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Comparison of Flexural & Compressive Strengths of Nano Hybrid Composites

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ABSTRACT
This study was conducted to evaluate the compressive strength & flexural strength of five nanohybrid dental composites. Cylindrical specimens (n=3) for compressive strength & rectangular shaped specimens (n=5) for flexural strength were made according to manufacturer's recommendations. Both tests were performed on a Universal Testing Machine (Star Testing System, India, Model No.STS 248) recording the fracture load (N). Strength values (MPa) were calculated and statistically analysed by One way ANOVA and F-tests ($p < 0.05$). The mean and standard deviation values (MPa) for compressive strength were Tetric N Ceram- 137.64±78.63, Charisma- 176.45±50.59, Z350-166.35±24.35, Brilliant NG-54.19±8.62 & Polofil NHT-143.57±64.99. The mean and standard deviation values (MPa) for flexural strength were Tetric N Ceram- 88.63 ± 28.77, Charisma- 83.45±28.77, Z350-102.52±26.54, Brilliant NG - 92.77±27.77 & Polofil NHT- 171.34±53.86. From the results, Charisma & Z350 showed higher $^{\delta}$t values than the other materials evaluated ($p < 0.05$). Also Polofil NHT showed higher $^{\delta}$f values than the other materials evaluated. These higher values among five types of nanohybrids may be due to variation in filler weight-volume & particle size.

Keywords:- *Compressive Strength, Flexural Strength, Nanohybrid, Universal Testing Machine.*

I. INTRODUCTION

Latest innovation in direct dental restorative materials is the amalgamation of the nanotechnology which is appreciative and control of material at dimension of approximately 1 – 100 nm [1]. Recent improvements in filler technology by manufacturers have allowed blends of both submicron particles (0.04 μm) and small particles (0.1 μm–1.0 μm) to be incorporated into a composite formulation. These materials are classified as micro-hybrid composites. The mixture of smaller particles distinguishes microhybrids from traditional hybrids and allows for a finer polish, along with improved handling. The desirable combination of strength and surface smoothness offers the clinician flexibility for use in posterior stress-bearing areas as well as anterior aesthetic areas. Although microhybrids offer superior strength, their polish ability is not better than a traditional microfiller composite resin.

The trend in the newer microhybrid materials is to maximize filler loading and minimize filler size. The latest version of microfilled hybrids has used nanofiller technology to create nanohybrid composite resins. Nanohybrids contain nanometre-sized filler particles (0.005–0.0l microns) throughout the resin matrix, in combination with a more conventional type filler technology. Nanohybrids are nothing but the universal composite resin with handling properties and polish ability of a microfilled composite and the strength and wear resistance of a traditional hybrid. These nanohybrids can be used in any situation similar to the microhybrids, with possibly a slight improvement in polishability because of the smaller particle size [2], [3].

The compressive strength, hardness, flexural strength and elastic modulus increase with the amount of inorganic fraction while the polymerization shrinkage is said to decrease. In

short, all important properties of composites are improved by using higher filler levels & reducing the particle size. [4]. There is no any research among five types of different nanohybrid composites giving the best compressive & flexural strength. So, the aim of this study is to analyze best values of compressive & flexural strength & hence to see the difference in filler weight, filler volume & particle size of studied composites. Also, filler composition affects to some extent on the mechanical properties of composites. Though nanohybrid composites give best results for anterior & posterior restorations, it is confusing for any clinician that to decide which type of nanohybrid should be used for a particular patient; hence this research is to give right decision.

II. MATERIALS & METHODS

A. Materials

Five dental nanohybrid composites have been studied in the present study, as shown in TableI

TABLE I
Composition Of The Five Different Types Of Light Activated Nanohybrid Composite Resins.
Product information is provided by manufacturers.I

Sr. No.	Composite Name & Shade	Manufacturer	Filler Fraction (Wt%, Vol. %)	Particle Size (µm)	Filler Composition
1	Tetric N Ceram (B2)	3MESPE[a] (USA)	78.5/59.5	0.6-10µm	BA glass, ytterbium trifluoride, mixed oxide, Sio_2.
2	Charisma Smile (A3)	Ivoclar Vivadent[a]	80.5/56	0.004-3µm	BA-Al-B-F-Si, glass, pyrogenic Sio_2
3	Filtek ™ Z350XT (C4 Dentin)	Haerious Kulzer[a]	78/58	0.02-2µm	Combination of agglomerated -Nonagglomerated Zr /Si cluster fillers.
4	Brilliant ™ NG (A2/B2)	Coltene Whaldent[a]	80/65	0.01-2.5µm	Dental glass, amorphous silica
5	Polofil NHT (A2)	Voco[a]	83/68	0.01-0.1 µm	Nano scaled particles with glass ceramic fillers.

B. Specimen Preparation

To perform the static compression tests (δt), 3 cylindrical specimens of 5 mm diameter and 5 mm height of each material were prepared according to the manufacturer's recommendations. By means of a two-part Teflon mould, each composite material was packed in bulk into the mould. A transparent strip of glass was applied across each end, and then the material was compressed between two glass plates to remove superfluous material. Glass plates were removed after ensuring the absence of porosity in specimens. The composites were cured for 40s or as per the manufacturer's instructions on each side to ensure adequate polymerization with a LED light curing unit (XL1500, 3M Dental Products, light intensity > 450 mW/cm^2) Afterwards, specimens were removed from their moulds. The specimens were then stored in distilled water at 37°C for 24h. The specimens are then polished by 1200 grit Emery Paper. The dimensions of specimens were checked using a digital calliper (Digimatic calliper, Mitutoyo Corp, Tokyo, Japan). After ensuring the perfectly finished surface of specimens, the following tests are carried out.

For the three-point flexural strength test (δf), bar-shaped specimens (n=5) of (25 ±1 mm x 2 ± 0.1 mm x 2 ± 0.1 mm) were fabricated from each composite resin. By means of a Putty Material, the mould of 25x2x2 is prepared. For this, a steel strip of dimensions 25x2x2 is placed in the flexible Putty material. After ensuring, the required dimensional mould, the composite resin was placed inside a mould positioned on a glass slab. A thin glass slab was positioned on the mould containing the material, to remove superfluous material. Glass plates were removed after ensuring the absence of porosity in specimens. The material were light cured by LED blue light, (XL1500, 3M Dental Products, light intensity > 450 mW/cm^2) for 20 or as per the manufacturer's instructions at each third of the upper and lower surfaces of the specimen. All specimens were removed from the mould. The dimensions of specimens were checked using a digital calliper (Digimatic calliper, Mitutoyo Corp., Tokyo, Japan). The specimens were then stored in distilled water at 37°C for 24 h.

C. Testing

For the compression test (δt), prepared specimens were placed with their long axes perpendicular to the applied compressive load on a Universal Testing Machine (Star Testing Systems, India, and Model No.STS 248) as shown in Fig.1, with a constant crosshead speed of 3mm/min. After each compressive test, the fracture load (P) in Newtons (N), Strength values (MPa) were calculated as per equation-1 and statistically analysed by one way ANOVA and F-tests. ($P \leq 0.05$). By substituting the values in equation (1) below, the resulting compressive strength for different no. of manufacturing brands of dental composites can be calculated.

$$\delta_t \equiv P \div A \quad (1)$$

$$\delta_t \equiv \mathrm{P} \div \pi r^2$$

Where,

P = Load of Fracture (in N)
r = Radius of specimens (2.5 mm) &
π=3.1416

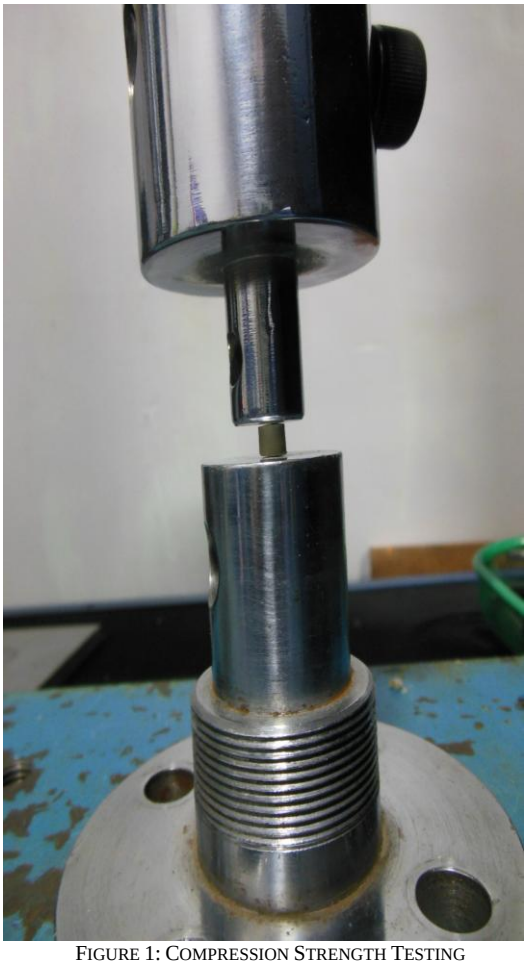

FIGURE 1: COMPRESSION STRENGTH TESTING

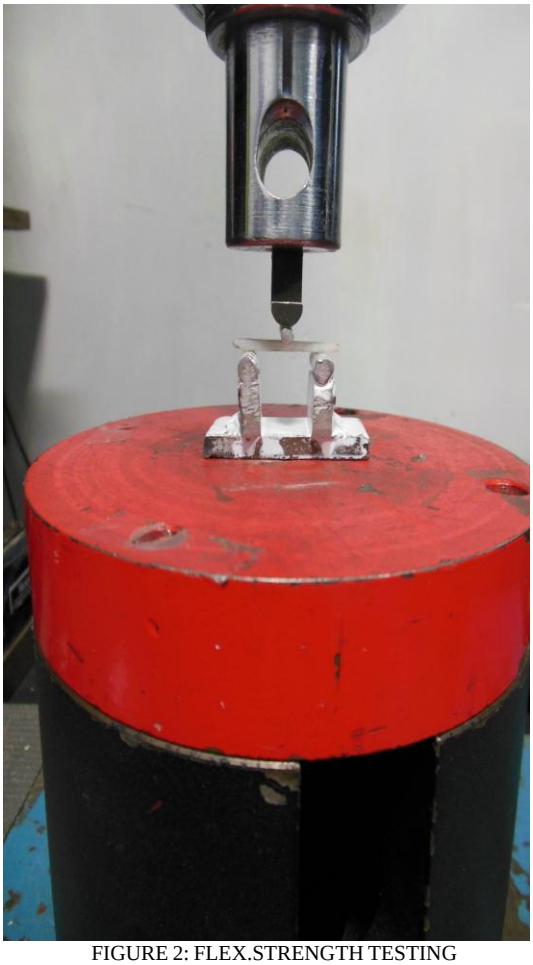

FIGURE 2: FLEX.STRENGTH TESTING

The $^{\delta}$f was measured using the 3-point bending test as shown in fig.2, in which bar shaped specimens were placed on a Universal Testing Machine (Star Testing Systems, India, and Model No.STS 248) with a constant cross-head speed of 3 mm/min. After each flexural test, the maximum fracture load (F in N) of each specimen was recorded, and the flexural strength ($^{\delta}$f), in MPa is calculated by formula-2. Also, the results were statistically analyzed by One way ANOVA (analysis of variance) and F-tests, at a significance level of 95%. By substituting the corresponding values in the equation (2) given below, the resulting flexural strength for different no. of manufacturing brands of dental composites can be calculated.

$$\delta_f \equiv 3Fl \div 2bh^2 \qquad (2)$$

Where,

l = distance between the supporting rollers (20mm),

b = specimen width (3 mm) &

h= specimen height (2 mm).

III. RESULTS & DISCUSSION

Table II lists the results of the mean and standard deviation values (MPa) for the compression strength ($^{\delta}$t) and the flexural strength ($^{\delta}$f). The mean value & standard deviation were calculated for each group of specimens. Analysis of Variance (ANOVA) & F-tests were used. Statistical significant was considered if $P < 0.05$. This was performed separately for each of the different mechanical properties. The mean $^{\delta}$f values for Polofil NHT and Z350 were significantly higher than those of the other materials investigated ($p < 0.05$), which may

be explained by the filler volume difference between these two materials (Table 1). There was no significant difference between the mean $^{\delta}$f values for Tetric N Ceram & Charisma. The mean $^{\delta}$t values for Charisma and Z350 were significantly higher than those of the other materials investigated ($p < 0.05$), indicating that these restorative materials support higher compressive load than the other materials. Also for Tetric N Ceram & Polofil NHT, there is no significant difference. Brilliant NG shows least $^{\delta}$t than remaining other materials.

TABLE II

MEAN & STANDARD DEVIATION VALUES

Brand Name (Manufacturer)	Flexural Strength (MPa) Mean S.D.	Compressive Strength (MPa) Mean S.D.
Tetric N Ceram	88.63 ± 28.77^{a}	137.65 ± 78.63^{A}
Charisma	88.63 ± 28.77^{a}	176.45 ± 50.59^{B}
Z350	102.52 ± 26.54^{b}	166.35 ± 24.35^{B}
Brilliant NG	92.77 ± 27.77^{a}	54.20 ± 8.62^{C}
Polofil NHT	171.34 ± 53.86^{c}	143.57 ± 64.99^{A}

Same lower & upper cases in the same column mean no statistically significant difference ($p < 0.05$).

IV. DISCUSSION

The most significant changes in commercial composites in recent years were modifications of the filler system [6]. The size of filler particles incorporated into the resin matrix of commercial composites has continuously decreased, resulting in nanohybrid and nanofilled materials with improved material properties. Nanohybrid composites are hybrid resin composites containing finely milled glass fillers and discrete nanoparticles or nanofillers in Prepolymerized filler form [7]. The performance of nanohybrid composites is material-dependent, which may be attributed to the fact that some composites with nanofillers added to conventionally filled hybrid type composites have been classified as nanohybrid composite resins.

Compressive & flexural strength are an important factor to be considered when selecting composite resin materials for clinical use because tooth and restorations are always subjected to both flexural and compressive forces during the chewing procedure. Also, as flexural strength reflects resistance to compressive and tension stresses that act in the material simultaneously, the evaluation of this property is important for restorations used in posterior teeth. The compressive strength test is easy to perform and particularly important because of chewing forces, but its clarification is complex as tension and shear forces act concurrently inside the material [8].

Modern composite resins vary in filler size, morphology, volume, distribution, chemical composition, matrix and photo polymerization initiator, creating a large variation in composite properties. The fillers are made of Quartz, Ceramic, Zirconium and silica. With increasing filler content the polymerization shrinkage, the linear expansion coefficient and water absorption are reduced. On the other hand, with increasing filler content, the compressive and tensile strength, the modulus of elasticity and wear resistance are generally increased [9]. Mechanical properties of dental composites are related to filler particle density in the mix. In short, the density & the composites properties are directly proportional to each other. [10]

It is generally assumed that, as the filler loading increases, the mechanical properties also increases [11]. In this study, from table II, Polofil NHT & Z350 materials are with highest flexural strength values. Similarly, in case of compression strength, Charisma &Z350 are having greater values among five types of material. Also there is no significant difference between Tetric N Ceram, Charisma &Brilliant NG considering flexural strength values.

This may be not only due to nearly equal filler content of material but also due to particle size & filler composition as referring table I. The high compressive strength of Filtek® Z350 might be attributed to its superior polymer matrix coupled with a favourable combination of aggregated zirconium/silica cluster filler with highest density.

The results of this study are in agreement with prior work done, where for the influence of filler volume fraction, the major reason of increasing the compressive strength of dental composites was to increase the amount of filler particles [12]. However, results of the present study indicate the appropriate relationship between filler fraction and compressive strength. There is great variety in the manufacturing brands of nanocomposites.

The results of this study may be explained by the volumetric content of the inorganic particles, as the filler content and size according to the manufacturer directly determine the physical and mechanical properties of composite resin materials as shown in table I. Today, in market there are various nanocomposites available. The clinician is often baffled to choose the correct material to achieve the best strength along with the low postoperative sensitivity.

The purpose of this study is to compare the flexural strength and compressive strength of five different nanocomposites available in the market. Within the limits of this study, charisma gave the highest compressive strength followed by Z350. Thus, it can be assumed that charisma will be more suited in the clinical practice to restore the tooth to its strength with low post- operative sensitivity. Also flexural strength of Polofil NHT is higher than other materials tested.

V. CONCLUSION

Within the limitations of this study, it can be concluded that,

• Polofil NHT has the highest flexural strength followed by 3M Filtek Z-350. There is no significant difference between flexural strengths of Brilliant NG, Tetric N Ceram & Charisma.

• Charisma has resulted in the highest compressive strength followed by 3M Filtek Z-350. There is no significant difference between compressive strengths of Tetric N Ceram & Polofil NHT. But Brilliant NG has resulted in the least compressive strength.

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