

COMPARATIVE EVALUATION OF MECHANICAL PROPERTIES OF THREE RESIN COMPOSITE MATERIALS WITH DIFFERENT FILLER PARTICLE SIZES

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ABSTRACT

Aim: The aim of this study was to evaluate and compare the mechanical properties of three resin composites core materials with different filler particle sizes.

Materials and methods: nanofilled (Filtek Z350 XT , 3M, ESPE USA), microhybrid (Te Econom, Ivoclar, Vivadent, India) and nanohybrid (Nexcomp, Meta biomed, korea) resin composites were used during this study. Mechanical properties regarding the compressive strength, diametral tensile strength and surface hardness were tested. Data were statistically analyzed using one-way Analysis of Variance and Tukey HSD test.

Results: The nanofilled type revealed the highest significant compressive and diametral tensile strength values while the nanohybrid type showed the least significant hardness values.

Conclusions: the tested nanofilled resin composite type is more appropriate for use as core material compared to the other tested types.

KEYWORDS: Core composite, nanofilled composite, microhybrid composite, nanohybrid composite, compressive strength, tensile strength, hardness.

INTRODUCTION

Recently, more than half of the posterior restorations depend on resin composites. Unfortunately, the need of these restorations in attention to mechanical properties leave a spacious room for more improvements, especially with attention to their difference in thermal expansion, polymerization shrinkage, polymerization stresses in addition to wear resistance, marginal leakage, and toxicity⁽¹⁾.

Strength is an important value for choice of a core material; it should allow sufficient tensile and compressive strength (CS) to resist multidirectional masticatory forces. This will provide better resistance and more uniform stress distribution, with less tensile or compressive failure.⁽²⁻⁵⁾.

Dental resin composites have been classified mainly according to their average size of the inorganic fillers⁽⁶⁾. Nanocomposites, have been introduced in the market for their claimed good

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mechanical properties, superior polishability, high wear resistance, excellent optical features and low polymerization shrinkage. The nanohybrid types encompass mainly milled glass fillers and isolated nanoparticles. The nanofilled types, on the other hand contain discrete nano filler particles and agglomerated particles “nanoclusters”, to provide reinforcement mechanism improving their strength compared to other composite types. Other classification methods of composite resin were proposed, due to differences found in the mechanical properties within each group due to differences found in their composition. The mechanical behavior of their organic matrix was ignored despite of the proved direct influence on their mechanical performance. Therefore; this study was conducted to evaluate and compare the compressive strength, diametral tensile strength and hardness of three different composite core materials to certify differences in their properties.

MATERIALS AND METHODS

Three types of commercially available resin composite core materials were used in this study and are represented in **table (1)**

A total of 45 specimens were prepared for this

study. The specimens were divided into three main groups according to resin composite filler type (n=15); first group: the nanofilled resin composite, second group: the microhybrid resin composite and the third group: nanohybrid resin composite. Each group were then subdivided into 3 subgroups (n=5) for compressive strength, diametral tensile and surface hardness testing.

Compressive strength testing (CS)

Five cylindrical specimens (6 x 4mm) of each composite type were prepared according to ADA specification no. 27⁽⁷⁾ using split Teflon molds. Each specimen was incrementally filled into the mold between two glass slabs covered with Mylar strip and photo-cured (Triad 2000, Dentsply, York, PA) for 40 sec. Excess material was removed using sofflex discs. The specimens were then incubated at 37 °C for 24 h before testing.

Compressive strength testing was done using Universal testing machine (Shimadzu 5KN Autograph AG-Xplus, Japan) with load cell 50N and cross head speed 0.5 cm/min⁽⁸⁾. The compressive strength (MPa) was automatically calculated using a software (TrapeziumX, Nexus 4000TM, Innovatest,model no.4503, Netherland) supplied by the machine.

TABLE (1)

Material	Manufacturer	Composition	Type
Filtek Z 350 XT	3M,ESPE, USA	Matrix: Bis-GMA, UDMA, Bis-EMA,TEGDMA, PEGDMA. Fillers: nanosilica, nano zirconia, nanoclusters (0.6-10 μm) (78.5 wt%)	Nanofilled
Te Econom	Ivoclar, Vivadent, India	Matrix: Dimethacrylate, TEGDMA Fillers: barium glass, ytterbium trifluoride, silicon dioxide(76% wt)	Microhybrid
Nexcomp	Meta, Biomed,Korea	Matrix: Bis-GMA, Bis-EMA,UDMA,TEGDMA Fillers: 0.04-0.7μm barium aluminum boro silicate (75% wt)	Nanohybrid

Diametral tensile strength testing (DTS)

Five disc specimens (6 x 3 mm) were prepared using split Teflon molds according to ADA specification no. 27⁽⁷⁾. Specimens were prepared as previously mentioned in compressive strength testing. Diametral tensile strength testing was done using universal testing machine (Shimadzu 5KN Autograph AG-Xplus, Japan) under compressive load at a cross head speed of 0.5cm/min and load cell 50N. Load to failure was recorded and the DTS (MPa) was calculated according to the following equation:

$$DTS = 2P/\pi DL$$

where P is the load at failure (N), D and L are diameter and height (mm) of specimens, respectively⁽⁸⁾.

Surface hardness testing

Five disc specimens (5 x 2mm) were prepared using split Teflon molds⁽⁹⁾. Surface hardness was tested using 100g force for 15 seconds dwell time using Vickers hardness tester (NEXUS 4000™, INNOVATEST, model no.4503, Netherlands). Three indentations were made randomly in each specimen's surface⁽⁹⁾.

Statistical analysis

The results were collected and tabulated. Statistical analysis was performed using IBM, SPSS® Statistics Version 20 for Windows (SPSS Inc., IBM Corporation; USA). One-way Analysis of Variance (ANOVA) and Tukey HSD test were used. The mean and standard deviation values were calculated. The significance level was set at P ≤ 0.05.

RESULTS

Compressive strength results

Results of compressive strength testing are shown in figure (1). The nanofilled resin

composite type revealed the highest significant compressive strength value (256.4MPa) compared to the microhybrid (179.3MPa) and the nanohybrid (143MPa) ($p < 0.05$). No significant difference was found between the microhybrid and nano hybrid types ($p = 0.27$).

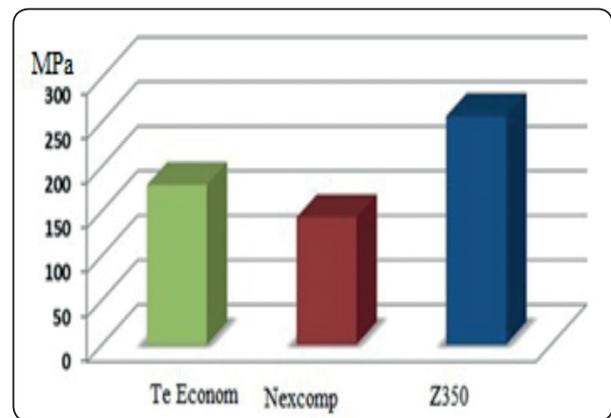


Fig. (1): Bar chart representing the compressive strength (MPa) among different tested materials

Diametral tensile strength (DTS) results

Results of diametral tensile strength results are shown in figure (2). The nanofilled resin composite showed significantly higher mean DTS value (48.9MPa) than nanohybrid type (36.2MPa), ($p < 0.05$). no significant difference was found between the microhybrid (42.6MPa) type the two other types; ($p = 0.3$).

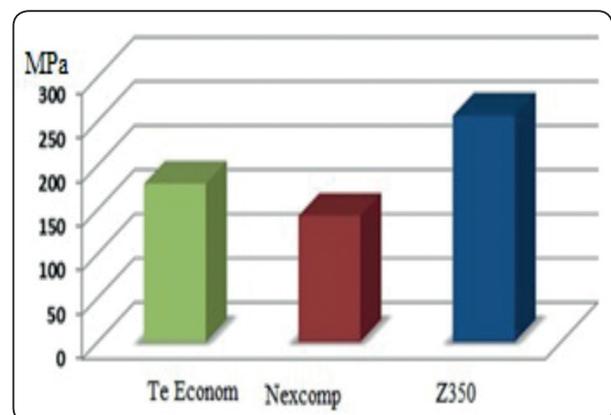


Fig. (2): Bar chart representing the DTS (MPa) among different tested materials

Surface hardness testing results:

The microhybrid type showed the highest insignificant Vickers hardness value (68.2 VHN) when compared to the nanofilled type (65.8 VHN), ($p=0.7$). least significant hardness value (44.6 VHN) was revealed by the nanohybrid type when compared to the microhybrid and the nanofilled types ($p<0.05$).

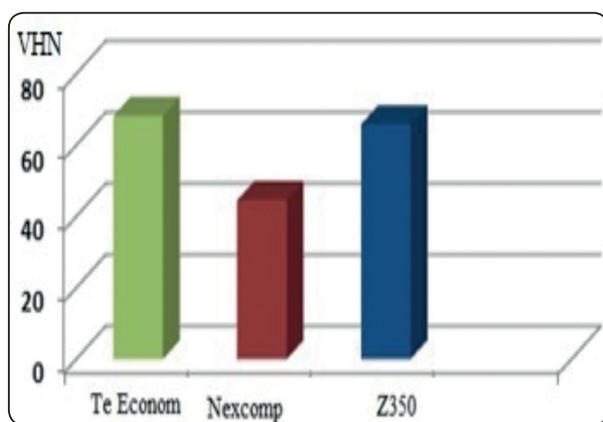


Fig. (3): Bar chart representing the hardness (VHN) among different tested materials

DISCUSSION

Nowadays, aesthetic restorations have become the first demand of most of the patients. Resin composites have the privilege performance as direct and indirect restorations; governed by maximum preservation of the tooth tissues and great esthetic properties. They also serve as a reliable core material against different subjected stresses in the oral cavity. Continuous developments in resin composites matrices and fillers in the material industry are going on to fulfill such target.

Tensile and compressive strengths testing measures the maximum strength, the filler and resin matrix could withstand and describes the cohesion of materials under tensile and compressive stresses⁽⁸⁾. Chemical composition of the resin matrix as well as filler particles size, distribution, shape and surface treatment are among the main factors affecting their

mechanical properties including the compressive strength of a restoration⁽¹⁰⁾. The resin matrix in the three commercial resin composites share the presence of Bis-GMA and TEGDMA monomers. However, the tested nano filled resin composite type has additional monomer type; PEGDMA added probably to decrease the matrix shrinkage, and to allow for maximum filler loading of nanosized particles (20 nm silica, 4-11nm Zr) and nanoclusters (0.06-10 μ m)⁽¹¹⁾. Moreover, the presence of spherical shape nanoparticles in the nanofilled composite have the privilege of increasing the strength of a restoration as stresses are more prone to concentrate at the sharp angles. This may explain the highest significant value of CS of nanofilled resin composite type. However both microhybrid resin composite and nanohybrid share the same cluster fillers size range (0.04-7 μ m) that may suggest the insignificant difference of CS between both types.

A positive correlation was found between compressive strength and diametral tensile strength where fracture results because of complex and tensile shear stresses within the material^(12,13). The diametral tensile strength test results; also showed significantly higher values of nanofilled composite type than the nano hybrid resin composite. The high filler loading of nanoparticles with their superior mechanical properties may be the reason for the obtained result. However, the insignificant difference of microhybrid resin composite compared to both nanofilled and nanohybrid types; may be due to the intermediate filler consistency of the hybrid resin composites. Furthermore, the hybrid filler particles are more liable for dislodgment out of the resin matrix that genuinely may affect their strength⁽¹⁰⁾.

According to *Davari et al*; 2012, the DTS of nano-filled composite was in the range of (26-32 MPa), with statistical insignificant difference in the compressive strength results between the tested nanofilled and nanohybrid composite resin types⁽¹⁴⁾. Such results proposed to be related to the effect of different resin matrix used in different

composite types. Studies reported that the addition of low molecular weight resins; e.g. TEGDMA and /or UEDMA to Bis-GMA increases the diametral tensile strength^(15,16).

Surface hardness testing of resin composite is a reliable test to evaluate the degree of conversion of resin matrix which is directly related to its wear resistance and stability in the oral environment⁽¹⁷⁾. Among factors that influence the hardness of the dental resin composites are; the resin type, shade, filler loading, curing time source of light, time of exposure and distance of radiation^(10,12). Large filler size proved to increase the light scattering efficiency from curing light, decreasing the degree of conversion hence; the hardness values⁽¹⁸⁻²⁰⁾. Such finding could explain the results obtained in the current study, where the tested nano hybrid type showed the lowest VHN, with insignificant difference between the tested Nanofilled and microhybrid composites types.

CONCLUSIONS

Within the limitation of the present investigation it could be concluded that; nanofilled resin composite had the highest mechanical strength results, adequate for use as a core material; while the nanohybrid resin composite was the least regarding the tested mechanical strength properties.

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