In Vitro Evaluation of the Compressive Strength of Microhybrid and Nanocomposites

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Abstract

Aim: The purpose of this study was to evaluate and compare the compressive strength of microhybrid and nanocomposites.

Materials and Methods: 100 specimens of resin composite were fabricated using customized cylindrical teflon mould measuring 5mm x 5mm and were grouped with twenty five specimens in each group, Group I: Filtek Z250XT; Group II: CharmFil Plus; Group III: Tetric Ceram; and Group IV: Esthet X. They were covered with Mylar strip and were cured using LED light curing unit. Compressive strength was evaluated using Universal testing machine.

Statistical analysis: One way Anova and Boneferri Post hoc test were used for statistical analysis.

Results and Conclusion: Statistical analysis showed that compressive strength of nanocomposites is higher than microhybrids in the present study. Also, it was observed that CharmFill Plus showed highest compressive strength and Tetric Ceram showed the least compressive strength, among the tested materials.

Key Words: Compressive strength, Nanocomposite, Microhybrid composite

Introduction

The eventual objective of dental restorative material is to substitute the biological, functional and aesthetic properties of healthy tooth structure. For more than a century, dental amalgam and gold alloys have been used as dental restorative materials, especially in posterior teeth, because their mechanical properties replicate those of natural teeth; however, these metallic materials are not aesthetic [1,2]. With the introduction of composites in dentistry over four decades ago, the issue of aesthetics has been overcome to a certain extent. Composites have an edge over other restorative materials as they offer advantages of easy handling, better aesthetics and relatively low cost [3,4]. Although considerable improvements have been made in the properties of dental resin composite since their introduction, however, major developments come from improvements in filler systems. Resin composites have undergone through generations of traditional macrofilled composites, microfilled, hybrid, microhybrid, nanocomposites and nanohybrids [1,2].

None of the composite materials have been able to meet the dual requirement of functional needs of posterior restorations and the superior aesthetics required for anterior restorations. Nanocomposites thus have been introduced to serve these functional needs through the application of nanotechnology [2]. Nanocomposites have improved mechanical properties i.e. better compressive strength, diametrical tensile strength, fracture resistance, wear resistance, low polymerization shrinkage, high translucency, high polish retention and better aesthetics [2].

The aim of the present study was to evaluate and compare the compressive strength of microhybrid and nanocomposites.

Materials and Methods

The methodology is based on the methodology used for a similar study done by Hegde et al. [2]. The study sample consisted of 100 specimens. Four groups were made of four different composite materials having 25 specimens in each group. All the specimens were fabricated using teflon mould measuring 5 mm × 5 mm.

Composite resins used in this study were grouped as follows: Group I: Filtek Z250XT (nanocomposites, 3M ESPE, St. Paul, Minnesota, USA; composition: surface-modified zirconia/silica with a median particle size of approximately 3 microns or less, non-agglomerated/non-aggregated 20 nanometer surface-modified silica particles); Group II: CharmFil Plus (nanocomposites, Dentkist, Inc. Korea); Group III: Tetric Ceram (microhybrid, Ivoclar Vivadent, Schaan, Liechtenstein; composition; monomer matrix consists of Bis-GMA, urethane dimethacrylate and decandiol dimethacrylate (19 wt%), the fillers are composed of barium glass, Ba-Al-fluoro-silicate glass, ytterbium trifluoride, highly dispersed silicon dioxide and speroid mixed oxide (81 wt%)); and Group IV: Esthet X (microhybrid, Dentsply, York, Pennsylvania, USA; composition: Bis-GMA adduct, a Bis-EMA adduct, and triethylene glycol dimethacrylate, camphorquinone, photoinitiator, stabilizer, pigments).

The composite resins were placed in cylindrical recesses and were covered with a mylar strip. A glass slide (1mm thick)

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was then placed over composites and pressure was applied to accommodate the material into the mold and to extrude excess material. After removing the glass slide, the composites were then irradiated from the top and bottom surfaces through the mylar strip as per the manufactures instructions using the using the LED light curing unit (Kerr, West Collins, CA, USA). The specimens were taken out of the Teflon mould and light cured in the middle of the specimen at opposing sides. In total, 100 specimens were fabricated according to the grouping done. Study was performed in controlled temperature by keeping it in distilled water bath for 24h at 37°C.

All specimens were transferred to the universal Instron testing machine individually and subjected to compressive strength analysis at crosshead speed of 1.0mm/min.

Results

Statistical analysis was drawn using descriptive statistics and inter group comparison was done using Boneferri Post hoc test (P value>0.05 statistically non-significant). The mean and standard deviation values obtained for various study groups have been summarized in *Table 1*. It was observed that CharmFil Plus had the highest compressive strength, followed by Filtek Z250 XT and Esthet X, whereas Tetric Ceram showed minimum compressive strength.

On comparing the compressive strength between the groups using Boneferri Post hoc test, it was found that group III differed significantly with groups I, II, and IV. However, there was no statistically significant difference between group II and groups I and IV; group I and group IV [*Table 2*].

Discussion

With the evolutionary development of filling materials, there is an ever increasing need for better tooth-colored restorative materials to replace missing tooth structure and to modify tooth colour and contour, thus enhancing facial aesthetics [5]. During the last few decades, the increasing demand for esthetic dentistry has led to the development of resin composite materials for direct restorations with improved physical and mechanical properties, esthetics and durability [2]. The most traditional dental composites for restorative purposes are hybrid and microfill types. Hybrids offer intermediate esthetic properties but excellent mechanical properties by the incorporation of fillers with different average particle sizes. Microfill composites were launched in the market to overcome the problems of poor esthetic properties. Unfortunately the mechanical properties are considered low for application in regions of high occlusal force. Based on the definition "nanoscale bulk technology" new classes of dental composites, so-called nanocomposites, have been developed and marketed during recent years [6].

Nanocomposites are available as nanohybrid types containing milled glass fillers and discrete nanoparticles (40–50 nm) and as nanofill types, containing both nano-sized filler particles, called nanomers and agglomerations of these particles described as "nanoclusters". The nanoclusters provide a distinct reinforcing mechanism compared with the microfill or nanohybrid systems resulting in significant improvements to the strength and reliability [6]. Nanocomposites possess a combination of favourable properties of hybrid and microfilled composites. They also exhibit optimal aesthetic properties and therefore are good candidates for anterior restorations. At the same time, they show suitable mechanical properties which make them good alternatives for posterior restorations as well. Composite resins manufactured using nanotechnology have high translucency, polishability and polish retention similar to those of microfills. Their physical properties and wear resistance are comparable with those of hybrid composites [7].

Compressive strength is significantly essential because in clinical setting, the restorations are subjected to endless combinations of forces and moments which result in the development of compressive, tensile and shear stresses. All these factors tend to influence the durability of the restoration [2]. Thus with this background in mind, the present study was undertaken to compare and evaluate the compressive strength of nanocomposite and microhybrid composite. Universal Instron testing machine was used for measuring compressive strength.

Filtek Z250 XT is a visible light-activated nanohybrid composite designed for use in both anterior and posterior restorations [8]. It consists of a combination of nanomer sized particles to the nano cluster formulations which minimizes the interstitial spacing of the filler particles. This provides increased filler loading capacity, good physical properties when compared to composites containing only nanoclusters. Average filler particle size is 5-20nm [2]. CharmFil Plus is a light curing composite resin. Because it has a nano-filler component, thus it possess a good depth of cure, low shrinkage, low absorption, good strength, excellent mechanical properties and good biocompatibility. It is suitable for esthetic restorations and filing in all cavities cases (Class I-V) because its hardness and abrasion are very similar to natural teeth [9].

Tetric Ceram is a type of microhybrid composite which is light curable, with fine radiopaque particle for the restorative purposes [2]. Esthet X has been well established worldwide in the universal composite market as it combines the following features: excellent physical properties for long lasting restorations, excellent aesthetic results due to the complete selection of shades and opacities and excellent sculpting, non sticky handling of the composite [10].

The results of the present study revealed that CharmFil Plus had the highest compressive strength, followed by Filtek Z250 XT and Esthet X, whereas Tetric Ceram

Table 1. *Mean and standard deviation values for compressive strength.*

Group (number of specimens)	Mean ± Standard Deviation	95% confidence interval		Minimum	Maximum
		Lower	Upper		
I(25)	209.89 ± 19.88	198.55	221.22	167.87	250.21
II(25)	211.84 ± 21.22	200.12	223.56	151.86	270.89
III(25)	167.13 ± 24.66	155.67	178.59	130.21	220.23
1V(25)	206.17 ± 18.77	195.53	216.82	180.12	234.57

Table 2. *Multiple comparisons using Bonferroni Post Hoc Tests.*

(I) Group	(J) Group	Mean Difference(I-J)	P value*
III	I	-38.21	0.000
	II	-41.56	0.000
	IV	-37.25	0.000
II	I	-4.31	1.000
	IV	-3.12	1.000
I	IV	-2.34	1.000

*****P value>0.05 statistically non-significant.

showed minimum compressive strength. On comparing the compressive strength between the groups, it was found that CharmFil Plus showed highest compressive strength. The results of the present study are in accordance with the studies done by Lu et al. [1], Hegde et al. [2], Mitra et al. [11] and Beun et al. [12]. But the results obtained in this study are in contrast to the results obtained the study done by Moezzyzadesh et al. [7], who showed that hybrid composite resins have higher compressive strength as compared to nanocomposites. The difference in the results may be due to the different composite resins in different studies.

The results of the present study, higher compressive strength of nanocomposites as compared to microhybrid composites, reinforce the belief that nanocomposites have great mechanical properties [7]. The results of our study showed that for the compressive strength, group III differed significantly with groups I, II, and IV. However, there was no statistically significant difference between group II and groups I and IV; group I and group IV. The differences obtained between the various study groups could be explained by the nanofiller content (wt %). Micro hybrid composite (Tetric Ceram) has 50 wt% of inorganic phase compared to 80 wt% for the nano filled. Nano fillers have higher contact surface with the organic phase when compared to mini filled composites, consequently improving the material strength [2].

The performance of composite depends on type of filler, composition of resin, filler matrix adhesion and curing conditions (Pallav et al. [13], Watts et al. [14], Lim et al. [15]). Mechanical behavior depends upon the concentration and particle size of the inorganic filler. Owing to the reduced dimension of the particles and to a wide size distribution, an increased filler load can be achieved in nanocomposites, without increasing their viscosity; and this result in better mechanical properties such as tensile strength, compressive strength and other mechanical properties [2].

Conclusion

From the findings of the present in vitro study; it was observed that nanocomposites have higher compressive strength as compared to microhybrid composites and among the materials under study, CharmFill Plus has highest compressive strength and Tetric Ceram has the least compressive strength.

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