

Compressive Strength Evaluation of Giomer and Compomer Storage in Different Media

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Abstract

The aim of the study was to evaluate and compare the compressive strength of both the giomer and compomer after storage in two different storage media: ethanol and artificial saliva.

Two types of direct restorative materials of A3 shade were selected for this study: Compomer (Dyract extra Dentsply, Yourk , PA, USA) and Giomer (Beautiful-II, Shofu, San Marcos, CA, USA). Both compomer and giomer were placed in a mold of dimension 12 mm in height and 5 mm in diameter. Twenty specimens were prepared from each restorative material (total number of specimens was 40). Two types of storage media were selected for this study: 50% ethanol solution and artificial saliva. The materials were divided into 4 groups (n=10). G1 (giomer stored in ethanol); G2 (giomer stored in artificial saliva); G3 (compomer stored in ethanol) and G4 (compomer stored in artificial saliva). The samples were placed in the molds in 3 increments and the first two increments were cured for 40 seconds with bluephase light cure device. The last increment was covered with glass slide and cured also for 40 seconds. All samples were stored for 7 days in the selected solutions according to the previously mentioned groups. After storage the samples were placed in acrylic molds then submitted for compressive strength testing using Universal testing machine Testometric AX and were loaded (Cross-head speed 1.0 mm/min) until failure of the sample. Compressive strength values were recorded for each sample in MPa. Data was statistically analysed with one way ANOVA and t-test at 5% level of significance.

Statistical analysis of the data revealed that, there was a statistically significant difference between the 4 groups being tested ($p \leq 0.05$). The highest mean compressive strength values were recorded for compomer samples which were stored in artificial saliva followed by giomer samples which were stored in artificial saliva, giomer samples which were stored in ethanol solution, and compomer samples which were stored in ethanol solution which exhibited the least mean compressive strength value.

In general, storage of giomer and compomer in ethanol resulted in much more reduction in their compressive strength values compared to storage them in artificial saliva. Although there was insignificant difference in compressive strength values between storage of giomer and compomer in ethanol or artificial saliva but the compomer tend to be more sensitive to ethanol storage than giomer. On the contrary, giomer tend to be more sensitive to artificial saliva storage than compomer.

Clinical significance: Certain components in the mouth like alcohol or artificial saliva contain chemical or water components that might affect the compressive strength of certain direct restorative materials that might weaken the matrix/filler interface and consequently produce a negative effect on the general performance of the restoration in oral service.

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Introduction

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The objective of the use of any restorative material is to substitute the biological, functional and esthetic harmony of the lost tooth structure.¹ Evolution of restorative materials is imperative for better delivery of treatment. Thus the newer materials should exhibit significantly better properties than its predecessors.² Compressive

strength of a material is any important factor to be considered in relation to masticatory forces. This property is the resistance exhibited by a restorative material against intraoral compressive and tensile forces which are produced both in function and para function. It is the amount of stress required to distort the material in an arbitrary amount³ hence it is essential for a restorative material to exhibit good compressive strength.

During mastication, bite forces are applied on the occlusal area of the tooth. These bite forces comprise a vertical compression force and a lingual side compression force.⁴

In the oral environment, restorations are subjected to stresses from mastication action. These forces act on teeth and/ or material producing different reactions that lead to deformation, which can ultimately compromise their durability over time.^{5,6} It is important to introduce some concepts that are extremely relevant to understand the performance presented by such material under specific test conditions. This information will be useful to analyze possible reaction of such restorative dental material when clinically in service⁶ that's why in this study we will examine the compressive strength of two direct dental restorative materials (giomer and compomer) stored in two different storage medium: ethanol and artificial saliva to simulate oral environment.

The "giomer" is a unique class of restorative materials that have the distinguishing feature of a stable surface pre-reacted glass core (S-PRG) that is coated with an ionomer lining in a resin matrix. Giomer is a new type of fluoride releasing resin materials with "Pre Reacted Glass" or PRG has been introduced with claims of good color matching, decreased micro leakage and increased fluoride discharge as compared with other materials.⁷ This arrangement allows for protection of the glass core from moisture, giving it long-term esthetics and the durability of conventional composites with ion release and recharge.⁸

The fluoride release and rechargeability of giomer materials results in highly biocompatible restorations that resist plaque accumulation despite a less than ideal oral environment.⁹ The giomer line is versatile and complete with flowables, sealants, nanohybrids, and bulk-fill materials. Beautifil® II, Beautifil® Flow Plus, BeautiSealant, BeautiCem, and both Beautifil

bulk-fill materials (Shofu, www.shofu.com) provide a complete restorative system that was designed to meet esthetic demands of the profession while promoting long-term tissue health through sustained fluoride release.¹⁰

On the other hand, compomer is a tooth colored restorative materials which is a combination of both glass-ionomer cement and light activated resin composite. The material was introduced in the market 1994; it had been used because of its handling properties, esthetics, and fluoride release. They are used for restoring primary teeth and non-stress bearing cavities in permanent teeth. Moreover compomer has less fluoride release but better mechanical properties than the GIC; it's polyacid-modified resin composites with less mechanical properties than the composite but more fluoride release. Compomers are dental products marketed as a hybrid class of direct restorative dental materials in an attempt to combined benefits of composites (the "comp" in their name) and glass ionomers ("omer"). Based on a critical review of the literature, the author argues that "compomers" do not represent another class of dental materials but are merely a marketing name given to a dental composite.¹¹

Materials and methods

Two types of direct restorative materials of A3 shade were selected for this study: Giomer (Beautiful-II, Shofu, San Marcos, CA, USA) and compomer (Dyract extra Dentsply, Yourk, PA, USA). The summary of direct restorative materials used in this study (manufacturer's data) are listed in Table 1. Both compomer and giomer were placed in a nickel chromium mold of 12 mm in height and 5 mm in diameter which can be splitted easily into two pieces to remove the cylindrical giomer or compomer specimen after curing (Figure 1).

Twenty specimens were prepared from each restorative material (total number of specimens was 40). Two types of storage media were selected for this study: 0.05% Conc. ethanol solution and artificial saliva for medical and dental research (Pickering Laboratories, Lot No.702012, USA). The 40 (20 giomer and 20 compomer) samples were assigned into four groups (n=10) as the following:

- G1 (Giomer stored in ethanol)
- G2 (Giomer stored in artificial saliva)

G3 (Compomer stored in ethanol)
 G4 (Compomer stored in artificial saliva).

Each specimen was prepared by placing one glass slide covered with acetate celluloid strip under the mold bottom and compressing sufficient amount of material into the splitted mold in three increments; then compressing the third increment by a second glass slide with acetate celluloid strip in between and curing the specimen by making the curing tip in intimate contact with the acetate celluloid strips covering the top surfaces of both giomer or compomer specimens.

All the three increments were cured for 40 seconds with a bluephase C5 (LED) light curing device with an output of 600 mW/cm². All the samples were stored for 7 days in the selected solutions according to the previously mentioned groups. After storage the samples were fitted vertically in acrylic cylindrical blocks by making a shallow depression limited to the diameter of each sample to be ready for compressive strength testing with universal testing machine (Testometric / UK) with a crosshead speed of 1.0 mm/min.

Product	Brand	Manufacturer	Resin Composition	Filler composition
Compomer	Composan Glass	PROMEDICA, Neumünster, Germany	urethane dimethacrylate difunctional resin monomer Propoxylated BIS-GMA	fluro-alumino-silicate glass, silanized ytterbium trifluoride, spheroidal mixed oxide, silanized barium-fluorosilicate glass and zirconia/silica
Giomer	Beautiful-II LS	Shofu, Marcos USA	San CA, Bis-GMA, TEGDMA	S-PRG filler, Fluoroboro-Al-Silicate Glass filler, Nano Filler

Table 1: Summery of direct restorative materials used in this study (manufacturer's data).



Figure 1. The splitted nickel chromium mold used to prepare the specimens.

Each specimen was placed in such a way that its long axis parallel to the long axis of the testing head and each specimen was subjected

to compressive testing until failure (Figure 2). Compressive strength values were registered for each sample in MPa. Data was statistically analysed with one way ANOVA and t-test at 5% level of significance.



Figure 2. The position of the samples during compressive testing.

Results

Table (2) summarizes raw compressive strength values in MPa, means, and standard deviation of the four groups being tested. G4 exhibited the highest mean compressive strength values followed by G2, G1 and G3 exhibited the lowest mean compressive strength values (Figure 3). Analysis of data with one-way analysis of variance (ANOVA) revealed that, there was a statically significant difference ($p \leq 0.05$) in compressive strength values between the four groups as shown in Table 3. Further analysis of the data with t-test indicated that, there was a statistically significant difference in compressive strength values between all the 6 pairs of the four groups ($p \leq 0.05$) except between pair 4 (G2 X G3) and pair 6 (G3 X G4) that showed insignificant differences between them as shown Table 4.

Groups	G1	G2	G3	G4
Sample	Gio Eth.	Gio Sal.	Com Eth.	Com Sal.
1	116.4133	103.5	46.95918	105.2908
2	59.41327	116.4	56.61735	104.7908
3	109.449	118.8	92.78061	77.03571
4	117.1378	80.7	90.22959	71.64286
5	70.29592	93	73.80612	95.18367
6	47.89286	42.3	102.5867	97.18878
7	58.52041	60.5	71.82143	115.9082
8	81.37755	86.4	46.95408	114.4643
9	115.6633	104.6	41.81633	110.9592
10	82.80612	104	52.08673	93.12245
Mean	85.8969	91.0200	67.5658	98.5587
SD	26.90	24.4	21.87	14.99

Table 2. Raw compressive strength data in MPa, mean and SD of G1-G4.

Source of Variatio	SS	Df	MS	F	P-value	F crit
Between Groups	5225.207138	3	1741.736	3.444192	0.026676	2.866266
Within Groups	18205.28222	36	505.7023			
Total	23430.48936	39				

Table 3. One way analysis of variance (ANOVA) of the four groups.

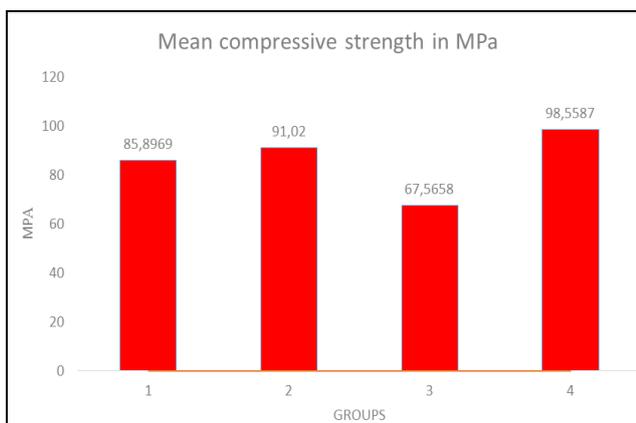


Figure 3. Bar chart representing mean compressive strength of each group in MPa.

Pair No.	Pair of groups	t	critical value
			2.101
1	G1 X G2	0.44	Not sig.
2	G1 X G3	1.67	Not sig.
3	G1 X G4	1.299	Not sig.
4	G2 X G3	2.26	sig.
5	G2 X G4	0.832	Not sig.
6	G3 X G4	3.69	sig.

Table 4. t-test of the compressive strength values between different pairs of the four groups.

Discussion

Compressive strength of a material is defined as the amount of stress required to distort the material in an arbitrary amount. It is calculated by dividing the maximum load by the original cross-sectional area of a specimen.¹² Compressive strength of a material can be considered one of the most important indicators for the mechanical property of any restorative material as chewing is one form of compressive strength behavior intraorally. The necessity for restorative material, with better compressive strength to withstand the stress of masticatory forces, leads to the latest advances in the restorative dentistry materials.^{13,14}

Water, saliva, drinks and food, these factors can reduce the physical and mechanical properties of resin based restorative materials intraorally.¹⁵ Giomer and compomer are softened by food-simulating liquids (FSL), especially ethanol. Aqueous ethanol-water solution simulates alcoholic liquids (beverages) while artificial saliva simulated the wet oral environment provided by saliva and water. That's why we selected artificial saliva and ethanol as a storage media in the current study to evaluate their negative effect on compomer and giomer from the aspect of compressive strength influence. In the current study, we found that compomer immersed in ethanol G3 achieved the least mean compressive strength values (67.56 MPa) among the four groups being tested (Figure 3) and this finding may be attributed to the fact that, alcohol is a good dimethacrylate solvent (urethane dimethacrylate in its composition Table 1) which can soften the matrix of compomer by

increased the amount of unreacted monomers and oligomers that diffuse out of the material as we mentioned before¹⁶⁻¹⁸ while giomer was less affected by ethanol G1 than compomer G3 (Figure 3) due to the absence of urethane dimethacrylate in its composition Table 1. The data of the current study also indicated that, giomer was more affected by artificial saliva G2 than compomer G4 (Figure 3) due to more degradation of its silane interface than that of compomer or due to its sensitivity to artificial saliva exposure due to incorporation of Pre Reacted Glass (S-PRG) filler which can be considered a unique filler type exclusively incorporated in the composition of Beautiful II LS giomer restorative material that tend to be affected by water exposure more than other filler types incorporated in Composan Glass compomer restorative material Table 1.¹⁹ Degradation of gomers also gets accelerated by water sorption²⁰ and cause harm to mechanical/physical properties such as compressive strength^{21,22} which occur essentially due to the following two reasons: first, bond between filler particles and silane break down hydrolytically, resulting in the debonding of the filler-resin matrix; second, water acts as a plasticiser which results in the softening of dental resins.²³ Water sorption initially caused a softening of the polymer resin component by swelling the network and reducing the frictional forces between the polymer chains.^{24, 25} Water sorption may eventually resulted in formation of microcracks through repeated sorption/desorption cycles. This is followed by hydrolytic degradation of the polymer with scission of the ester linkages and gradual deterioration of the infrastructure of the polymer over time.²⁶

Our findings agreed with the other studies, that compomer and giomer showed a general reduction in their mean compressive strength values when stored in ethanol compared to their artificial saliva storage, due to the fact that, ethanol can penetrate the polymer network causing expansion of the polymer structure, allowing release of residual monomers resulting in decreased mechanical properties.²⁷ The data of our study were in agreement a previous study concluded that, the strength of compomer and Giomer decreased drastically in ethanol solution, compared to artificial saliva.²⁸

Among the limitations of the current study, was the inability to register the compressive strength values of each specimen before and after exposure to the storage media to have a clear image about the net amount of compressive strength reduction for both restorative materials being tested science each specimen was destroyed completely during each compressive testing procedure.

The second limitation was using artificial saliva instead of natural saliva to simulate real oral conditions, which might be more difficult to be obtained and affecting group standardization negatively as considered another variable in the study.

Conclusions

Within the limits of this study we can conclude that, in general, storage of giomer and compomer in ethanol resulted in much more reduction in their compressive strength values compared to storage them in artificial saliva. Although there was insignificant difference in compressive strength values between storage of giomer and compomer in ethanol or artificial saliva (t-test:pairs 2&5 Table 4) but the compomer tend to be more sensitive to ethanol storage than giomer. On the contrary, giomer tend to be more sensitive to artificial saliva storage than compomer.

Clinical Significance

Certain components in the mouth like alcohol or artificial saliva contain chemical or water components that might affect the compressive strength of certain direct restorative materials that might weaken the matrix/filler interface and consequently produce a negative effect on the general performance of the restoration in oral service.

Declaration of Interest

The authors report no conflict of interest and the article is not funded or supported by any research grant.

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