



Research Article

Effect of Instrument Lubricant on Water Sorption and Solubility of Incrementally Applied Nanofilled Resin Composite

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Abstract

The stickiness of nanofilled resin composite is still one of its major disadvantages that haven't been corrected yet. Many techniques have been developed to overcome this issue, including the use of bonding agent as instrument lubricants. This research aimed to compare between 2 bonding agents when used as instrument lubricants and their effects on water sorption and solubility of nanofilled resin composite according to the number of increments applied. A total of 45 samples of nanofilled resin composite were prepared and divided into three groups according to the used instrument lubricants. The specimens were divided based on the number of increments applied (2, 3 and 4 increments). Water sorption and solubility were measured using calibrated electronic microbalance. Resin composite applied with 1-step adhesive system (5th generation) and 2-steps adhesive system (7th generation) showed a significant difference of water sorption when compared with nanofilled resin composite applied without lubricants. Resin composite applied with both lubricants showed insignificant difference in solubility when compared to nanofilled resin composite applied without lubricants. It was concluded that, using adhesive resin as instrument lubricants for nanofilled resin composite showed a significant effect on water sorption of the specimens. There was insignificant effect on the solubility of the nanofilled resin composite after using of the adhesive resin as instrument lubricants.

Keywords: Incremental application; Lubricants; Nanofilled composite resin; Resin adhesives

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Introduction

Tooth colored restorations were introduced to the field of dentistry over 40 years ago. In 1995, silicates were used as a restorative material followed by Polymethyl Methacrylate (PMMA) with its properties of ease of manipulation, insolubility in oral environment. In order to overcome these problems quartz powder particles were added to form a composite structure, it reduced the volume of the resin and thus reduced thermal expansion and contraction to approach the coefficient of thermal expansion of the tooth [1].

In 1962, a new type of composite materials was developed based on using bisphenol-A Glycidyl dimethacrylate (bis-GMA) a monomer that forms a cross-linked matrix and a surface treatment using silane coupling agent to bond the filler particles and the resin matrix which may decrease water sorption and solubility [1]. Composite was originally indicated for application in anterior teeth only, with later improvements in mechanical properties it was accepted to be used in posterior teeth too [2]. Resin composite has optical characteristics that mimic the tooth structure [1]. With recent advances in adhesive technology it became one of the most used restorative materials [3].

Many advances have been made to improve the properties of resin composite increasing the filler loading is one, it improves aesthetics and leads to reduction in polymerization shrinkage, water sorption and generally improves mechanical and physical properties [1]. Classification of dental composite was made according to the particle size of inorganic filler, based on this, it's divided into three main types: macrofilled, microfilled and hybrid composite, recent development of composite include nanocomposites, with (0.01 μm) filler size, these composite have superior optical characteristics and polishability, improved strength and reliability compared with microfilled composite [1,4,5].

Resin composite must be placed incrementally to overcome the problem of polymerization shrinkage and to ensure that the material is fully polymerized [6]. A phenomenon known as the air-inhibiting layer makes incremental building up possible [7-9]. It is believed that oxygen inhibits polymerization of a thin superficial layer of resin composite. Thus, supplies double methyl methacrylate bond for copolymerization with another increment of the resin [10,11].

Difficulties with incremental building up of resin composite are adherence of the material to the instrument during application [12]. Despite the many advances in dental composite, its stickiness is still one of its major disadvantages [13]. Resin composite adheres to the instrument during insertion and condensation as reported by many clinicians [14,15]. Thus, increases the risk of voids and porosities in the final restoration, many techniques have been developed to overcome this issue, including development of plastic-ended, titanium coated instrument [16,17]. Another technique involves wiping the instrument with isopropyl alcohol-saturated gauze before sculpting composite [18].

Lubricating the instrument with unfilled adhesive resin before sculpting composite is also a well known technique used to overcome composite adherence. It has been agreed that using lubricant adversely

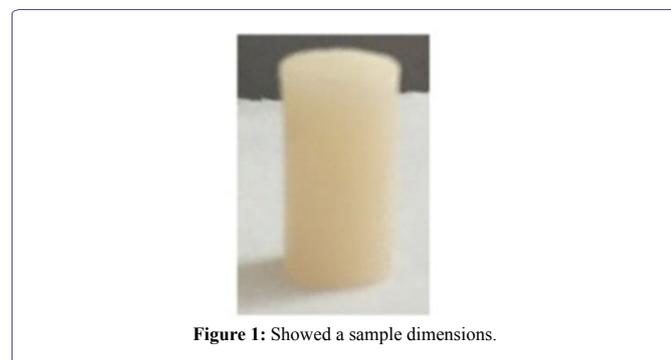
affect the properties of composite, on the other hand incremental building up of composite also adversely affects the flexural strength of the final restoration [19]. This study was aimed to test the effects of using adhesive resins as lubricating agent for incremental application of nanofilled composite resins regarding water sorption and solubility.

Materials and Methods

The materials used in this study and their manufacturers are presented in table 1. 45 specimens of nanocomposites resin were prepared using a stainless steel split mold of 5 mm in diameters and 8 mm in depth. The composite resin paste was applied incrementally, each 2 mm thickness. The composite was condensed and contoured with un-lubricated stainless steel plugger to prepare the control group. Light polymerization was performed using halogen light curing unit (1000 Watt) for 10 seconds as recommended by the manufacturer. For preparation of the test groups, the plugger was dipped into each respective lubricant for 1 second (up to a 3 mm marked line on the instrument) and left to drip/drain for 2 seconds prior the condensation of the nanofilled composite resin [20]. The procedure was repeated to reach the planned number of increments for each group (Figure 1).

Material	(Tetric® N-Ceram)	Tetric® N-Bond Universal	Tetric® N-Bond
Composition	-Bis-GMA -Ethoxylated Bis-EMA -Barium glass ytterbium trifluoride, mixed oxide, silicon dioxide -Prepolymers	-Methacryloyloxydecyl dihydrogen phosphate -Methacrylated carboxylic acid polymer. -Hydroxyethyl ethacrylate. Bis-GMA -Decandiol dimethacrylate	-Bis-GMA, dimethacrylate, hydroxyethyl methacrylate, phosphonic acid acrylate -Nano-fillers (SiO ₂) -Ethanol
Manufacturers	Ivoclar Vivadent, Schaan/Liechtenstein	N-Bond Universal, Ivoclar Vivadent, Schaan/Liechtenstein	N-Bond Universal, Ivoclar Vivadent, Schaan/Liechtenstein
Form	Nanofilled composite paste	1-step adhesive system (self-etch bottle)	2-step adhesive system (adhesive bottle)

Table 1: Materials used.



The specimens were classified as follow:

Group A: Specimens lubricated with 1 step adhesive system:

- Subgroup A1: Specimens were prepared in 2 increments (5 samples)
- Subgroup A2: Specimens were prepared in 3 increments (5 samples)
- Subgroup A3: Specimens were prepared in 4 increments (5 samples)

Group B: Specimens lubricated with 2 step adhesive system:

- Subgroup B1: Specimens were prepared in 2 increments (5 samples)
- Subgroup B2: Specimens were prepared in 3 increments (5 samples)
- Subgroup B3: Specimens were prepared in 4 increments (5 samples)

Group C: Specimens without adhesive lubrication:

- Subgroup C1: Specimens were prepared in 2 increments (5 samples)
- Subgroup C2: Specimens were prepared in 3 increments (5 samples)
- Subgroup C3: Specimens were prepared in 4 increments (5 samples)

Specimens were placed in desiccators for desiccation, then were weighed using calibrated electronic microbalance and recorded as W1. Specimens were stored in deionized water container at 37°C for 1 week. Following storage, specimens were removed from water with a tweezer and waived in air, then reweighed W2.

Percentage of weight change was calculated as follow:

$$\text{Weight change (water sorption, mg)} = \frac{W1 - W2}{W1} \times 100\%$$

The specimens were desiccated again and weighted W3. Water solubility was calculated as follow:

$$\text{Water solubility } (\mu\text{g}/\text{mm}^3) = W1 - W3 / V .$$

Statistical Analysis

The recorded data were analyzed using ANOVA and LSD test was used to compare between groups at the level of significance $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 16.

Results

The statistical analysis of the results showed a significant difference in water sorption ($P \leq 0.05$) (Table 2). In the control group (Group C), there were significant differences in water sorption between 2-layers and 3-layers and 4- layers (Table 3). Group A (Tetric N-Bond Universal) showed significant differences in water sorption between the different subgroups (A1, A2 and A3) at $P \leq 0.05$. Group B (Tetric N-Bond) showed significant differences in water sorption between the different subgroups (B1, B2 and B3) at $P \leq 0.05$. The highest amount of water sorption was recorded for Tetric N-Bond Universal (2-layers) followed by the 4-layers in the same group. The lowest amount of water sorption was recorded for the control group (2-layers). In general, Group A (Tetric N-Bond Universal) showed the highest amount of water sorption. Group C (control group) showed the lowest amount of water sorption. Group B (Tetric N-Bond) showed intermediate amount of water sorption.

	Sum of squares	Df	Mean Squares	F	Significant
Between Groups	0.025	2	0.012	5.394	0.008
Within Groups	0.096	42	0.002		
Total	121	44			

Table 2: ANOVA test of water sorption of nanofilled composite resin applied with different adhesives.

The statistical analysis of the results showed no significant difference in water solubility ($P \geq 0.05$) (Table 4). In the control group (Group C), the greatest amount of solubility was noted in 4-layers technique, while the least amount was seen in 2-layers application

(Table 5). Group A (Tetric N-Bond Universal) showed higher water solubility in 4-layers technique, while the least amount was seen in 2-layers application. Group B (Tetric N-Bond) showed higher water solubility in 3-layers technique, while the least amount was seen in the other layers.

Groups	Mean±	SDP-value
Control (Group C)		
Subgroup C1 (2-layers)	0.09 mg ^E ± 0.01	P value ≤ 0.05
Subgroup C2 (3-layers)	0.104 ^D ± 0.01	
Subgroup C3 (4-layers)	0.108 ^{DA} ± 0.04	
Tetric® N-Bond Universal (Group A)		
Subgroup A1 (2-layers)	0.218 ^A ± 0.09	
Subgroup A2 (3-layers)	0.12 ^C ± 0.03	
Subgroup A3 (4-layers)	0.152 ^B ± 0.04	
Tetric® N-Bond (Group B)		
Subgroup B1 (2-layers)	0.14 ^B ± 0.03	
Subgroup B2 (3-layers)	0.126 ^C ± 0.02	
Subgroup B2 (4-layers)	0.108 ^D ± 0.03	

Table 3: Mean values and standard deviations of water sorption of nanofilled composite resin applied with different adhesives.

Means with different superscripted letters are significantly different

	Sum of squares	Df	Mean Squares	F	Significant
Between Groups	0.001	2	0.00	0.388	0.681
Within Groups	0.033	42	0.001		
Total	0.034	44			

Table 4: ANOVA test of water solubility of nanofilled composite resin applied with different adhesives.

P-value was not significant ($P \geq 0.05$)

Groups	Mean±	SDP-value
Control (Group C)		
Subgroup C1 (2-layers)	0.022 ± 0.01	$P \geq 0.05$
Subgroup C2 (3-layers)	0.03 ± 0.012	
Subgroup C3 (4-layers)	0.048 ± 0.07	
Tetric® N-Bond Universal (Group A)		
Subgroup A1 (2-layers)	0.018 ± 0.004	
Subgroup A2 (3-layers)	0.028 ± 0.008	
Subgroup A3 (4-layers)	0.034 ± 0.02	
Tetric® N-Bond (Group B)		
Subgroup B1 (2-layers)	0.02 ± 0.007	
Subgroup B2 (3-layers)	0.034 ± 0.01	
Subgroup B2 (4-layers)	0.02 ± 0.01	

Table 5: Mean values and standard deviations of water solubility of nanofilled composite resin applied with different adhesives.

Means with different superscripted letters are significantly different

Discussion

Composite is made of a matrix composed of dimethacrylate monomers and urethane dimethacrylate which form a highly cross-linked, rigid and strong polymer matrix. Filler particles and a coupling agent to bond the two components together. The filler particles consist of

aluminum silicate and lithium aluminum silicate glass particles or barium aluminum silicate or strontium glasses. Also addition of colloidal silica ultrafine particles helps controlling the handling characteristics of composite [1]. Monomers used in composition of dental composite include base monomer and diluents monomer, the first is relatively viscous while the latter has lower viscosity, making composite of high viscosity and causing adherence of composite to the instrument during application [7-9]. Various lubricants have been used to coat the instrument of application overcome this problem, including alcohol and bonding agents. Lubricants have been proved to cause deleterious effect on the properties of composite [20].

A study tested the degree of conversion and cross-linking density showed decreased degree of conversion and cross linking density, when lubricants was used [21]. Another study was conducted to assess the effect of instrument lubricant on the diametral tensile strength and water sorption of resin-composite, the results showed extremely reduced diametral tensile strength and increased water uptake in specimens placed with instrument lubricant compared with the control group. It's may be due to the decrease in the cohesive interface between the increments, also presence of unfilled content and HEMA caused the increased water uptake. However, resin composite placed with ethanol showed much less water sorption compared to those placed with bonding agent lubricants [20].

Exposed surfaces of the restoration leads to leaking of water into the bulk of the material. However composite exhibits two phenomena when immersed in water, the first is weight gain of the material as a result of hygroscopic absorption. Which can be measure as water sorption, the other is leaching out of unreacted monomers which leads to weight loss of the material, it can be measured as solubility [2]. Water sorption and solubility may be the reason of several physical and chemical processes that lead to deleterious effects in the resin composite structure. Water sorption and solubility affect dimensional changes of the resin; they also decrease surface hardness, wear resistance as well as impair color stability. Factors affecting water sorption and solubility of composite include types of composite used, chemical composition, storage time, pH of the storage solution and degree of polymerization [1].

The solubility of nanocomposites in comparison to conventional hybrid composite was comparable [22]. Heat treatment significantly decreased the sorption and solubility of the composite resin [23].

The results of this study showed that, composite resin which applied in two increments, three increments and four increments for each of the lubricants, and a control group with the same number of increments exhibited different values. For water sorption, specimens lubricated with 1 step adhesive system exhibit more weight gain in comparison with either the control or the 2 step adhesive system groups. Specimens applied in two layers with one step adhesive system showed the highest amount of water sorption. The control and the two test groups showed comparable solubility. However solubility records were increasing with the number of layers applied. Highest solubility was noted in specimens with 4 layers for all groups including the control group.

The change in the degree of conversion in resin composite when lubricants were used could be noted [21,24]. Using alcohol or unfilled resin during incremental application of composite doesn't affect the flexural strength of the final restoration [15]. The lubricant used

to reduce the stickiness between the composite instrument and the resin composite used for direct restorations did not affect the physical properties of the hybrid composite resin [25]. Thus, the instrument lubricants were proven to have deleterious effects in resin composite properties.

Conclusion

Within the limitation of our study the following conclusion was drawn:

1. Using adhesive resin as instrument lubricant for the nanofilled resin composite, it showed a significant effect on water sorption of the specimens
2. There was insignificant effect on the solubility of the nanofilled resin composite after using of the adhesive resin as instrument lubricants

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