Research Article

Evaluation of compressive strength of different types of composite resins: An *in vitro* study

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ABSTRACT

Aim: The aim of this study is to compare the compressive strength of different composite resins (Coltene SwissTEC, Ivoclar Tetric EvoCeram, and SHOFU Beautifil II). **Background:** The purpose of a dental restorative material is to simulate the biological, functional, and esthetic properties of a healthy tooth structure. Composite resins, due to their high esthetic properties, are being increasingly used in the recent past. Mechanical properties of posterior composites have an important role in the efficacy and durability of the restored tooth. Compressive strength, being the most important mechanical property of posterior restorative materials, owes a great deal to assess the quality of a posterior restorative material. This study, therefore, aims to compare the compressive strength of recently developed composites and analyze any significant differences making one better than the other. **Materials and Methods:** In this *in vitro* study, three different types of composites are used as follows: Group A – SwissTEC, a hybrid composite (Coltene Whaledent, Inc.); Group B – Tetric EvoCeram, a nanocomposite (Ivoclar Vivadent Inc.); and Group C – Beautifil II, a nanocomposite with Giomer technology (SHOFU Dental Corp). Ten cylindrical samples of 6 mm height and 4 mm diameter of each group were made using a custom split plexiglass mold. The composites filled in the mold were photopolymerized using light-emitting diode light-curing unit and the cured samples were stored in water at 37°C for 48 h before testing. The compressive strength of the stored samples was tested using a universal testing machine (M/S Zwick GmbH & Co., Germany) at a crosshead speed of 1.0 mm/min. The compressive strength was calculated by dividing the maximum load with area of the samples. **Results:** Results were statistically analyzed using one-way analysis of variance with Tukey's *post hoc* test. Analysis showed that there was a statistically significant difference between the three groups ($P < 0.05$) and Giomer composite (Beautifil II) showed the highest compressive strength while the hybrid composite (SwissTEC) showed the least compressive strength. **Conclusion:** Within the limitations of the study, it can be concluded that Giomer exhibited superior compressive strength compared to the nanocomposite and hybrid composite.

KEY WORDS: Compressive strength, Giomer, Hybrid composite, Nanocomposite, Posterior composites, Surface pre-reacted glass-ionomer

INTRODUCTION

Replacing the biological, functional, and esthetics of a tooth structure is the definitive role of a dental restorative material. For more than 100 years, due to their mechanical properties, dental amalgam and gold alloys have been long used as restorative materials, especially in the posterior teeth. Although these metallic materials match the mechanical properties of natural teeth, they are not esthetic.[1] Dental composites have proven to be a very successful restorative material for the past 40 years. This material has undergone various transformations to improve its physical and mechanical properties, making it increasingly acceptable for dental restorations in the posterior teeth.[2]

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The advent of hybrid composites has completely revolutionized dentistry. These composites are made up of polymer groups (organic phase) reinforced by an inorganic phase, comprising 60% or more of the total content, composed of glasses of different compositions and sizes, with particle sizes ranging from 0.6 to 1 μm, and containing 0.04 μm sized colloidal silica. These hybrid composites make up a large majority of the composites currently used in dentistry and offer a variety of benefits including the availability of a wide range of colors and ability to

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mimic the dental structure, less curing shrinkage, low water absorption, excellent polishing and texturing properties, abrasion and wear very similar to that of tooth structure, similar thermal expansion coefficient to that of teeth, and different degrees of opacity and translucency in different tones and fluorescence.[3,4]

Lately, there have been several attempts to employ nanoparticle-sized fillers in dental composites, and some of these attempts have given esthetic, tooth-colored restorative materials called nanocomposites. Nanocomposites have proven to show superior compressive strength, fracture resistance, wear resistance, low polymerization shrinkage, high translucency, high polish retention, and esthetics.[5]

Giomer, one of the recent developments in composites, is based on pre-reacted filler technology (pre-reacted glass-ionomer [PRG]) where pre-reacted glass particles are incorporated in the resin matrix. PRG fillers are fabricated by acid-base reactions between fluoride-containing glass and polyacrylic acid in the presence of water to form a wet siliceous hydrogel. PRG technology is of two types, namely; full reaction type (FPRG) and surface reaction type (surface PRG [S-PRG]). With FPRG, the entire glass filler is reacted with polyacids while in S-PRG, only the surface of the glass filler is reacted and the glass core remains.[6,7] Thus, Giomer is the true hybridization of glass ionomer and composite resin. Giomer combines the fluoride release, recharge of glass ionomer, and the esthetics, physical, and handling properties of composite resins.[8]

The efficacy and durability of a restored tooth largely depend on the mechanical properties of the composite.[9] Compressive strength, being the most important mechanical property of them all, owes a great deal to the fracture resistance of the restored tooth and its ability to withstand the masticatory forces. A restorative dental material of lower compressive strength has a greater tendency to fail, fracture, and lead to loss of sound tooth structure.[10,11]

Research on the mechanical properties of restorative materials is of paramount importance clinically, especially when the material is to be applied in stress-bearing areas like posterior teeth. In literature, there exists very little knowledge comparing the mechanical properties of newer composites. Therefore, this study aims to investigate and compare the compressive strengths of SwissTEC, a hybrid composite (Coltene Whaledent, Inc.); Tetric EvoCeram, a nanocomposite (Ivoclar Vivadent Inc.); and Beautifil II, a Giomer nanocomposite (SHOFU Dental Corp).

MATERIALS AND METHODS

The present study includes three different types of composite resins, Group A – SwissTEC (Coltene Whaledent, Inc.), a hybrid composite (n = 10); Group B – Tetric EvoCeram (Ivoclar Vivadent Inc.), a nanocomposite (n = 10); and Group C – Beautifil II (SHOFU Dental Corp), a nanocomposite with Giomer technology (n = 10) [Table 1]. Ten cylindrical samples of each group were fabricated and subjected to compressive strength testing.

Specimen Fabrication

Composite resins of respective group were applied and packed inside custom plexiglass spilt mold [Figure 1] of dimensions 6 mm × 4 mm using incremental technique, and each layer was light cured according to manufacturer's instructions. The last increment of composites was covered with a Mylar strip. A glass slab (1 mm thick) was then placed over the composite and pressure was applied to force the material into the mold and to expel the excess material. After removing the glass slab, the composites were then light cured from above and bottom through the Mylar strip using the light-emitting diode (LED) light-curing unit. To have maximum curing, each specimen was post cured 10 min after preparation for 20 s with LED light in all directions.

After completion of the polymerization process, the specimens were conditioned for 48 h in distilled water at 37°C.

Compressive Strength Testing

The cylindrical specimens [Figure 2] were transferred on to the universal testing machine (M/S Zwick GmbH & Co., Germany) individually and subjected to compressive testing at crosshead speed of 1.0 mm/min. The compressive strength was calculated by dividing the maximum load with area of the samples.

Statistical Analysis

The data were statistically analyzed with the help of one-way analysis of variance (ANOVA) and Tukey's test. $P < 0.05$ was considered statistically significant.

RESULTS

Data received from the study were subjected to statistical analysis using one-way ANOVA and the intergroup comparison was done with the help of Tukey's test [Table 2]. Compressive strength of

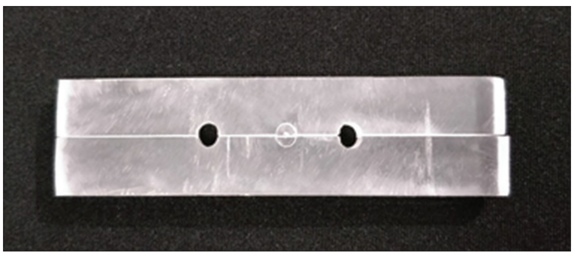

Figure 1: Custom mold

Table 1: Name and product details of the materials used

Material category	Brand name	Manufacturer	Filler volume (% weight)	Composition and particle size
Group A – hybrid composite	SwissTEC	Coltène, Whaledent Inc., Switzerland	77	Composition: Methacrylates, barium glass, silanized amorphous silica, hydrophobed Particle size: 1 µm
Group B – nanohybrid composite	Tetric EvoCeram	Ivoclar Vivadent Inc., Liechtenstein	80	Composition: Dimethacrylates, pre-polymer barium glass filler, ytterbium trifluoride, mixed oxide Particle size: 0.4–0.8 µm
Group C – Giomer (S-PRG filler) composite	Beautifil II	SHOFU Dental Corp, Kyoto, Japan	83.3	Giomer nanocomposite Composition: Methacrylates, multifunctional glass filler and S-PRG filler based on fluoroaluminosilicate glass Particle size: 0.01–4.0 µm

S-PRG: Surface pre-reacted glass-ionomer

Group C is significantly higher compared with that of Groups A and B ($P < 0.05$). There exists a significant difference in compressive strength observed between all three groups ($P < 0.05$). Group C showed the greatest compressive strength followed by Group B and Group A. The statistical analysis of intergroups is shown in Table 3. The graphical representation of results is shown in Figure 3.

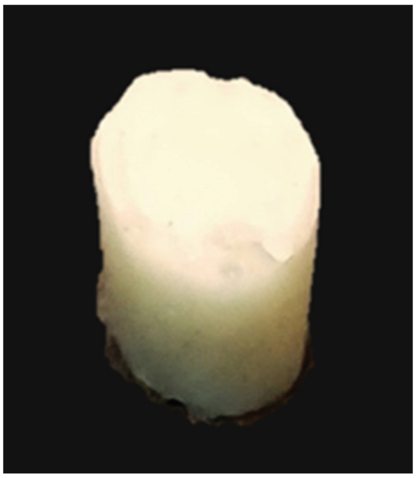

Figure 2: Fabricated specimen

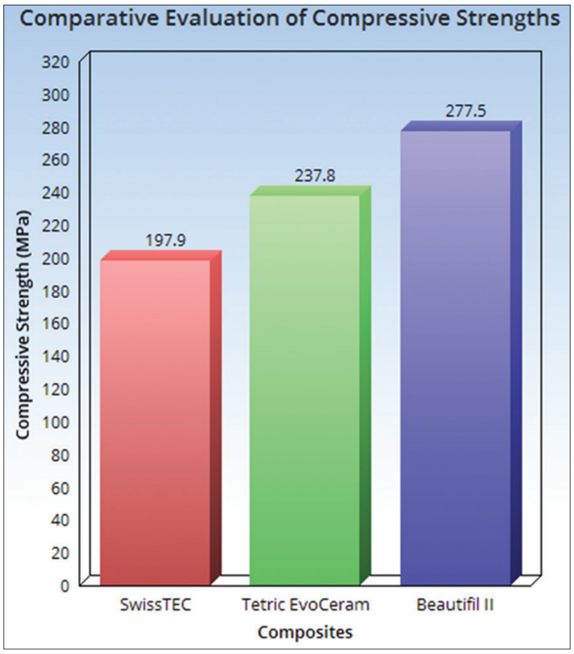

Figure 3: Graphical representation of compressive strengths

DISCUSSION

With the recent advancements and awareness regarding the esthetic requirements among the patient community, there is an ever-increasing necessity for the development of better tooth-colored restorative materials to replace missing tooth structure with enhanced esthetics and handling. In the past few decades, the growing demand for esthetic dentistry has led to the invention of composite resin materials for direct restorations with improved physical and mechanical properties, esthetics, and longevity.[1] Chemical constituents, filler load, size and shape of filler particles, method, and duration of curing are some of the factors that can affect the survival and longevity of composite resins.[12,13]

Hybrid composites can incorporate maximum amount of filler into a resin matrix due to its distribution of particle sizes. These hybrids are potentially superior because increased filler loading improves the stress transfer between particles in the composite.[14] Therefore, they are being used as tooth-colored restorative materials due to their fillers with different average particle sizes, exhibiting superior mechanical properties than its ancestral counterparts.

However, hybrid composites do not meet the increasing demand for high esthetics and functionality. To overcome these downsides, nanocomposites have been developed and marketed in recent years.[15] Nanocomposites possess the essential esthetic properties required for anterior restorations while at the same time have mechanical properties

Table 2: Mean and SD values for compressive strength

Groups	Number of specimens	Mean±SD
Group A	*n*=10	197.9±10.333
Group B	*n*=10	237.8±25.006
Group C	*n*=10	277.5±12.774

SD: Standard deviation

Table 3: Intergroup comparison of compressive strength between groups using Tukey's test

Groups	*P* value
A versus B	*P*=0.0001
A versus C	*P*=0.00
B versus C	*P*=0.0001

necessary to tolerate masticatory forces when used for posterior restorations. Literature shows that nanocomposite resins have high surface quality,[16] high polish retention,[17,18] low wear,[19] low shrinkage, and high strength.[20] Nanocomposites are believed to offer good wear resistance, strength, and ultimate esthetics due to their excellent surface quality, polish retention, and lustrous appearance.

One of the recent advancements in nanocomposite technology is Giomer. Giomer technology is based on PRG where pre-reacted glass particles are incorporated in the resin matrix. Giomer composites provide the fluoride release and recharge of glass ionomers and the esthetics, physical properties, and handling of composite resins.[21,22]

Compressive strength is used for the evaluation of the mechanical properties of dental restorative materials. Since most of the masticatory forces fall into the category of compressive forces, assessment of the compressive strength signifies the durability of restorative materials. Clinically relevant compressive strength values may be based on the compressive strength values of natural mineralized tissues. The compressive strength of enamel has been measured to be 384 MPa while the fracture strength of natural molars is around 305 MPa, while other teeth have generally lower fracture strengths. This value offers a good mechanical standard to select the optimal composite resin to be used to restore posterior teeth. The universal testing machine was employed in this study to obtain the maximum resistance to compression which was calculated by the original cross-sectional area of the test specimen and the maximum force applied.

Compressive strength of a material describes its response to loading.[23] Giomer composite showed the highest compressive strength, whereas the hybrid composite showed the least compressive strength. This disparity in the compressive strengths of the three materials is largely due to the different types of filler particles in the materials.[24,25]

SwissTEC is a fine hybrid composite with 77% filler volume. Tetric EvoCeram is a nanofilled composite (80% filler volume) with a combination of nanomer sized particles to the nanocluster formulations which reduces the interstitial spacing of the filler particles. This provides increased filler loading and better physical properties. Beautifil II is a Giomer nanocomposite with 83.3% filler volume that combines the increased filler loading of nanocomposites, due to reduced interstitial spacing of the filler particles, with the benefits of glass ionomer. Thus, the Giomer composite with its increased S-PRG filler content shows maximum compressive strength.

Other *in vitro* studies using Giomer composites also show that dentin remineralization occurs at the preparation surface adjacent to the Giomer.[26] Furthermore, S-PRG filler particles in Giomer were reported to act as a fluoride reservoir that recharges with brushing or rinsing with fluoridated products.[27] Giomers form an acid-resistant film, resist plaque formation as it inhibits bacterial adhesion. Due to their fundamental composite resin nature, Giomers also had superior surface finish than glass ionomers and resin-modified glass ionomer.[28]

The results of the present study showed that the Giomer composite showed superior compressive strength when compared to the nanocomposite and hybrid composite, signifying its superiority in terms of mechanical endurance as well, along with its already established superiority in terms of biocompatibility, its fluoride releasing, dentin remineralizing, anticariogenic properties, and high surface finish.

CONCLUSION

Within the limitations of the present study, the observations can be concluded as the maximum compressive strength was shown by Group C (Giomer) followed by Group B (nanocomposite) and the least was in Group A (hybrid composite).

Further, long-term clinical trials need to be carried out to establish the long-term durability and longevity of Giomer composites when compared to other composites.

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