Original Article

Influence of salivary pH on the sorption rate of nano-filled composite resin

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ABSTRACT

Background: *Physical properties of a resin composite are as important for the longevity of composite material as the mechanical properties are for its survival in the oral environment.*

Objectives: *The aim of this study is to evaluate the effect of artificial saliva with different pH (4.6, 5.1, 5.7, 6.3, 6.9, 7.5 & 8.1) on the sorption of dental nano-filled composites.*

Material and Methods: *5 disc shaped specimens were made for each group of pH with nano-filled composite resin and immersed for four weeks. Optical density was measured in Ultraviolet Vis Spectrophotometer. Statistical one-way analysis of variance (one-way ANOVA) and the two-way analysis of variance (ANOVA) were used throughout this study.*

Results: *No significant differences were detected in specimens of any group of pH.*

Conclusions: *Salivary pH has no effect on the nano-filled dental composite material. Future research needs to test more experimental designs that could depict the clinical behavior of the restorative material in vitro environment.*

Keywords: *Anova, nano-filled composite, physical properties, salivary pH, sorption*

Introduction

Over the years, dental composites' fillers have been changed fundamentally in their evolution. [1] Now a day variety of dental composites are available in the market including macrofilled composites, microfilled composites, hybrid composites, microhybrid composites and nanocomposites. Studies have proven that fillers play a vital role in some properties such as elastic modulus, polish retention, wear resistance, flexural strength, bond strength, color

stability, translucency, opalescence and fracture toughness. [2] Also, some other studies have shown the effects of filler size and filler shape on physical and mechanical properties of dental composites. [2]

To improve the properties of dental composites, many attempts have been made to enhance their clinical longevity or performance. [3] These attempts were mostly centered on salinaization, filler particles' loading, distribution and shapes; [4] more recently on formation of new particles. [5] Studies were also conducted to form new kind of monomers. [6] These studies are of great importance as physical properties of dental composites greatly rely on filler size and loading. [4] With the advent of nanotechnology in dentistry, an improvement in dental composites' properties has been made. Mechanical, physical, chemical, and optical properties may be improved. [7] This technology would have a great impact in the field of restorative dentistry. In nanocomposites, nano particle fillers are in the range of 40-50nm. [8] Different types of nanocomposites are available such as nanohybrid types in which milled glass fillers with discrete nano-particles in the range (40–50 nm) are present. Another type called nanofill contains nano-sized filler particles called nanomers and agglomerations of these particles described as nanoclusters Nano dental composites are said to have improved mechanical and physical properties of the hybrids and superior polish of the microfills. [9]

However, the matrix of the dental composites is susceptible to softening in the oral environment due to consumption of organic acids and other solid and liquid foods having low pH. [10] The longevity of dental composites may be compromised due to softening of matrix in the oral environment which may lead to deterioration of physical properties i.e. solubility and sorption. [11] Studies have shown that resin based composites absorb significant amount of water when exposed to aqueous environment. [12] When a resin based materials are exposed to water, firstly they gain weight due to intake of water under the mechanism of sorption. Secondly, water is lost from them due to dissolution of resin based material in aqueous medium. The properties of water sorption and solubility of resin based restorative materials are of considerable importance due to continuous contact of these materials with saliva in the mouth. It is a well-established fact that resin based materials are prone to sorption and solubility in conventional, hybrid and micro-filled dental composites. Hengtrakool et al. found deterioration of physical properties of composite material when immersed in water. [13] Catelan et al [14] found solubility and dissolution of a composite material when exposed to low pH environment. Fontes et al [15] found perceptive color change for the group of nano-filled composite specimens stored in the grape juice.

Our study is also focused on these short-comings of resin based composite material. The primary aim of this study is to evaluate the effect of artificial saliva with different pH on the sorption of dental nano-filled composites. The hypothesis of this study is that like other dental composites, salivary pH affects the sorption rate of nano-filled composites.

Materials and methods

A halogen light curing unit was used to prepare a sum of 35 samples of dental composite. A dental composite material used in this study was Te- Econom Plus by Ivoclar Vivadent. Circular Teflon mold 5 mm in diameter and 2.0 mm in thickness was used. Mylar strip (Dentart, Polidental, Sao Paulo, Brazil) having a dimensions (10x 120x0.05 mm) was placed over the top and bottom of the mold and pressed on top with a microscope slide to form a flat surface of the sample. Light curing unit was held rigidly and placed 2.0 mm over the Mylar Strip for 40 seconds to cure down the dental composite samples.

Preparation of Artificial Saliva

The artificial saliva used in this study was of the following composition: Sodium chloride (NaCl) 0.400g; Potassium chloride (KCl) 0.400g; Calcium chloride monohydrate ($CaCl_2H2O$) 0.795g; Sodium dihydrogen phosphate (NaH_2PO_4) 0.69g; Disodium sulphide hydrate (Na_2Sx9H_20) 0.005g; urea 1.0g; distilled water 1000ml. The pH was then adjusted to 4.6, 5.1, 5.7, 6.3, 6.9, 7.5 and 8.1 with Sodium hydroxide (NaOH) or Hydrochloric acid (HCl).

Preparation of Methylene Blue Staining Solution

10% Methylene blue staining solution was prepared in laboratory by mixing 10ml of methylene blue dye material with 90ml of deionized water. The prepared solution was used for the test.

Specimens Storage Protocols

5 specimens of each group were stored in 3 ml of varying pH of artificial saliva containing test tubes. These test tubes of varying pH were stored at 37±3°C for 28 days in an incubator. The test tubes containing specimens with pH 6.9 was a control group.

Analytical Method

After 28 days storage in artificial saliva of varying pH, the specimens were taken out and washed with distilled water for 1 minute and put into new test tubes containing 1 ml absolute alcohol. These test tubes of different pH groups were incubated again for 24 hours (37± 3ºC). After 24 hours the solution was filtered from each test tube and centrifuged (Centrifuge Model 800, China) for 3 minutes at 4000rpm and supernatant were used for analysis. Absorbance were recorded in Ultraviolet Vis Spectrophotometer (Schimadzu 160 UV-Vis, Germany) at 590nm.

The results were analyzed by means of one-way ANOVA and Two-way ANOVA tests. SPSS version 19 software by IBM, USA was used to analyze the results. A one-way within subjects (or repeated measures) ANOVA was conducted to compare the effect of varying pH of artificial saliva on the sorption rate of dental nano-filled composite.

Results

The effects of varying pH (4.6, 5.1, 5.7, 6.3, 6.9, 7.5 & 8.1) of artificial saliva on the sorption rate of nano-filled composite found to be non-significant in each group. Table 1 shows the mean and standard deviation of each group. These results suggest that pH of saliva has no effect on this particular type of dental composite. So, we reject the hypothesis of this study. In fig 1, the mean value of optical density of the specimens is represented against the corresponding

pH. Although the values were insignificant yet optical density was found to be lower at pH 5.7 (0.068) and higher at pH 6.9 (0.088)

Table 1: Showing results of ANOVA testing method

pH	No. of Specimens (n)	Mean ± SD	Variance
pH4.6	05	0.082± 0.002	2.75
pH5.1	05	0.060± 0.003	1.3
pH5.7	05	0.068± 0.002	2.2
pH6.3	05	0.083 ± 0.005	7.3
pH6.9	05	0.088 ± 0.001	4.3
pH7.5	05	0.074 ± 0.001	2.5
pH8.1	05	0.075 ± 0.001	5.7

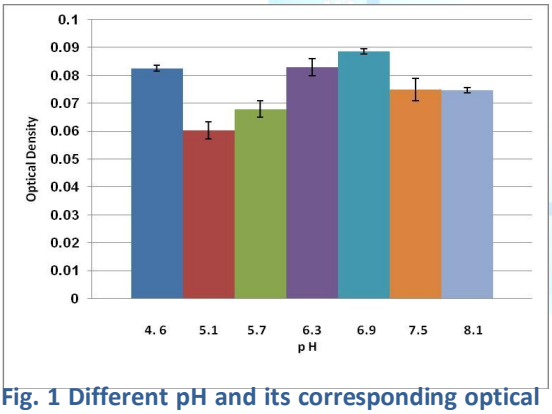

Fig. 1 Different pH and its corresponding optical density

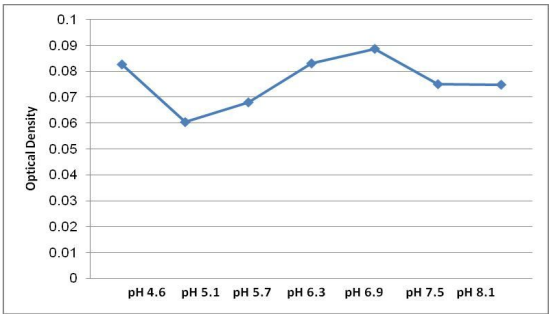

Fig. 2 Representation of varying salivary pH and its correlation with Optical Density

Discussion

The present study tested the hypothesis that salivary pH affects the sorption rate of nano-filled composites. Results didn't support the hypothesis. These unexpected results can be interpreted in several ways. It may be that there truly is no link between acidic/alkaline salivary pH and the sorption ability of the nano-filled composites. Alternately, it may be that there is an association but the present study's design was not sensitive enough to identify the association due to a variety of potential factors that are present in the oral environment but couldn't be created during in-vitro testing. Another possible limitation of this study could be the duration of this study. Possibility exists that immersion of the specimens for a longer period of time may show sorption.

Neamat et al [16] have shown that

fillers tend to fall out from resin materials and the matrix component decomposes when exposed to low pH environments. Many soft drinks are acidic and the pH is 3.0 or lower. This means that drinking acidic drinks over a long period and with continuous sipping can erode the tooth enamel and the resin material as well. This study does suggest against the findings of other studies; an uncontrolled third variable may be confounding these results.

No doubt many factors are involved in damaging or destroying the clinical performance of dental restorative materials. These factors either act alone or in combination with other factors in breaking down the resistance of the restorative materials.[17] In vitro environment can't truly depict the natural conditions of the oral cavity. It is strongly suggested that future research should be directed for a longer period of time and immersion of the samples in more acidic and basic environment might give the answer to our queries.

An in vitro study must always be performed with caution. Although the study was as far as possible performed in a standardized manner yet there are always the chances of handling errors. To avoid those errors the required operations were divided between the authors and the same person was always performing the same operation throughout the whole study. The results of this study were statistically non-significant in all the pH groups as shown in (Fig 1). This shows that the effect of varying pH on the sorption rate of nano composites is negligible as shown in (Fig 2). This proves that nano composites have improved physical properties yet we presume that oral environment would cause more deleterious effect on restorative materials due its complexity and the mechanism involved in sliding, abrasion, chemical degradation and fatigue.

Polymers are sensitive to hygroscopic and hydrolytic effects with varying intensity according to their chemical composition: matrices with Bis-GMA and TEGDMA tend to suffer more water sorption, and the amount of inorganic component in the composite is inversely proportional to this phenomenon.[10] The composite material tested in this study showed greater resistance against varying salivary pH. Although the material used in this study (Te-Econom Plus) contained TEGDMA, which is considered a hydrophilic polymeric material prone to sorption yet the material didn't show any significant difference in absorbance after 4 weeks immersion in varying pH of artificial saliva. The reason of this low absorbance could be the low content of polymeric material present in nanocomposite (22 wt%) and higher filler content (76wt%)

The present study is important, in that the results provides support that there is no association between acidic or akaline nature of the saliva and the sorption of the composite material, particularly with nano-filled material. An idea that was pure speculation prior to these findings. Future research needs to test more experimental designs that could depict the clinical behavior of the restorative material in vitro environment. In vivo studies are needed to carry out prior to recommend nano-filled composite material as a preferable restorative material.

Abbreviations and acronyms

BISGMA= bisphenol A glycidyl methacrylat, TEGDMA = triethyleneglycol-dimethacrylate, ANOVA = Analysis of Variance

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