

## INFLUENCE OF COMPOSITE RESTORATIVE MATERIALS COMPOSITION ON THEIR DIAMETRAL TENSILE STRENGTH VALUES

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### Abstract

**Purpose:** To evaluate and compare the diametral tensile strength (DTS) values of the newly introduced nanofilled composites with the conventional types.

**Methods:** Eight types of dental restorative composites of A3 shade were selected in this study for (DTS) testing: Filtek Supreme XT (3M Espe), Z100 Restorative (3M Espe), Filtek P60 (3M Espe), Filtek Z250 (3M Espe), Premise (Kerr), Point 4(Kerr), Herculite classic (Kerr), and Solitaire (Heraeus-Kulzer). Eight groups of specimens (n = 10) were prepared for diametral tensile strength evaluation. Resin composite specimens were prepared by incremental (two increments) insertion of composite into a circular nickel-chromium split mold of 6 mm in inner diameter and 3 mm in height and cured for 40 seconds for each increment of composite thickness. Specimens were placed into a dark bottle containing distilled water at 37°C for 7 days. DTS tests were performed in a Universal Testing Machine (0.5 mm/min).

**Results:** The results showed that the highest DTS values were found for the Premise composite followed by Point 4, Herculite, Solitaire, Z250, Supreme XT, P60 and Z100 which exhibited the lowest DTS values.

**Conclusion:** The composition of light activated composites significantly influences their DTS values. (*Journal of International Dental and Medical Research 2009; 2: (3), pp. 67-70*)

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### Introduction

Composite resin technology has continuously evolved since its introduction by Bowen (1963) (1) as a reinforced Bis-GMA system. A major breakthrough in composite technology was the development of photo-curable resins (2). A continued development resulted in materials with reduced particle size and increased filler loading that significantly improved the universal applicability of light-cured composite resins (3). Resin composites are widely used in dentistry and have become one of the most commonly used esthetic restorative materials because of their adequate strength, excellent esthetics, moderate cost compared with ceramics, ability to be bonded to tooth structure (4), improvements in composition, simplification of the adhesive procedures and the

decline in amalgam usage due to fear of mercury toxicity (5) represent additional advantages. During the last decades, the increasing demand for esthetic dentistry have led to the development of resin composite materials for direct restorations with improved physical and mechanical properties, esthetics and durability. The latest development in the field has been the introduction of nanofilled materials by combining nanometric particles and nanoclusters in a conventional resin matrix. Nanofilled materials are believed to offer excellent wear resistance, strength and ultimate esthetics due to their exceptional polishability, polish retention and lustrous appearance (6).

The essence of nanotechnology is in the creation and utilization of materials and devices at the level of atoms, molecules, and supramolecular structures, and in the exploitation of unique properties and phenomena of particles (7) with size ranging from 0.1 to 100 nanometers. The compressive and diametral strengths and the fracture resistance of the nanocomposite materials are equivalent to or higher than those of the other commercial composites tested (hybrids, microhybrids and microfill) (8). Nanofilled resin

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composites show mechanical properties at least as good as those of universal hybrids and could thus be used for the same clinical indications as well as for anterior restorations due to their high aesthetic properties (9).

### Materials and Methods

Eight commercially available light-cured composite resin restorative materials, namely, Filtek Supreme XT (3M-ESPE, St. Paul, MN, USA), Z100 Restorative (3M-ESPE, St. Paul, MN, USA), Filtek P60 (3M-ESPE, St. Paul, MN, USA), Filtek Z250 (3M-ESPE, St. Paul, MN, USA), Premise (Kerr, orange, CA 92867, U.S.A.), Point 4 (Kerr, Italia S.p.A.), Herculite classic (Kerr, Orange CA 92867, U.S.A.), and Solitaire (Heraeus Kulzer GmbH, D-63450 Hanau, Germany), shade A3, were tested. These materials are described in Table 1. The materials were handled according to the manufacturer's instructions.

Eighty composite specimens were prepared forming 8 experimental groups (G1-G8) (n=10) of each composite type selected respectively.



Figure 1. Composite matrix used in this study.

Composition				
Composite	Organic/inorganic Matrix	Inorganic Filler	Filler size	% in Volume (Filler)
Supreme (XT) nanofilled	BIS-GMA, BISEMA, UDMA and TEGDMA	Zirconia/Silica	(clusters of 0.6 to 1.4 µm particules of 5 to 20 nm)	57.7*
Z100	Bis-GMA and TEGDMA	Zirconia/Silica	0.01-3.5 µm	66*
P60	Bis-GMA, UEDMA and Bis-EMA	Zirconia/Silica	0.01-3.5 µm	61*
Z250	Bis-GMA, UEDMA and Bis-EMA	Zirconia/Silica	0.19 – 3.3 µm	60*
Premise nanofilled	The ethoxylated Bis-GMA	Non-agglomerated silica nanoparticles, prepolymerized filler, 0.4 micron barium glass	0.02 µm	69%*
Point 4	Bis-GMA	barium aluminoborosilicate glass, fumed silicon dioxide	0.4 µm	57.2%*
Herculite classic	Bis-GMA, TEGDMA	Barium glass and silicon dioxide	0.6 µm	59%*
Solitaire packable	Bis-GMA, PENTA, HTMA, ETMA	Boro-Silicate, Aluminum, Barium and SiO2	2.0-20 µm	90%*

\* Manufacturer's information

Table 1. Composition of composite resins evaluated in the present study.

The composites were placed into nickel-chromium split matrixes (h = 3 mm, d = 6 mm) (Figure 1) according to ADA specification #27, item 5., with increments of 1.5 mm in thickness, cured after placement of each increment with bluephase C5 (LED) light-curing device (Ivoclar, Vivadent AG, FL-9494 Schaan/Liechtenstein, Austria) for 40 seconds. The matrix was placed on a glass slab with a clear polyester strip for material's placement. The last increment was also covered with a polyester strip and pressed with a glass slab to accommodate the composite into the matrix.

The fully cured composite specimens were removed from the spited mold and stored in a light-proof container with distilled water at 37°C for 1 week.

Diametral tensile strength testing was performed using a Universal Testing Machine (Instron Corporation, Canton, MA) at a crosshead speed of 0.5 mm/min. Specimens were positioned vertically on the testing machine base and subjected to compressive load until failure.

The diametral tensile strength (DTS) was calculated using the equation:  $DTS = \frac{2L}{\pi Dh}$ , where L is the failure load, D the diameter, and h the height of the specimen (Figure 2).

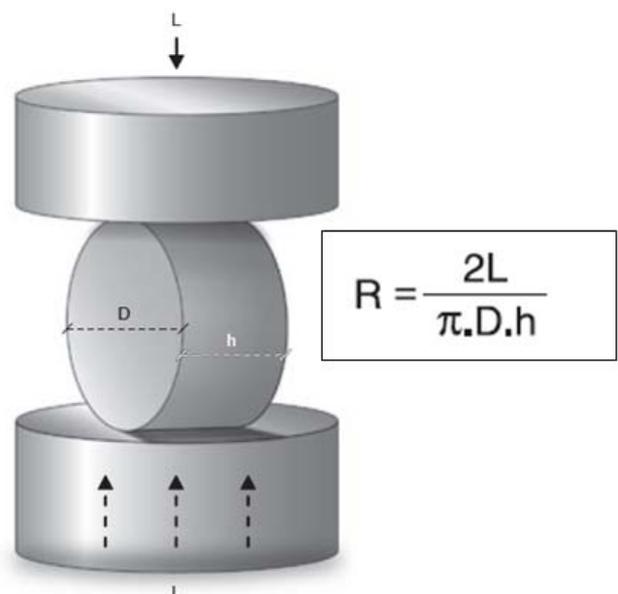


Figure 2. Diagram of DTS test. R=DTS, L: load, D: diameter, h: height.

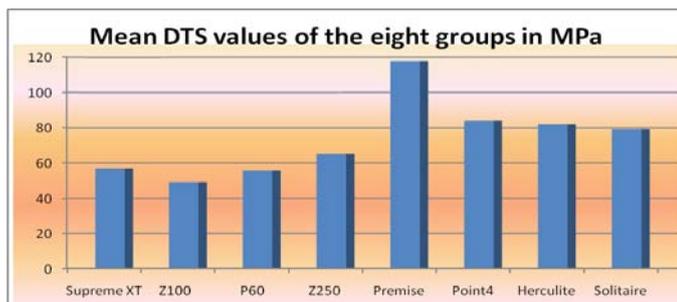
Mean DTS values were expressed in MPa and data were analyzed by one-way ANOVA, followed by t- test at the 0.05 level of significance.

### Results

Mean DTS values in MPa, standard deviation of the tested groups are presented in Table 2. The results showed that the highest DTS values were found for the Premise composite followed by Point 4, Herculite, Solitaire, Z250, Supreme XT, P60 and Z100 which exhibited the lowest DTS values (Figure 3).

Composite type	Supreme XT	Z100	P60	Z250	Premise	Point 4	Herculite	Solitaire
Mean	56.89	49.09	55.83	65.35	117.79	83.82	82.04	79.15
SD	7.15	9.62	8.47	9.88	40.83	17.01	20.69	25.41

**Table 2.** Mean DTS values for the experimental groups (MPa).



**Figure 3.** Mean DTS values (MPa) for the tested composites.

The values obtained from the DTS testing were subjected to one way analysis of variance (ANOVA), which revealed a significant difference ( $P < 0.05$ ) among the experimental groups (Tables 3). Further analysis of the data was needed to examine the differences between different pairs of groups using the ( t-test analysis ) and indicated that , all pairs showed statistically significant differences (  $P < 0.05$  ) except pairs 2, 3, 8, 21, 22, 26, 27 and 28 showed statistically insignificant differences (  $P > 0.05$  ) Table (4).

### Discussion

The DTS is a mechanical property used to understand the behavior of brittle materials when exposed to tensile stress commonly observed in anterior restorations. DTS is an acceptable and common test for dental composites (10-13).

The results of this study demonstrated that, there were significant differences between one nanofilled composite (Premise) and all the other composites being tested in this study including the

other nanofilled composite Supreme XT (Table 4).

Monomeric composition affects the degree of conversion of dental composites and quality of the restoration (14-17). In this study, the incorporation of ethoxylated Bis-GMA monomer (Table 1) could be one of the most important factors related to the relatively high average DTS values for Premise composite compared to other conventional composites or to other nanofilled composite (Supreme XT) (Figure 3). This study revealed that, composites that their organic matrix composed from only one type of monomer in a form of the ethoxylated Bis-GMA or Bis-GMA (Premise and Point4), exhibited higher DTS values compared to other composites being tested in this study that incorporating more than principal monomer and/or diluent monomers in their organic matrixes composition (Figure 3) (Table 1). In addition to the previously mentioned causes, Premise composite is the only composite in this study which showed a unique difference from the other composites being tested in this study in its incorporation of prepolymerized filler and could be considered an additional factor for its high mean DTS values (Table 1). This study also revealed that, there was no correlation found between the percentage of filler loading by volume and the DTS values (Table 1) and this finding does not coincide with the findings of Chung & Greener (14) in that, an increase of filler content in resin matrix improves DTS values. Finally, this study demonstrated an inverse relationship between the average filler particle size and DTS values of the tested composites (0.02  $\mu\text{m}$  for Premise nanofilled composite) (Table 1) and Supreme (XT) nanofilled composite (clusters of 0.6 to 1.4  $\mu\text{m}$ ) or other conventional composites being tested in this study.

### Conclusions

- 1- The DTS of resin composites is mainly influenced by their organic monomer composition, prepolymerized filler and average filler particle size.
- 2- There was no correlation found between the percentage of filler loading by volume and the DTS values.

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Pair No.	Composites in pair	Sig.
1	Supreme X Z100	.004
2	Supreme X P60	.803
3	Supreme X Z250	.080
4	Supreme X Premise	.002
5	Supreme X Point4	.002
6	Supreme X Herculite	.008
7	Supreme X Solitaire	.022
8	Z100 X P60	.149
9	Z100 X Z250	.012
10	Z100 X Premise	.001
11	Z100 X Point4	.001
12	Z100 X Herculite	.003
13	Z100 X Solitaire	.013
14	P60 X Z250	.016
15	P60 X Premise	.002
16	P60 X Point4	.001
17	P60 X Herculite	.011
18	P60 X Solitaire	.027
19	Z250 X Premise	.006
20	Z250 X Point4	.017
21	Z250 X Herculite	.063
22	Z250 X Solitaire	.134
23	Premise X Point4	.045
24	Premise X Herculite	.003
25	Premise X Solitaire	.031
26	Point4 X Herculite	.825
27	Point4 X Solitaire	.584
28	Herculite X Solitaire	.774

Table 4. t-test of the differences between different pairs of groups.