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Research Article

Comparative Evaluation of the Effect of Water on Three Different Light Cured Composite Restorative Materials: An In Vitro Study

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Abstract: Aims and Objectives of current to Evaluate the weight gain in three different light cured composites occurs due to water absorption. The composite restorative materials selected for this study included a micro-fine hybrid (Filtek Z 250 XT) and two nano-filled composites (CERAM X duo and FILTEK Z 350). Ten specimens of each material were fabricated with each composite material. Group A: Filtek Z 350, Group B: Filtek Z 250 XT, and Group C: CERAM X Duo. Specimens were stored in 10 ml distilled water in test tubes, and then placed in an incubator at 37˚C for six weeks. The weight changes of these specimens were measured daily for the first week, and later, once a week, for the next five weeks, by using an electrical analytical balance. The statistical analysis of the results showed FILTEK Z 250 showed the maximum amount of water absorption in the first week. However, FILTEK Z 350 showed the maximum amount of water absorption from the second week to the sixth week, as compared to CERAM X Duo and FILTEK Z 250.All composite restorative materials absorb some amount of water. The water absorption of the composite may decrease the physical and mechanical properties of the composites hence, it is necessary to consider the type of the material before starting treatment.
Keywords: Micro-Fine Hybrid; Nano-Filled Composite; Water sorption; Electrical Analytical Balance.

INTRODUCTION

Direct composite restorative materials offer esthetic solutions for clinicians and patients. Esthetic solutions must be achieved in tandem with the functional requirements of strength, volumetric and morphologic stability, and physical compatibility with the surrounding tooth structure, biocompatibility, and the ability either to self-adhere to the tooth surface or to adhere with an adhesive system for a durable bond at the tooth-restoration interface [1].

Additional desirable properties include the ability to inhibit biofilm formation, thereby reducing the load of acidogenic and periodontal bacteria, stain resistance, and user-friendliness. Ideally, a restorative material will meet all these requirements, allowing it to be used for both anterior and posterior restorations [1].

While amalgam fulfills the physical requirements for direct restorations because it is quicker and easier to place than esthetic restorative materials, and is more tolerant of moisture, and can now be hybrid-bonded with the use of amalgam bonding techniques which has reduced the need for classical amalgam preparations, although results have been found to be variable its lack of esthetic results means it is suitable only for posterior restorations [2, 3]. Its use for posterior restorations has also gradually declined as patients have become increasingly aware of esthetics and want the improved posterior esthetic materials that have become available in response to this demand [4].

Clinicians demand esthetic materials with improved physical and handling properties. Physical requirements differ for anterior and posterior restorations. Anterior restorations, especially those involving incisal edges, require high strength as well as high esthetics. Posterior restorations have the added requirement of low wear [1].

Mechanical properties of composites are not only influenced by their chemical composition but also by the environment to which they are exposed. The corrosion process promoted by water and the presence of constant load on the surface of resin are responsible for the appearance and propagation of interfacial debonding matrix cracking, superficial flaws, filler dissolution, and filler particle dislodgement [5].

Since the introduction of composite resin materials, one of their major disadvantages was that they undergo a sequence of dimensional changes during and following placement [6].

These changes considered to be one of the main reasons for failures in the bond. The initial rapid polymerization shrinkage may be sufficient to disrupt the seal between the composite material and the structures to which it is bonded [6]. The clinical effects of shrinkage can be minimized by using incremental placement technique, and slow low intensity light activation [7].

Once composite resins have polymerized, they are far from stable and will constantly be interacting with their surrounding environment. The principal interaction occurs with water since the restorative materials are continually bathed in saliva and water absorption for some materials is inevitable [8].

MATERIALS AND METHOD

Ten specimens from each composite material were prepared, using brass mold (6 mm diameter X 2 mm height). The composite material was covered with acetate strips and compressed between two glass slabs, to remove voids and extrude excess composite material. The composite was then light cured through the acetate strip for 40 seconds by using quartz tungsten halogen light curing unit (QHL-75, Dentsply). The light curing unit was held at a distance of 1 cm from the specimen and curing was done at an intensity of 450 mW/cm. The tip diameter of the light curing unit was 11 mm.

Following light curing, the specimens were removed from the mold and finished with carborundum paper and later polished with coarse, medium, and fine Sof-Lex discs (3M ESPE) in respective orders.

The specimens were then weighed by electrical analytical balance (DANVER INSTRUMENT), (Figure 1) and each specimen was placed in separate test tube (BOROSIL) containing 10mL distilled water. (Figure 2).The specimens were sealed in a test tube with cotton pellet and placed in an incubator for 6 weeks at 37℃ (Figure 3).

After 24 hours, the specimens were removed and placed on filter paper (Whatman) for a period of 1 min, to drain the excess water (Fig.4) and then weighed accurately, using an electrical analytical balance. After weighing the specimens, they were transferred to the test tubes filled with 10 ml of fresh distilled water, measured using a measuring jar. The procedure was repeated every day for the first week followed by once a week for the next five weeks.

ANALYSIS OF DATA

Data obtained was analyzed statistically using analysis of variance (ANOVA) and Student's *t* test. The data was analyzed using multivariate approach of repeated measures analysis of variance (ANOVA) of SPSS Version 13.00. ANOVA test was used to test whether there is any significant difference between the three different types of composite resins at each storage interval.

Table-1: Materials used are as follows:

Materials used	Manufacturer	Composite type	Matrix
Filtek Z 350 XT (Group A)	3M ESPE	Nano-composite	Universal restorative material. Aggregated zirconia/silica cluster filler, with an average particle size of 0.6 – 1.4 micron
Filtek Z 250 XT (Group B)	3M ESPE	Nano Hybrid	Surface-modified zirconia/silica with a median particle size of approximately 3micron or less Non-agglomerated/non-aggregated 20 nanometer surface-modified silica particles • The filler loading is 82% by weight (68% by volume
Ceram X duo (Group C)	Dentsply	Nano-composite nano-ceramic	methacrylate modified polysiloxane, dimethacrylate resin, fluorescence pigment, camphoroquinone.

Table-2: The mean weights of three composite specimens, measured daily during the first week of the observation.

		N	Mean	Std. Deviation	Std. Error
First Week	A	10	.1460	.01506	.00476
	B	10	.1520	.01229	.00389
	C	10	.1620	.01814	.00573
	Total	30	.1533	.01626	.00297
Six week	A	10	.1520	.01476	.00467
	B	10	.1600	.01333	.00422
	C	10	.1620	.01814	.00573
	Total	30	.1580	.01562	.00285
Six month	A	10	.1540	.01506	.00476
	B	10	.1600	.01333	.00422
	C	10	.1640	.01838	.00581
	Total	30	.1593	.01574	.00287

Table-3: Comparison of mean weight between the three groups of composite specimens during the entire period of observation.

Group	First week	Six week	Six month
Group A with Group B	0.390	0.260	0.401
Group A With Group C	0.027	0.162	0.167
Group B With Group C	0.157	0.776	0.776

RESULT

All the groups showed maximum amount of water absorption in the first week followed by a gradual decrease in the water absorption from the second to the sixth week.

Among the groups, FILTEK Z 250 showed the maximum amount of water absorption in the first week, as compared to FILTEK Z 350 and CERAM X Duo. However, FILTEK Z 350 showed the maximum amount of water absorption from the second week to the sixth week, as compared to CERAM X Duo and FILTEK Z 250.

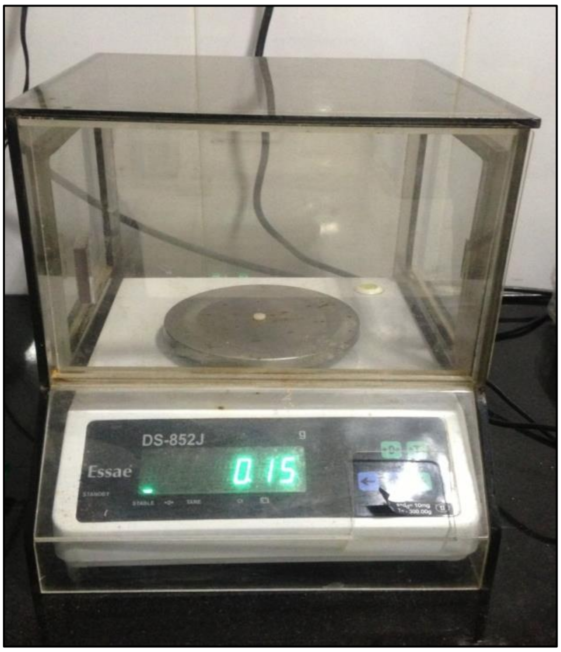

Fig-1: Specimen placed in electrical analytical balance.

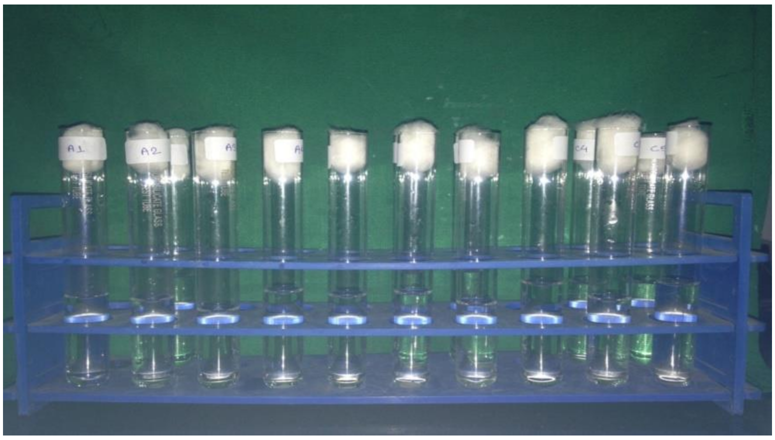

Fig-2: Specimen placed in a test tube containing 10 ml distilled water

Fi-3: Specimens incubated for 37◦C for six weeks

Fig-4: Specimens were placed on filter paper (Whatman) for a period of 1min

DISCUSSION

Considering that composite resin is a widely used restorative material, and patients are increasingly demanding esthetic restorations not only in the anterior teeth, but also in the posterior teeth. Dental material composites being used widely today are chosen not only for their esthetic properties, but also for the ability to adhere to tooth substance. Mechanical properties of composites are influenced not only by their chemical composition but also by the environment to which they are exposed.

Laboratory tests simulating the conditions of the oral cavity are needed to test its behavior in this environment [9].

The water sorption and solubility of dental restorative materials are of considerable clinical importance and cannot be neglected [10].

Tae Hyung Kim, etal showed that high strength and low solubility are desirable for any base or lining material. A strong base material is needed to support the overlying restoration and the subsequent occlusal forces acting upon it during clinical function.

Some reduction observed in compressive strength may be attributed to dissolution or water sorption during storage. Moreover, marginal infiltration may influence on liners hardness, which reinforces the need for studies related to their physical properties [11].

Nowadays hybrid resin composite is used in a wide range of clinical situations. It contains fine and microfine filler particles that occupy around 80wt% of the resin material [12]. This formula provides mechanical properties superior to other classes of resin composites [13].

With this aim, the present study evaluated different kinds of hybrid composite resins regarding water sorption.

Filtek Z250 XT Nano Hybrid Univeresal Restorative is a unique hybridization of particles, including engineered nanoparticles. It was derived from the Filtek™ Z250 Universal Restorative filler system, known for its excellent handling and strong mechanical properties. With the goal of achieving a better performing, more esthetic nanohybrid composite, the Filtek Z250 restorative filler system was improved with the addition of proprietary nanoparticles and nanoclusters which are bound in the resin matrix.

Filtek Z350 XT universal restorative nanocomposite contains a unique combination of individual nanoparticles and nanoclusters. Nanoparticles are discrete nonagglomerated and nonaggregated particles of 20 nm in size. Nanocluster fillers are loosely bound agglomerates of nano-sized particles. The agglomerates act as a single unit enabling high filler loading and high strength [16].

The combination of nanomer sized particles to the nanocluster formulations reduces the interstitial spacing of the filler particles. This provides for increased filler loading, better physical properties and improved polish retention when compared to composites containing only nanoclusters [1].

Ceram X duo comprises organically Modified Ceramic nano-particles and Nanofillers as used in Prime & Bond NT combined with conventional glass fillers of 1 μm.

Ceram X merges hybrid composite filler technology with advanced Nano-Technology. This Results in Nano-Ceramic Technology. The Organically Modified Ceramic nano-particles comprise a polysiloxane backbone. The chemical nature of the siloxane backbone is similar to that of glass and ceramics. The degree of condensation was investigated by 29Si-NMR-analasys shows that the backbone is highly condensed.

Weight change in distilled water was evaluated because saliva is a dilute fluid consisting of 99.5% of water. The concentrations of dissolved solids (organic and inorganic) are characterized by wide variations, both between individuals and within a single individual therefore, deionized distilled water was used for a test standard [8].

Brass was chosen for this study, because many of its physical properties are similar to those of the tooth substance. For example, Young's modulus of brass is very close to that of enamel while its hardness lies in between the hardness of enamel and dentin. The coefficient of thermal expansion of brass is similar to that the tooth structure [14].

Quartz tungsten halogen light curing unit, with an intensity of 450 mW/cm2 and wavelength between 400 and 500 nm, which was sufficient to cure composite specimen's up to a depth of 2 mm, was used.

Acetate strips were used to prevent the formation of oxygen-inhibited layer on the surface of the composite [15].

The factors which affect the amount of water absorption of the composite restoration materials are resin content, filler content and the coupling agent. The more the filler content, the lesser will be the water absorption, the proper the bonding of the coupling agent, and the lesser the water absorption [16].

The rate of water sorption depends also on the type of filler, filler loading and filler-matrix adhesion. The volume of the filler occupying the total volume of the composite resin material will determine the amount of the resin matrix and the resultant capacity of the composite material to absorb water. Therefore, the material with lower filler content and higher resin matrix content had higher water sorption [17].

The rate of water sorption also depends on the accessibility of water to the composite resin material. The rate and degree of water sorption and stress relief in composite restoration will be much lower than those found in the in vitro studies in which, composite resin blocks or disks were allowed to absorb water freely through all surfaces. Composite restorations with a large surface area of resin exposed to the mouth will absorb water more than smaller restorations in which, the resin is confined within two or three tooth surfaces.

The present study showed the maximum amount of water sorption in the first week of the experiment. The dimensional changes in composite restorative materials in the first week were the result of the shrinkage of the resin monomer during polymerization in the first week. Shrinkage was compensated for by the expansion resulting from the water absorption of set resin. This fact has drawn much attention, with regard to the adaptation of the composite to the dental cavity walls.

A study done by Iwami and Yamamoto also showed the maximum amount of water absorption in the first week of the experiment. A study done by Filiz and Yalgin also showed the maximum amount of water absorption in the first week of the experiment [1].

This study showed that Filtek Z 250 absorbs the maximum amount of water, as compared to Filtek Z 350 and Ceram X Duo. This is because Filtek Z 250 contains increased resin to filler ratio. However, in this study, the focus was only on the relationship between immersion times, water absorption of the resin. In other words, weight loss due to dissolution was not included in the measurement.

In this study, all materials showed a 90% increase of final volumetric expansion and change in weight within seven days. Thereafter, there was a slower and more gradual increase in the volume and weight. This two stage expansion may be caused due to the hydrolytic degradation of monomer bonds or stretching of these bonds beyond their elastic limit, causing them to rupture.

The study done by Iwami and Yamamoto also showed that more than 90% of water absorption occurred in first week [1, 17].

The increase in the dimension shown by the materials may be beneficial in relieving some of internal polymerization shrinkage stresses and it may increase the longevity of the adhesive union to surrounding tooth [1, 18].

Water sorption affects the physical and mechanical properties of resin composite, such as dimensional change, decreases in surface hardness and wear resistance, filler leaching and change in colour stability reduction in elastic modulus, an increase in creep and a reduction in ultimate strength, fracture strength, fracture toughness, and flexural strength [13].

Further study is needed in this field to evaluate other physical properties after specimen immersion in water and artificial saliva, and other novel materials will be included.

CONCLUSION

The present in vitro study evaluated the weight change of nanohybrid (Filtek Z 250) and two different nanofilled (Filtek Z 350 and Ceram X Duo) composite restorative materials.

The following conclusions were drawn:

- All the groups showed some amount of weight gain due to water absorption.
- All the groups showed the maximum amount of weight gain in the first week and slowly decreased from the second to the sixth week
- Filtek Z 250 showed the maximum amount of water absorption in the first week, as compared to Filtek Z 350 and Ceram X Duo.
- Filtek Z 350 showed the maximum amount of water absorption from the second to the sixth week, as compared to Ceram X Duo and Filtek Z 250

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