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Research Article

Influence of Dietary Solvents on Strength of Nanofill Composites – An *In Vitro* Study

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Abstract

Objective: The objective of this study was to determine the influence of the dietary solvents on the strength of nanofill and glass ceramic inserts composites. The strength of the new materials were also compared with other direct esthethic restorative materials used in dentistry.

Materials and Methods: Forty samples each of nanofill (Filtek Supreme),ceram-x mono (Dentsply), and three types of direct esthetic restorative materials including posterior composite (P60), a flowable composite(Dentsply), and a highly viscous glass inomer cement (Ketac Molar) were used. The specimens of each material were stored in distilled water at 370 C for one week and randomly divided into four groups. The specimens were subjected to a shear punch test in custom designed shear punch apparatus using Instron Universal Testing Machine. One way ANOVA and Scheffe's post-hoc test were used to determine inter-medium and inter-material difference The interaction between materials and conditioning media was evaluated using two-way ANOVA.

Result: There was no statistically significant difference in strength between Filtek Supreme ($p < 0.730$), flowable composites ($p < 0.890$), P60 ($p < 0.610$), and Ketac molar ($p < 0.992$) after conditioning in various dietary solvents.

Conclusion: Regardless of conditioning medium, the composite materials were significantly stronger than highly viscous glass ionomer cement.

Keywords: Nanofill Composite; Ceram-x; Ketac Molar; P60; Flowable Composite; Dietary Solvents

Abbreviations

ANOVA: Analysis of Variance; P60: Posterior Composite; ºC: Degrees Celsius; FDA: United States Food and Drug Administration; MPa: Megapascal; SiO_2: Silicon Dioxide.

Introduction

The clinical use of dental composite has increased substantially over the past few years due to improvements in formulation, simplification of bonding techniques, and increased esthetic demands [1]. Composites may involve a three-dimensional combination of two or more chemically different materials with the distinct interface [2]. Dental composite consists of resin matrix (organic phase), inorganic filler particles (dispersed phase), filler matrix coupling agent (interface), and minor additions including polymerization initiators, stabilizers and coloring pigments [3]. However, the depth of cure and polymerization shrinkage still poses major challenges to dentists who have resorted to incremental layering to address the issue [4]. Today, dentists use various restorative materials with nanofill composites being the most popular. Dental composite nanotechnology has advanced significantly over the past ten years [5]. Composite based on nanofill and glass ceramic inserts have also been introduced into the market recently. The first nanofill commercial product, Filtek supreme (3M ESPE), contains a unique combination of nanofillers measuring 5-75 nm (nanometer) and nanoclusters embedded in a organic polymers matrix [6]. These nanosized filler particles allow polishing and polish retention typical of a microfill in addition to good handling, strength and wear properties [7]. The technology used in Ceram-X is different from that of conventional composites that are based on purely organic polymer matrix [8]. Ceram-X consists of ceramic polysiloxane, while polysiloxane is biocompatible and exhibits low shrinkage.

The physical properties of nanofill composites have been subject to debate among various researchers [9]. While some researchers believe that nanofill composite have lower mechanical properties compared to conventional composites, others have disagreed [10,11]. Nanofill composites are subject to chemical and physical degradation inside the mouth [9]. According to Drummond (2008), nanofill composites can experience softening of the resin matrix, debonding, dissolution, and filter damage which can decrease longevity, restoration, and durability [12]. The intra-oral environment causes aging and degradation of dental restorations because of the constant interaction with beverages, saliva, and various food components [10]. Research indicates that various liquid and food components and organic acids weaken resin matrices in dental composites [11]. Consequently, the chemical environment in the oral cavity can significantly influence *in vitro* degradation of nanofill composites. Krüger., *et al*. (2018) indicated that composites have varying performance in terms of strength and mechanical properties [10]. Differences in strength among patients can result from occlusal bite forces and parafunction habits such as clenching and bruxism, diet, and, salivary and plaque compositions [13]. The intraoral degradation of composite cannot be attributed to mechanical factors alone as chemical degradation also occurs [9]. Thus, interactions among many substances in the oral cavity may have a negative impact on the long-term durability of dental restorations [14].

Many researchers have studied the mechanical properties of restorative materials [9-11]. However, evidence on the impact of dietary solvents on the strength of nanofill composites is still scarce. Therefore, there is a need to investigate how nanofill composites are affected by dietary solvents. This study was aimed at evaluating how dietary solvents such as distilled water, citric acid, 50% ethanol, and heptane affect the strength of nanofill and glass ceramic inserts composites including Filtek supreme, P60, flowable composite, Ceram-x, and ketac molar. The strength of these materials was also compared with other direct esthetic restorative materials.

Material and Methods

The test restorative materials used in the study were: Filtek supreme, Ceram X mono, P 60, flowable composite and ketac molar. All materials were of the A2 shade.

Shear punch specimens were made by placing the restorative materials into the brass washers (with an inner diameter of 8mm and 4.5-mm thick). The top surface of the composite resin specimens were cured using the Elipar curing light (3M ESPE) according to manufacturers' instructions. The glass ionomer cement (ketac molar) was allowed to set for 5 min.

Forty specimens of each test material was made and pre-conditioned in distilled water (DW) in an air tight glass vial, separately, at 37°C for 1 week. The specimens of each of the four groups, together with their washers, were then divided into four sub groups of ten each and conditioned in four different dietary solvents: Group I (distilled water at 37ºC) as control, Group II (0.02 M citric acid at 37ºC), Group III (50% ethanol-water solution at 37ºC), and Group IV (Heptane at 37ºC).

At the end of 1 week of conditioning period in the respective solutions, the specimens were washed and blotted dry. Prior to placement in shear punch apparatus, the thickness of each specimen was measured with vernier caliper. Shear punch strength testing was conducted using custom designed shear punch apparatus. Specimens, along with the washers were positioned in the apparatus by means of a self-locating recess. A tool steel punch with the flat end 2 mm in diameter was used to create shear force by sliding through a punch hole with a radial clearance of 0.01 mm. The specimens were subjected to shear punch test in universal testing machine at the crosshead speed of 2.0 mm/min and the maximum load to make punch through the specimen was recorded in Newton's (N). The peak load values obtained in Newton's (N) formed the basis for computing of shear punch strength (MPa) in accord to the following formula:

$$\text{Shear strength} = \frac{force\,(N)}{\pi \times punch\,diameter\,(mm) \times Thickness\ of\ specimen\,(mm)}$$

Where,

Value of π = 3.14

Punch diameter = 2 mm

Thickness of specimen = 4.5 mm.

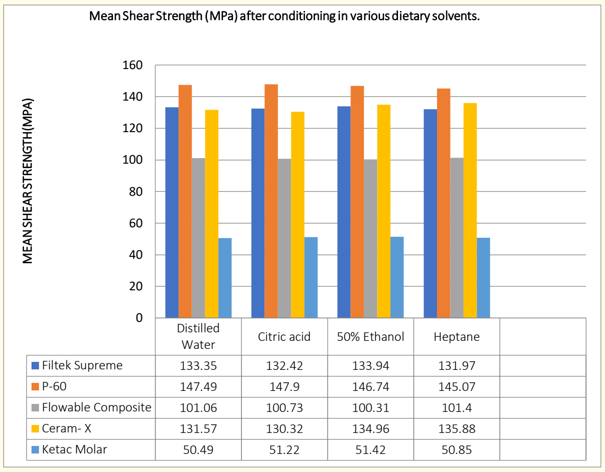
Statistical analysis was conducted at a significance level of 0.05. Two-way ANOVA was used to investigate interactions between the composite materials and conditioning media. One-way ANOVA and Scheffe's post-hoc test were used to calculate the inter-medium and inter-material difference between the composites.

Result

Table 1 presents a summary of the nanofill composites' mean shear strength (MPa) after conditioning in various dietary solvents.

Materials	Distilled water	Citric acid	50% Ethanol	Heptane	'F' ratio (p)
Filtek Supreme	133.35 ± 2.12	132.42 ± 2.40	133.94 ± 4.65	131.97 ± 2.10	0.436 (0.730)
P-60	147.49 ± 3.30	147.90 ± 3.64	146.74 ± 5.02	145.07 ± 0.84	0.623 (0.610)
Flowable composite	101.06 ± 0.83	100.73 ± 2.21	100.31 ± 1.68	101.40 ± 3.54	0.208 (0.890)
Ceram-X mono	131.57 ± 1.41	130.32 ± 0.92	134.96 ± 1.64	135.88 ± 6.21	3.213 (0.051)
Ketac Molar	50.49 ± 4.42	51.22 ± 4.88	51.42 ± 4.81	50.85 ± 6.10	0.033 (0.992)
The mean shear strength of filtek supreme,ceram-x(dentsply), posterior composite (P60), flowable composite, and ketac molar. Significant at $p = 0.05$.					

Table 1: Mean Shear Strength and ANOVA of Composites after Conditioning.



Figure

There was no statistically significant difference in the strength of Filtek Supreme ($p < 0.730$), P60 ($p < 0.610$), flowable composites ($p < 0.890$), and Ketac molar ($p < 0.992$) after conditioning in four dietary solvents. No significant difference was observed between Ceram-X mono specimen in the control group and those conditioned in citric acid, heptane, and 50% ethanol. Posterior composite had the highest strength in all conditioning media, while Ketac molar had the lowest. P60 was stronger than Filtek supreme. Ceram-X was also weaker than P60 when conditioned in distilled water, ethanol, citric acid, and heptane.

Discussion

Current restorative techniques utilize the adhesive propoerties of resin-based components. Though adhesive systems have undergone significant improvements, bonded surface is still the weakest part of tooth-colored restorations [15]. These failures are associated with dissolution and disintegration in the intraoral environment by bacterial ctivity, saliva, and chewing [16]. Because there are no *in vitro* tests that can reproduce the complex proceesses in the mouth, this study was conducted to compare the differences in strength in nanofill composites and direct esthetic restorative materials that are commonly used in clinical practice after exposure to conditioning media. The different specimens were pre-conditioned in distilled water (control), citric acid, 50% ethanol, and heptane. The dietary solvents used in this study are recommended by the FDA for simualting foods [17]. Exposure of the composites to conditioning for one week can be considered lenghty because restorations normally interact with food ocassionally for a short time *in vivo*. There is a possibility that the findings from this experiment exaggerate the impacts of dietary solvents on compsite restorations.

Shear stresses in teeth and restorations are caused by parafunction and mastication, thus, the qualities of clinical significance are reflected on the shear punch test [19]. The food-simulating liquids used for conditioning are recommended by the FDA as food simulants [17]. Heptane simulated fatty meats, butter, and vegetable oils, while the ethanol solution represented beverages such as syrup, fruits, alcohol, candy, and vegetables [16]. Distilled water simulated the wet intraoral environment provided by water and salvia. A one-week break was incorporated before conditioning to allow for composite post cure and establishment of acid-base reaction in the glass ionomer [19,20]. The strength ranking in all composites was consistent with the clinical performance of different materials irrespective of conditioning medium. Composites demonstrated significantly higher strength compared to highly viscous glass ionomer cements. Hence, highly viscous glass ionomer cement should never be used in the stress bearing situation. Significant differences in strength between the composite material were dependent on conditioning medium. As the polymer and filler content between minifill and nanofill composites were similar, the significant differences in strength may be attributed to differentiation in filler size. Yap., *et al*. (2000) stated that the interface between loosely bound nanofill filler in nanofill composite can create possible pathways for crack propagation when testing shear strength [21]**.** The difference in strength between minifill and Ceram-X composites could be attributed to the lower filler content and possible hydrolytic effect of water on the Silicon dioxide (SiO_2) inorganic backbone of inorganic-organic network matrix [22]. The nanofill composite, Filtek Supreme, as the strongest which is consistent with a study by Mitra., *et al*. (2003) who found that nanocoposites posses sufficient mechanical properties suited for high-stress restorations [23]. The findings are also consistent with Kaur and Nandlal (2013) who indicated that compounds such as heptane reduce oxygen inhibition and removes combined metals and silica after conditioning in various solutions [24].

Conclusion

Under the conditions of this *in vitro* study, the strength of glass ceramic inserts and nanofill composites was not significantly affected by dietary solvents. The composite materials were significantly stronger compared to highly viscous glass ionomer cement. Based on the findings of this study, it can be condluded that dietary solvents influence the strength of nanofill composites especially in conditioning media *in vitro*. Additionally, nanofilled composites demonstrate higher flexural strength compared to highly viscous glass ionomer cement. Thus, the use of nanofilled composites in posterior and anterior restorations should be promoted. However, there is a need for further investigation on the clinical performance of new composites to ensure universal acceptance. These findings also allow clinicians to recommended controlled inteake of foods containing dietary solvents to patients who have acrylic denture for extended periods.

Conflict of Interest

The authors declare that they have no conflict of interest.

Bibliography

1. Khalaj K., *et al*. "The evaluation of surface sealants' effect on the color stability of Nano-hybrid composite after polishing with One-Step system (in-vitro)". *Journal of Clinical and Experimental Dentistry* 10.9 (2018): e927.

2. Malhotra SK., *et al*. "Part one introduction to polymer composites". *Polymer Composites* 1 (2012): 1-2.

3. Rahim TN., *et al*. "Synthesis of nanosilica fillers for experimental dental nanocomposites and their characterisations". *Journal of Physical Science* 22.1 (2011): 93-105.

4. Jang JH., *et al*. "Polymerization shrinkage and depth of cure of bulk-fill resin composites and highly filled flowable resin". *Operative Dentistry* 40.2 (2015): 172-180.

5. Shah P and Stansbury JW. "Role of filler and functional group conversion in the evolution of properties in polymeric dental restoratives". *Dental Materials* 30.5 (2014): 586-593.

6. Stefanski S and van Dijken JW. "Clinical performance of a nanofilled resin composite with and without an intermediary layer of flowable composite: A 2-year evaluation". *Clinical Oral Investigations* 16.1 (2012): 147-153.

7. Yadav RD., *et al*. "A comparative analysis of different finishing and polishing devices on nanofilled, microfilled, and hybrid composite: A scanning electron microscopy and profilometric study". *International Journal of Clinical Pediatric Dentistry* 9.3 (2016): 201.

8. Kalra S., *et al*. "Ormocer: An aesthetic direct restorative material; An in vitro study comparing the marginal sealing ability of organically modified ceramics and a hybrid composite using an ormocer-based bonding agent and a conventional fifth-generation bonding agent". *Contemporary Clinical Dentistry* 3.1 (2012): 48.

9. Pitacas HM., *et al*. “Effect of external tooth bleaching on the surface of resin composites–An in vitro study”. *Revista Portuguesa de Estomatologia, Medicina Dentária E Cirurgia Maxilofacial* 56 (2015): 149-155.
10. Krüger J., *et al*. “In vitro aging behavior of dental composites considering the influence of filler content, storage media and incubation time”. *PloS One* 13.4 (2018): e0195160.
11. Leprince JG., *et al*. “Physico-mechanical characteristics of commercially available bulk-fill composites”. *Journal of Dentistry* 42.8 (2014): 993-1000.
12. Drummond JL. “Degradation, fatigue, and failure of resin dental composite materials”. *Journal of Dental Research* 87.8 (2008): 710-719.
13. Sarrett DC., *et al*. “The effects of alcoholic beverages on composite wear”. *Dental Materials* 16.1 (2000): 62-67.
14. Cenci MS., *et al*. “Influence of thermal stress on marginal integrity of restorative materials”. *Journal of Applied Oral Science* 16.2 (2008): 106-110.
15. Krithikadatta J. “Clinical effectiveness of contemporary dentin bonding agents”. *Journal of Conservative Dentistry* 13 (2010): 173-183.
16. Eweis AH., *et al*. “Impact of dietary solvents on flexural properties of bulk-fill composites”. *The Saudi Dental Journal* 30.3 (2018): 232-239.
17. Ayad NM., *et al*. “Food simulating organic solvents for evaluating crosslink density of bulk fill composite resin”. *International Journal of Dentistry* (2017).
18. Roydhouse RH. “Punch-shear test for dental purposes”. *Journal of Dental Research* 49.1 (1970): 131-136.
19. Eliades G., *et al*. “Acid–base reaction and fluoride release profiles in visible light-cured polyacid-modified composite restoratives (compomers)”. *Dental Materials* 14.1 (1998): 57-63.
20. Watts DC., *et al*. “Surface hardness development in light-cured composites”. *Dental Materials* 3.5 (1987): 265-269.
21. Yap AU., *et al*. “Effects of food-simulating liquids on the flexural strength of composite and polyacid-modified composite restoratives”. *Operative Dentistry* 25.3 (2000): 202-208.
22. Soderholm KJ and Roberts MJ. “Influence of water exposure on the tensile strength of composites”. *Journal of Dental Research* 69.12 (1990): 1812-1816.
23. Mitra SB., *et al*. “An application of nanotechnology in advanced dental materials”. *The Journal of the American Dental Association* 134.10 (2003): 1382-1390.
24. Kaur H and Nandlal B. “Effect of dietary solvents on the strength of nanocomposite, compomer, glass ionomer cement: An in-vitro study”. *Journal of Conservative Dentistry* 16.6 (2013): 527.

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