orange juice and Pepsi cola while 10 samples of nano-hybrid were used to test the hardness before and after immersion in orange juice and Pepsi cola (Table 1 and 2).

Table 1: Base line values before immersion

Composites	Base line values before immersion					Mean	Std. dev
	1	2	3	4	5		
Micro filled	56.6	57.2	57.9	57.3	56.9	57.18	0.48
	58.5	56.6	57.2	57.6	55.2	57.02	1.22
Nano hybrid	64.2	60.6	65.7	63.5	62.9	63.38	1.87
	68.9	63.4	60.6	62.3	62.2	63.48	3.19

Table 2: Hardness values after immersion

Composites	Hardness values after immersion						Mean
	Medium	1	2	3	4	5	
Micro filled	Pepsi cola	48.8	47.3	49.3	48.5	48.2	48.42
	Orange juice	54.2	51.4	50.8	52.1	51.6	52.02
Nano hybrid	Pepsi cola	55.4	54.8	53.6	54.6	52.6	54.20
	Orange juice	61.2	59.9	57.9	59.7	58.3	59.40

Table 3: Paired Samples Statistics applied, Mean difference of hardness (VHN) of micro-filled composite before and after immersion in orange juice and pepsi cola

	Mean	n	Mean Difference	Std. Deviation	P-value
Hardness before immersion in Pepsi cola	57.18±0.48	5	8.76	0.75	0.000
Hardness after immersion in Pepsi cola	48.42±0.74	5			

					< 0.05
Hardness before immersion in orange juice	57.02±1.22	5	4.98	1.08	0.000
Hardness after immersion in orange juice	52.04±1.29	5			< 0.05

Table 4: Paired Samples Statistics applied, Mean difference of hardness(VHN) of Nano-hybrid composite before and after immersion in orange juice and pepsi cola

	Mean	n	Mean Diff:	Std. Deviation	P-value
Hardness before immersion in pepsi cola	63.38	5	9.18	2.31	0.001
Hardness after immersion in pepsi cola	54.20	5			
Hardness before immersion in orange juice	63.48	5	4.08	2.09	0.012
Hardness after immersion in orange juice	59.40	5			

Table 5: Mean difference of hardness (VHN) between microfilled and nano hybrid composite after immersion in orange juice and pepsi cola

	Sample	n	Mean	Mean diff:	Std. Error Difference	P-value
Hardness after immersion in pepsi cola	Nano-hybrid	5	54.20	5.780	0.596	< 0.05
	Micro-filled	5	48.42			
Hardness after immersion in orange juice	Nano-hybrid	5	59.40	7.360	0.828	< 0.05
	Micro-filled	5	52.04			

The mean hardness of micro filled composite before and after immersion in Pepsi cola were 57.18±0.48 and 48.42±0.74 (x ± SD) respectively (Table:IV-03). Similarly, the mean hardness of micro filled composite before and after immersion in orange juice were 57.02±1.22 and 52.04±1.29 (x ± SD) respectively (Table:IV-04). The mean difference of hardness of micro filled composite before and after immersion in Pepsi cola with 95% confidence interval and 0.05 level of significance were 8.76 VHN that was statistically significant. Similarly, mean difference of hardness of micro filled composite before and after immersion in orange juice with 95% confidence interval and 0.05 level of significance were 4.98 VHN that was statistically significant.(Table: 3).

The mean hardness of nano-hybrid composite before and after immersion in Pepsi cola were 63.38±1.872 and 54.20±1.104 (x ± SD) respectively (Table:IV-06). Similarly, the mean hardness of nano-hybrid composite before and after immersion in orange juice were 63.480±3.190 and 59.40±1.326 (x ± SD) respectively (Table: IV-07). The mean difference of hardness of nano-hybrid composite before and after immersion in Pepsi cola with 95% confidence interval and 0.05 level of significance were 9.180 VHN that was statistically significant. Similarly, mean difference of hardness of nano-hybrid composite before and after immersion in orange juice with 95% confidence interval and 0.05 level of significance were 4.080VHN that was statistically significant.(Table 4).

The another statistical comparison were made to find out the mean difference of hardness between micro filled and nano-hybrid composites after immersion in Pepsi cola and orange juice and the result showed that the mean difference of hardness with 95% confidence interval and 0.05 level of significance were 5.78 VHN and 7.36 VHN respectively that were significant. (Table: IV-09). The results of the study showed greatly significant decrease in hardness in both composite after the 30 (thirty) minutes immersion in acidic beverages, (orange juice and Pepsi cola).

DISCUSSION

The present study, in agreement with previous research, confirms the erosive potential of certain acidic juices, soft drinks, and alcoholic beverages, which are recognized as potentially damaging factors to dental composite materials. These acidic substances, due to their low pH, can compromise the surface integrity of composite resins, leading to a significant reduction in hardness over time[15]. In micro-filled composites, our results after 30 minutes of exposure showed a decrease in hardness with orange juice (4.98±1.08, p=<0.05) and cola drink (8.76±0.75, p=<0.05). Similarly, in hybrid composites, hardness decreased after exposure to orange juice (4.08±2.09, p=<0.05) and cola drink (9.18±2.31, p=<0.05). These findings align with the results reported by Nazish Fatima in 2013, which demonstrated a comparable reduction in hardness for both micro-filled and hybrid composite resins (mean difference 10.572, p=<0.05 after one and five days of exposure) [16]. This consistency across studies suggests a predictable pattern in how acidic beverages affect composite resin hardness, reinforcing the need for material durability improvements.

Moreover, similar results indicating a decrease in hardness for nano-filled composites were reported in a recent study that also tested micro-hardness using the same acidic agents over a longer duration

of seven days. Their findings showed that orange juice (58.11±3.39) and cola drink (53.34±2.65) significantly reduced hardness (p=<0.05, analyzed via Tukey's HSD test) [17]. This trend suggests that extended exposure times further exacerbate the erosive effect, indicating that the frequency and duration of acidic beverage consumption may be critical factors influencing composite longevity in clinical settings.

Furthermore, a comparative study conducted in Thailand using the same composite sample thickness (2.5 mm) revealed that exposure to acidic juices markedly reduced the hardness of composite materials. Hengtrakool et al. (2011) demonstrated the effects of acidic exposure from green mango and pineapple juice, showing a progressive decrease in hardness after six hours, one day, two days, three days, and seven days (p < 0.05), results that align with our findings in the present study[18]. This similarity across diverse acidic agents further supports the robustness of these outcomes and highlights the influence of specific acids on composite degradation.One limitation of this study is the controlled in vitro environment, which may not fully replicate oral conditions such as salivary flow and pH buffering, potentially influencing composite durability. Future studies should incorporate more complex simulation models or clinical trials to better assess composite resin resilience under real-world conditions. Additionally, examining a broader range of beverages and acids across varying pH levels and durations could yield more comprehensive insights into the factors affecting composite material stability. It is also recommended to investigate alternative filler materials or protective coatings that may enhance the acid resistance of composites, as well as the influence of periodic remineralization treatments that may counteract erosion effects.

CONCLUSION

This in-vitro study confirms the erosive potential of the cola drink and orange juice on the surface hardness of the both composite resins (Nano-hybrid composite and Micro-filled composite). Findings clarify that more acidity leads to more decrease in hardness.

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