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Comparative Evaluation of Compressive And Flexural Strength of Newer Nanocomposite Materials with Conventional Hybrid Composites-An Invitro Study

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Abstract: *During the recent years, different brands of nanocomposites have been introduced and it is a matter of utmost importance to choose the one with most favorable properties. The present study aimed at comparison of compressive and flexural strength of hybrid and nanocomposites available in the market and also to compare the nanocomposites of different brands. The newer nanocomposite materials used in this study include Filtek Z350XT, Tetric N ceram & Brilliant NG. Hybrid composite include Filtek Z250.*
Methods: *A total of 100 specimens were selected. Four groups were made of four different composite materials having 25 specimens in each group.13 in each group were subjected to compressive test and 12 in each were subjected to flexural test. The specimens were stored in distilled water at 37 ∘C, 24 h. and transferred to the universal testing machine, subjected to compressive & flexural strength analysis.*
Results: *Filtek Z350XT had the highest compressive and flexural strength and Tetric N Ceram had the lowest*
Conclusion: *Within the limitations of our study it can be concluded that nanohybrid resins (Tetric N Ceram and Brilliant NG) tested presented inferior properties compared with the nanofilled composite (Filtek Z350XT).The performance of Hybrid composite Filtek Z250 was comparable to nanocomposite.*
Keywords: *Nanocomposites, hybrid composites, compressive strength, flexural strength, universal testing machine*

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I. Introduction

The use of composites based on Bowen's resin heralded a new era in restorative dentistry. Nowadays, composite restorations have gained more popularity and are widely used due to their high aesthetic properties, rapid application, ease of use and low costs. No single property can give a true measure of the quality of a restorative material. Several combined properties determined from standardized laboratory and service tests are employed to give a measure of quality and are of great importance in the clinical evaluation of a particular product. Composite resins have been available to the dental profession for over many years. During this time a tremendous amount of basic and clinical research have been conducted on this versatile class of materials. These materials have been improved far beyond the limits of the orginal formulations.

The latest development in the field has been the introduction of nanofilled materials by combining nanometric particles and nanoclusters in a conventional resin matrix. Nanocomposites thus have been introduced to serve these functional needs through the application of nanotechnology[1]. Nanotechnology is the production of functional materials and structures in the range of 0.1- 100 nanometers nanoscale by various physical and chemical methods. 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 esthetics[2]. They possess a combination of favorable 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[3]. Their physical properties and wear resistance are comparable with those of hybrid composites[1]. Hybrid composites have smooth surface and good strength, hence widely used for anterior restorations including class IV. They are also widely employed for stress bearing restorations. In this study we have taken Filtek Z250, a hybrid composite as standard to compare with three nanocomposites. During the process of mastication, teeth are constantly subjected to mechanical and thermal cycles and restorative materials develop fatigue and fail/fracture eventually[4].Therefore it is especially important to restore teeth with materials than can handle such pressures. In our study we have evaluated two mechanical properties - compressive strength and flexural strength. These properties have a great implication in clinical scenario.

Compressive strength is most useful for comparing materials that are brittle and generally weak in tension like composites. Flexural strength or transverse strength or modulus of rupture is essentially a strength test of a beam supported at each end under a static load[5]. Test for flexural strength not only determine the strength of the material but also the amount of distortion. During the recent years, different brands of nanocomposites have been introduced to the dental material market and it is a matter of utmost importance to choose the one with most favorable properties in terms of application and long term prognosis. The present study aimed at evaluation and comparison of compressive and flexural strength of hybrid and nanocomposites available in the market. The newer nanocomposite materials used in this study include Filtek Z350XT, Tetric N ceram and BrilliantNG. The hybrid composite selected here is Filtek Z250.

II. Materials And Methods

Four different commercially available composite restorative materials were selected for the study- A hybrid composite resin and three nanocomposite resin. Filtek Z 250 and Filtek Z350 XT were provided by same company 3M whereas Tetric N Ceram was supplied by company Ivoclar and Brilliant NG by company Coltene. Filtek Z250 falls under the category of hybrid composite whereas the rest three comes under nanocomposites. Filtek Z 350 XT is a nanofill composite whereas Tetric N Ceram and Brilliant NG are nanohybrid composite. The materials were divided into four groups

Group I: Filtek Z 250 (Hybrid)

Group II: Filtek Z350 XT (nanocomposite)

Group III: Tetric N Ceram (nanocomposite)

Group IV: Brilliant NG (nanocomposite)

The sample size calculated was 25 in each group. For the determination of flexural strength twelve specimen of each material were prepared thereby fabricating 48 specimens in total. Thirteen specimen of each material were made for the testing of compressive strength making a total of 52 specimens. A total of 100 samples were prepared. Plexi glass mould of 5mm thickness with cylindrical holes of 5mm diameter was made as shown in figure 1, thus fabricating cylindrical specimens(figure 3) for compressive strength test and by means of a Putty Material, the mould of 25x2x2 mm is prepared as shown in figure 2 for preparing specimens for flexural strength(figure 4). In total, 52 specimens were fabricated according to the grouping done for compressive strength and 48 for flexural strength. The samples were stored a water bath at 37 ± 10 C for 24 h before testing. The samples were tested using a Universal Instron testing machine. The specimens were kept between the platens of a universal testing machine and the load at break was determined (figure 5,6). A cross head speed of 1mm/min was maintained Compressive strength (CS) in Mega Pascal was calculated for each sample using the formula[6] ,

CS (MPa)=$P/\pi r2$

Flexural strength was determined using the formula[7],

TS(MPa) =3 PL/2bd2(Where P is the load in KN ,L is the length of the specimen between the metal rods at the base plate, b is the thickness and d is the depth in mm.)

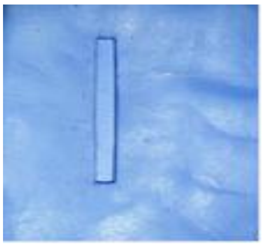
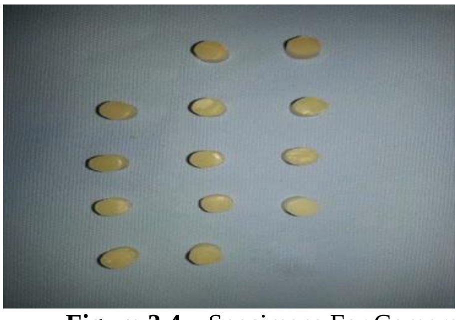


Figure 1,2 – Mould For Compressive And Flexural Strength Test



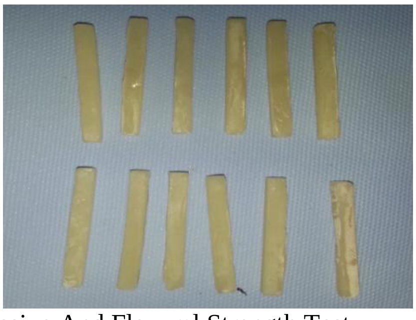


Figure 3,4 – Specimens For Compressive And Flexural Strength Test

Figure 5,6 –Specimens Subjected To Load On Universal Testing Machine

III. Results

The data for compressive strength and flexural strength were obtained directly from the universal testing machine software. The results of the test were statistically analyzed. The statistical analysis was performed using commercially available software(SPSSs 11, SPSS Inc., Chicago, IL ,USA). One way analysis of variance (ANOVA) test, followed by Tukey`s test for multiple comparisons between means to determine significant differences, at significance level set at p≤ 0.05.

groups	Compressive strength(MPa)		Flexural strength(MPa)	
	Mean	SD	Mean	SD
Group I	255.29	77.09	122.00	19.65
Group II	256.16	31.68	124.26	15.54
Group III	180.38	59.90	79.05	15.38
Group IV	218.00	70.49	89.62	8.40

Table 1- Mean Compressive And Flexural Strength And Standard Deviation

Groups compared	Compressive strength P value	Flexural strength P value
Group I – group II	1.00	0.983
Group I – group III	0.018	0.000
Group I – group IV	0.430	0.000
Group II – group III	0.016	0.000
Group II – group IV	0.409	0.000
Group III- group IV	0.422	0.339

Table 2-Intercomparison Within Groups

There was statistically significant difference in compressive strength between group I &III and II & III (p<0.05). There was no statistically significant difference between group I & II, group I &IV, group II & IV, group III & IV (p>0.05). Group II had the highest mean value than the other test groups and group III had the lowest mean value. Intercomparison between group I & III, group I & IV, group II & III, group II & IV showed statistically highly significant difference (p < 0.010) in flexural strength. The rest of the intergroup comparisons turned out to be insignificant. Group II had the highest mean value whereas group III had the lowest mean value for flexural strength.

IV. Discussion

A thorough knowledge and understanding of the physical and mechanical properties of biomaterials is very important in dentistry as it helps the dentist to predict how a material will behave in-vivo and how it should be manipulated. Since most restorative materials must withstand forces in service either during mastication or fabrication they must possess adequate mechanical properties. In the present study ranking of flexural strength and compressive strength from highest to lowest was: Filtek Z 350XT> Filtek Z 250> Brilliant NG> Tetric N ceram. This can be explained by the difference in filler content of composites. In our study, the mean value for compressive strength obtained for Filtek Z 250 (Group I) was 255.29 MPa and for flexural strength it was 122 MPa. In our study there was no statistically significant difference in compressive & flexural strength between Filtek Z 250 and Filtek Z 350XT (P>0.05).This was in accordance to the study conducted by Ensanya A. Abou Neel et al[8] in 2015. They compared the compressive and flexural strength of Filtek Z 250, Filtek Z 350 XT and

Tetric N ceram. In their study there was no significant difference between Z 250 and Z 350 XT in terms of compressive strength. The similarity in behaviour of Filtek Z 250 and Filtek Z 350XT may be due to the similarity in resin matrix, filler shape and filler loading.77 Both Filtek Z 250 and Filtek Z 350XT have similar filler content – zirconia and silica. Also the morphology of the fillers were similar. Morphology of the fillers have a great effect on the properties of composite resin as they are determining factors in both filler loading and material strength.[9,10] .Composites with smooth spherical shaped fillers are related to increase in volume fraction of the filler due to improved packing of the particles and accounts for higher fracture strength. This could explain the high flexural strength obtained for Filtek Z250 & Filtek Z350XT. Both group I and II had similar morphology of fillers. This could be the reason for the comparable flexural and compressive strength obtained for Filtek Z 250 and Filtek Z 350XT.

In this study highest compressive strength was obtained for Filtek Z 350 XT followed by Filtek Z 250. Filtek Z 250 performed superior to nanohybrid composites – Tetric N ceram and Brilliant NG. This is attributed to higher filler load, shape of filler particle, increase amount of filler content, size of filler & resin matrix. Filler content could be an important factor affecting the physical and mechanical properties of different composite material. Tetric N ceram has a filler content of 70.5% by weight which was same as that of Filtek Z 350XT .However they did not exhibit better or equivalent mechanical properties compared to Filtek Z 250 or Filtek Z 350XT. Therefore along with filler content other factors such as filler size, composition, morphology, amount of initiators and quality of silanisation can also contribute to the development of physical and mechanical properties[11]. Filtek Z 250 consists of small and medium round shaped filler particles whereas nanohybrid composites like Tetric N ceram and Brilliant NG consists of irregularly shaped filler particles. Mechanical stress tend to distribute more uniformly with rounded particles than the irregularly shaped particles, that present sharp angles already known as stress concentration areas from where cracks may start.[12] This can be another reason for the superior property of Filtek Z250 over nanohybrid composites. Filler size of Tetric N ceram is large when compared to FiltekZ 250. The large surface area to volume ratio of the fillers present in Tetric N ceram tend to increase water uptake and lead to degradation of filler matrix interphase thereby
affecting the mechanical properties when compared to group I and II[13] .

The composition of monomer has an effect on mechanical properties of present composites. Studies reported that flexural strength increases when Bis GMA or TEGDMA are substituted by UDMA. Furthermore reduction in flexural strength was observed when Bis GMA was substituted by TEGDMA[14] . Filtek Z 250 contain UDMA which may explain the reason for the higher flexural strength whereas Tetric N ceram contain TEGDMA which may contribute to the lower flexural strength. The increased strength of Filtek Z250 is attributed to the presence of zirconium fillers. The small size of filler particle contribute to increased mechanical strength due to increased filler surface area to filler particle content. The presence of aromatic cycles in monomers like Bis –GMA and Bis –EMA present in Filtek Z 250 result in reduced cyclization and increased cross linking in polymer and confers improved mechanical properties and durability/ strength. Therefore the stiffness of Bis-GMA and Bis- EMA is important factor for increased compressive strength of Filtek Z250 [15]. Filtek Z350XT is a nanofilled composite with a combination of nanomer sized particle to the nanocluster formulations which reduce interstitial spacing of the filler particles. This provides increased filler loading ,better physical properties when compared to composites containing only nanoclusters[16]. Nanofillers in Filtek Z350XT have higher contact surface with organic phase when compared to minifilled composite(Filtek Z250), consequently improving material strength.[17]

Filtek Z350XT proved superior to other two nanocomposites in terms of C.S & F.S and the result was statistically significant. Filtek Z350XT is a nanofilled composite whereas Tetric N Ceram & Brilliant NG are nanohybrid composites. The difference may be explained in terms of filler type and shape. Nanofilled composite consist of round shaped nanoclusters wheras nanohybrids comprise of irregularly shaped small & medium particles which present sharp angles from where cracks may start[18]. This may be the reason for the inferior property of nanohybrid composite. Nanofilled composite presented Silica and zirconium as main component of inorganic fillers whereas nanohybrids presented silica and barium as main components[16]. This may be one reason for the superior behaviour of Filtek Z350XT.

The significantly lower F.S observed with Tetric N Ceram in spite of having high filler content may be attributed to the composition of filler. BA glass ,ytterbium triflouride which was incorporated into Tetric n ceram for fluoride release might be related to low F.S[11] . Also the presence of TEGDMA monomer lead to lower F.S[14]**.** Brilliant NG stands third in terms of C.S & F.S following Filtek Z350XT & Filtek Z250. They consist of prepolymerized filler particles in addition to high nanometric particle.The presence of prepolymerized particles cause drop in mechanical properties due to microcracking present in some nanoparticles which was introduced during impregnation procedures resulting in inbuilt flaws. This may be one of the reasons for the inferior property of Brilliant NG with respect to Filtek Z250 & Filtek Z350XT.

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. From the results obtained from our study group II presented the highest compressive & flexural strength and group III the least. The ranking of C.S & F.S from highest to lowest is as follows- Filtekz350XT>Filtek Z250> Brilliant NG> Tetric N Ceram. Within the limitations of our study we can arrive at the conclusion that nanofilled composites performed better than nanohybrid composite resins and comparable to hybrid composites with regard to the properties tested .

V. Conclusion

Due to the differences in the composition of commercial composites it is very difficult to compare their performance or make conclusion as to the influence of external factors on the property variation. There are too many variables which have distinct importance on the overall behaviour. Thus, from the general information of the study and considering the limitations it is possible to conclude that:

1. Filtek Z350XT has the highest compressive and flexural strength followed by FiltekZ250. However statistically significant difference was not seen between them.
2. Tetric N Ceram reported the least compressive and flexural strength.and there was no statistically significant difference between the compressive and flexural strength between Tetric N Ceram and Brilliant NG.
3. Nanofilled composite FiltekZ350XT and hybrid composite FiltekZ250 showed highly significant difference in terms of flexural strength with nanohybrid composite -Tetric N Ceram and Brilliant NG.
4. Out of the three nanocomposites available in the market Filtek Z350XT showed remarkably superior properties
5. The nanohybrid resins (Tetric N Ceram and Brilliant NG) presented inferior properties compared to nanofilled composite(Filtek Z350XT)
6. Hybrid composite FiltekZ250 showed comparable compressive and flexural properties to nanocomposite Filtek Z350XT
7. Based on the finding from this study, for high stress bearing applications, the materials of choice would be Filtek Z250 and Filtek Z350XT

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