

A Comparative Evaluation of Water Absorption of Three Different Esthetic Restorative Materials – An In-Vitro Study

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Abstract: *The water absorption in the composite resins may decrease their physical and mechanical properties; hence, it is necessary to consider the type of the material needed before starting treatment. Three composite restorative materials were selected for this study. Thirty specimens of each material were fabricated with each composite material and divided into three groups – Group A: Tetric N Ceram (nano-hybrid), Group B: Charisma (micro-hybrid), and Group C: Beautifill II (Giomar). The specimens were stored in 10 ml distilled water in test tubes, and then placed in an incubator at 37°C for seven weeks. The weight changes of these specimens were measured daily for the first week, and later once a week, for the next six weeks, by using an electrical analytical balance. The data was analyzed using one-way analysis of variance and Student 't' test. There was a tendency for the weight of the specimens to increase with the passage of time, when stored in water. All the groups showed maximum amount of water absorption in the first week. However, Charisma showed the greatest stability in an aqueous environment.*

Keywords: *Composite resins, electrical analytical balance, hygroscopic expansion, water absorption, weight gain.*

I. Introduction

There is an increasing demand for esthetic restorations in patients, not only in the anterior teeth but also in the posterior teeth. These days dental composites are used widely, not only because of their esthetic properties but also for the ability to adhere to tooth structure. One of their major disadvantage is that they undergo a sequence of dimensional changes during and following placement.[1] These changes are considered to be one of the main reasons for failures in the bond.[2]

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. [3] Water absorption by a material is the amount of water absorbed through the exposed surface and into the body of the material.[4]

Water absorption and solubility are important properties of composite resins and influence their strength, abrasion resistance, volume and color stability. ISO 4049 is a standard method which is commonly used by researchers to determine water sorption and solubility of restorative dental composites.[5] 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.[6] Conversely, hygroscopic absorption of water leads to a swelling of the material and increase in weight. This phenomenon may allow for some degree of relaxation of the stresses which are set up within the matrix during polymerization shrinkage.[7] This fact has drawn much attention regarding the adaptation of composite to the dental cavity walls. Henceforth, present study has been designed to check the water absorption of composite resin materials at different intervals of time.

II. Materials and Methodology

Thirty disc specimens from each material were prepared using stainless steel mold (10mm diameter × 2mm height) [fig 1]. The material was covered with mylar strips and compressed between 2 glass slabs to

remove voids and extrude excess composite resin material. The composite was then light cured through the mylar strip for 40 seconds on both the sides by using LED curing light (Satelec).

Following light curing, the specimens were removed from the mold and divided into 3 groups according to the type of composites : Group A: Tetric N Ceram, Group B: Charisma, Group C: Beautifill II. Each group was then finished and polished with coarse, medium, and fine Sof-Lex discs (3M ESPE) in respective orders. The specimens were then weighed by electrical analytical balance (Mettler Toledo) for baseline measurements. Each disc was placed in separate test tube containing 10mL distilled water. The specimens were sealed in a test tube with cotton pellet and placed in an incubator (Yorko) for 7 weeks at 37°C.

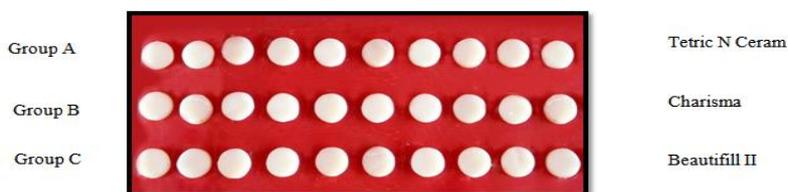


Figure 1: 30 disc specimens

After 24 hours of keeping the specimens in the incubator, they were removed and placed on filter paper (Whatman) for a period of 1 min, to drain the excess water and then weighed accurately, using an electrical analytical balance.

For recording the first day readings the specimens were weighed and then transferred back to test tubes filled with 10mL of fresh distilled water. This procedure was repeated every day for the first week and then once a week for the next six weeks.

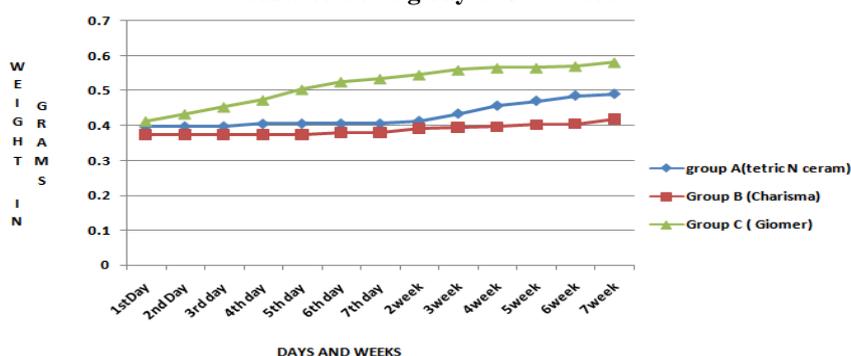
III. Statistical analysis and Results

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. All disc specimens exhibited percentage mass changes with time when immersed in distilled water, but percentage mass change gradually decreased with time (Table 1 and Graph 1).

Table 1: Intergroup readings of mean weights (gms) of three composite groups measured during day 1 to 7th week

	No. of specimens per group	Group A (Tetric N ceram)	Group B (Charisma)	Group C (Giomer)
1stDay	10	0.3962	0.3742	0.4123
2nd Day	10	0.3972	0.3743	0.4326
3rd day	10	0.3973	0.3743	0.453
4th day	10	0.4046	0.3745	0.473
5th day	10	0.405	0.375	0.5032
6th day	10	0.4051	0.38	0.52536
7th day	10	0.4053	0.381	0.5341
2week	10	0.413	0.392	0.545
3week	10	0.434	0.395	0.559
4week	10	0.457	0.3971	0.565
5week	10	0.471	0.403	0.5652
6week	10	0.486	0.4051	0.57
7week	10	0.491	0.419	0.581
Mean		0.4279	0.3880	0.5168
Standard deviation		0.036	0.015	0.057

Graph 1: Line graph showing intergroup comparison of mean weights (gms) of three composite groups measured during day 1 to 7th week



There was a significant difference in water absorption between Giomer and Charisma at all times, while there was no significant difference between Charisma and Tetric N Ceram. (Table 2)

For intragroup comparison Students t- test was used. Statistical analysis of data using t-test between the groups showed that there was highly significant difference in water absorption with $p < 0.001$. (Table 3)

Giomer showed the maximum amount of water absorption at all times, however least amount of weight change was observed in Charisma making it the most stable material.

Table 2: One way Anova test between groups A, B and C

Source	sum of squares SS	degrees of freedom v	mean square MS	F statistic	p-value
Between the groups	0.1322	2	0.0661		
Within the groups	0.2001	38	0.0053	12.5579	0.000065
TOTAL	0.3323	40			** $p < .0001$

Table 3: Students t test showing comparison of mean weights (gms) of three composite groups measured during day 1 to 7th week

GROUPS	MEAN DIFFERENCE	STD. ERROR	95% CI FOR MEAN DIFFERENCE		T	P
			LOWER LIMIT	UPPER LIMIT		
GROUP A	0.0948	0.0113	0.0693	0.1203	37.59	<.0001
GROUP B	0.0448	0.0047	0.0342	0.0554	81.8	<.0001
GROUP C	0.1687	0.0180	0.1281	0.2093	28.67	<.0001

IV. Discussion

Saliva is a dilute fluid consisting of 99.5% of water, hence weight change of different composites was evaluated in water. The concentrations of dissolved solids (organic or inorganic) in saliva are characterized by wide variations, both between individual and within a single individual. Due to this variation, water was used as a test standard.³

The consequences of polymerization shrinkage in restorative dentistry have considerable effects like flexion and crack formation of the natural tooth structure or a break in the bond which will lead to the formation of gaps, micro leakage and the potential for caries formation.[8,9,10] The polymerization shrinkage stresses can be relieved by the hygroscopic expansion of the material. The expansion resulting from water absorption can be clinically desirable if it fully counteracts the effects of shrinkage. If the hygroscopic expansion exceeds the polymerization shrinkage, further stresses may be introduced into the tooth. There are several factors that influence water absorption, for instance the hydrophilicity of the polymer matrix, crosslinking density, fillers, porosity and solvents.[11] Viscosity of the monomer requires the addition of some diluent monomers, like TEGDMA. These monomers are associated with the presence of hydroxyl groups of Bis-GMA molecule, which also favor the increase of water absorption.[12,13]

Water molecules induce the degradation of composites via two mechanisms. Firstly, water molecules diffuse into the polymer network and occupy the free volume between polymer chains and microvoids, causing plasticization and swelling of polymer matrix and also initiate the chains scission causing monomer elution.

Secondly, the water molecules also tend to degrade the siloxane bonds (bond between silanol groups of the silica surface and the silane coupling agent) via a hydrolysis reaction, causing filler debonding.

These occurrences lead to the degradation or softening of resin composites which may diminish some physical and mechanical properties such as hardness, strength and modulus of elasticity. The more the filler content of the composite, lesser will be the water absorption. The proper the bonding of the coupling agent, lesser the water absorption.

The air-filled voids incorporated in the composite resin during the handling of the material manually, may lead to inhibition zones with unpolymerized materials, which may result in higher water absorption.[14] Also it can be hypothesized that these voids may be filled with water, thus increasing the weight.

The rate of water absorption also depends on the accessibility of water to the composite resin material.[15] The rate and degree of water absorption and stress relief in composite restoration will be much lower than those found in the in vitro studies in which, composite resin blocks or discs 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.[1] The study done by Knobloch et al. also showed maximum amount of water absorption in the first week of the experiment.[16] The study done by Keyf and Hegde et al also showed maximum amount of water absorption in the first week of the experiment.[17,18]

Within the limitations of this study, water absorption values of micro hybrid resin composites are significantly less than Nanohybrid resin composites and Giomer restorations. Microhybrid resin composites have the lowest degree of water absorption as it may be due to only hydrophobic monomers present in its resin matrix.

Regarding the highest degree of water absorption recorded with Beautifill II, that may be due to presence of pre-reacted glass polyacid zones which become part of the filler in the Giomer structure. It seems likely that these zones are responsible for generating the osmotic effect which leads to water absorption, swelling and pressure.[19]

Tetric N-Ceram showed higher water absorption, because the monomers in these materials are hydrophilic in nature due to the presence of polar groups in their structure which tends to be attracted by water molecules to form hydrogen bonding.

V. Conclusion

Within the limitation of this study, it has been shown that resin-composite specimens investigated were found to undergo progressive water absorption over a period of 7 weeks.

Charisma (Microhybrid composite) however, showed statistically the greatest stability in an aqueous environment. By contrast, Beautifill II (Giomer) and Tetric N-Ceram (Nanohybrid composite) were the least stable materials, due to the incorporation of hydrophilic monomers.

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