Comparative Evaluation of Nanocomposite and Microhybrid Composite Resins Compressive Strength (An In Vitro Study)

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Abstract: *The aims of this in vitro study is to evaluate and compare compressive strength of newer nanocomposites (FiltekZ350, Ceram X Mono,Herculite XRV Ultra) with microhybrid (FiltekZ250) and to assess difference in compressive strength of newer nanocomposites.*

Materials and Methods: *Forty specimens of composite were made using plastic mold measuring 5mm x 5mm and were grouped with ten specimens in each ,Group I: Filtek Z 250, Group II: Filtek Z 350, Group III: Herculite XRV Ultra, Group IV: Ceram X Mono. Composite resins are placed in cylindrical plastic mold and covered with celluloid strip and were cured by light curing device. Compressive strength was recorded using universal testing machine. Results are statistically analyzed using one way ANOVA and LSD test.*

Results: *Nanocomposites have better compressive strength value than microhybrid composite but they are not significantly different*

and not all of nanocomposites used were higher than microcomposite.

Conclusion: *Nanocomposites (Filtek Z 350) have comparable compressive strength with microhybrid composite resins (Filtek Z 250) in which using both of them is indicated in anterior and also posterior areas where the functional loading is higher and need super mechanical properties to withstand these forces. While other nanocomposite groups (Herculite XRV Ultra, Ceram X Mono) used in this study have lower compressive strength than others groups.*

Keywords: Compressive strength, nanocomposite, microhybrid composite.

Introduction

The definitive goal of dental restorative procedure is to substitute the functional, esthetic properties of remaining tooth structure. Dental resin composites were introduced in the conservative field to replace amalgam in the restorative procedure; especially their usages have been grown in posterior teeth restoration. Although significant developments have been made in the properties of composite resin along many years, no essential change in monomer systems has occurred since Bowen introduced dimethacryltaes; the form of bis – GMA in 1962. Improvements in filler systems have been the major advancements. Dental Resin composites were divided through generations of traditional macrofilled, microfilled composites, hybrid, microhybrid composite and nanocomposites [1].

There is no resin materials are able to match both the functional requirements of posterior class I and class II restoration; and the superior esthetics requisite for anterior teeth restorations. Therefore Nanocomposites have been introduced to assist these functional

requirements through the use of nanotechnology [2]. Nanotechnology is the manufacture of functional materials and structures; in the range of 0.1 -100 nanometers (nanoscale) by several physical & chemical techniques. The usage of nanomaterials stems from the knowledge that they may be used to operate the structure of materials to afford dramatic developments in the chemical, mechanical, electrical, and optical properties [2, 3].

Nanocomposites have developed mechanical properties i.e. superior compressive strength, good fracture resistance, diametrical tensile strength, lower polymerization shrinkage, well wear resistance, maximum polish retention, great translucency, and superior esthetics [4, 5].

Materials and Methods

Four different resin composite materials are forming the four groups having 10 samples in each group, thus constructing 40 samples figure (1) using customized plastic mold measuring (5mm × 5mm) [6].The composite resin materials figure(2) used for this study were grouped as follows:

- Group I: Filtek Z 250(3M) (microhybrid composite resin).
- Group II: Filtek Z 350(3M) (nanocomposite).
- Group III:Herculite XRV Ultra (Kerr)(nanocomposite).
- Group IV:Ceram X Mono (Dentsply) (nanocomposite).

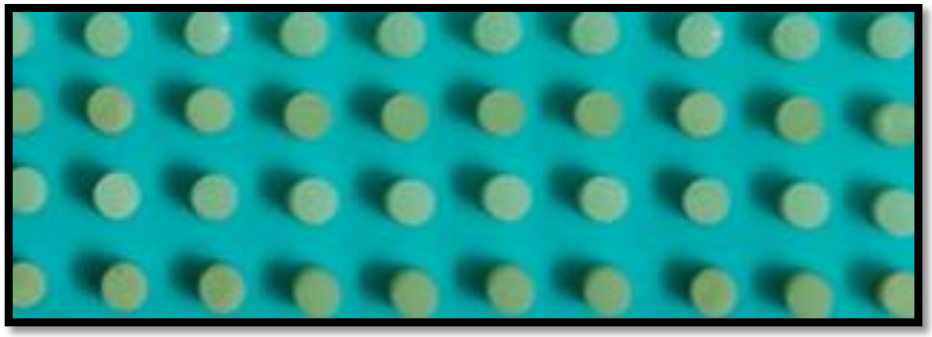

Figure (1): All samples groups

Figure (2): Materials used in this study

The composite materials are placed in the cylindrical mold, and then are covered with a celluloid strip. A glass slide (1mm thick) is applied over composite materials and pressure exerted to accommodate the composites into the mold and to expel the excess material. After the glass slide has removed, the composites were then cured from the top and bottom sides through the celluloid strip; as per the manufactures instructions using the QHL light

curing system. The sample are withdrawn from themold and then light cured in the middle of the samples at opposing sides. In total, 40 specimens are fabricated according to the grouping done. Study is performed in controlled temperature by keeping it in a distilled water bath for 24h at 37°C.

Testing procedure

All specimens are transferred to the universal testing machine figure (3) individually and subjected to compressive strength analysis at crosshead speed of 1.0 mm/min figure (4) until fracture occurred figure (5) and the maximum strength of each specimen recorded.

Figure (3): Universal testing machine

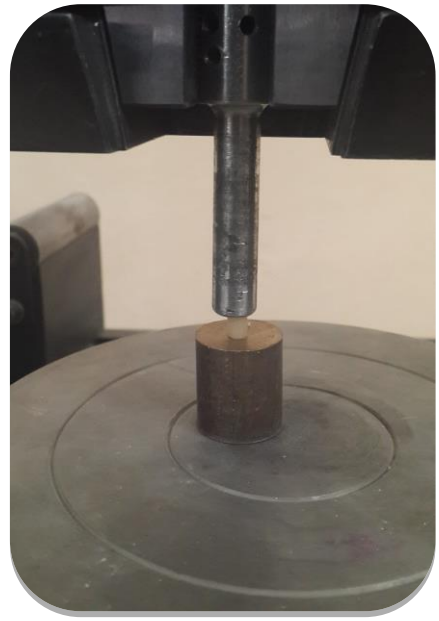

Figure (4): Sample placed in the machine

Figure (5): Sample fracture

Result

Data gained in the existing study is subjected to statistical analysis, by using one way ANOVA and make the group comparison is done by LSD (least significant difference).Means and standard deviation of each group listed in Table 1.

Table (1): Mean and SD

Groups	Mean	N	Std. Deviation
I	253.92	10	.34577
II	254.40	10	.69921
III	234.90	10	.56765
IV	200.00	10	.66667
Total	235.80	40	22.4064

The compressive strength of investigational groups is compared with one way ANOVA test; p value < 0.001 is obtained which indicates highly statistically significant difference between experimented groups, Table(2).

Table (2) One Way ANOVA

	Sum of Squares	df	Mean Square	F	P value	Sig
Between Groups	19567.443	3	6522.481	18972.95	0.000	***
Within Groups	12.376	36	.344			
Total	19579.819	39				

***** Very highly significant.**

At the comparison of each individual group with other groups using LSD test it is found that Flitek 250 has significant difference with group 3 and 4 its value is higher than group 3 &4, Flitek 250 statistically not different with Filtek 350 p>0.05,but group 2 has higher compressive strength values than group 1, Table (3).

Table (3) LSD Multiple Comparisons

Groups		P –value	Sig.
I	II	.075	N.S
	III	.000	***
	IV	.000	***
II	III	.000	***
	IV	.000	***
III	IV	.000	***

***** Very highly significant; N.S Non-significant difference.**

Discussion

Recently, the increasing request for esthetic dentistry has led to the advance of resin composite for direct restorations with better esthetics and durability, physical and mechanical properties [7, 8].

Posterior restorations are continually subjected to occlusal loading [2]. Nanocomposite restorations are believed to offer super wear resistance, strength and definitive esthetics due to their well polishability and glossy appearance. Nano filled composites have mechanical properties no less than those of universal hybrids and could so it's used for restorations in the anteriorareas due to their high esthetics. Characteristics for example chemical composition, filler load, shape and size of filler particles, duration and method of curing are important factors that can affect the persistence of composites [9, 10].

Compressive strength testing is used for assessment of the mechanical properties of such materials. Because of most the masticatory loads fall into the category of compressive forces, evaluation of the durability of resin materials in this conditions is very important [11]. Developments made in nano technology field have greatly influenced the composition of resins [12]. Wide range of composites have been manufactured and presented based on nanotechnology. Their major purpose is to gather the hybrid and microfilled composites advantages [13]. Compressive strength measuring is important in vitro study that have been described as good indicators for simulating the functional forces that loaded upon restorative materials under mastication [14,15].

Subsequently in this project the compressive strength of nanocomposites resin is estimated and compared with micro hybrid composite resin. Measurement of Compressive strength is done using Universal testing machine.

Filtek Z 350 is a nano filled composite resin with combination of nano cluster formulations (which reduces the interstitial spacing of the filler particles) to the nanomer sized particles. This offers higher filler loading, superior physical properties comparing with those composites having only nan oclusters. Filler particle average size is (5- 20) nm.A spherical shape have many advantages like improvement in composites filler load and also increase their fracture strength asthe mechanical stresses have a tendency to concentrate on the protrusionsand angles of the filler particles. Filtek Z 350 and most nano composites have the spherical shaped filler particles which have the improvement in filler load.

In this in vitro study, Filtek Z 350 has compressive strength highest than those of other 3 groups, but its comparable to those of Filtek Z 250 composites group, both of them has significantly different to those of group 3&4 . This study is agreed in the increased nanocomposite resin strength value with Lu et al, Mitra et al, Beunetal [1, 2, 16].

This study results pointed that microhybrid composite have comparable compressive strength compared to nanofill composites

resin .A small defect occurs in micro hybrid composite subjected to functional loading which is attributed to increased filler content and elastic modulus. Therefore, post-operative cracks and strain do not easily arise in this type of composite [17]. Higher number and larger size of filler particles in microhybrid composite resins improve the mechanism of crack holding off and result in increasing fracture toughness [18].

It appears that in addition to higher filler particles sizes in Z 250 composite resin, the presence of zirconium fillers has also important role in its improved strength. Presence of aromatic cycles in monomers like Bis-GMA and Bis-EMA found in Z 250 composite leads to reduce cyclization and increase cross linking in the polymer and gives successive improvement in mechanical properties and strength / durability comparable with nanocomposites. However, in TEGDMA monomers and UDMA especially due to its high flexibility, there is a greater possibility of intramolecular cyclization. So that the stiffness of Bis GMA and Bis EMA is also a factor for improvement of filtek Z 250 compressive strength [19].

Nanocomposite esthetic characteristics are comparable to those of natural teeth. As they have good wear resistant they do not cause enamel wearing of the analogous teeth. Their polymerization shrinkageis very little so that their tension is less and this leads to decrease in post-op over-sensitivity. Filler particles present in nanocomposites increase matrix strength and result in higher fracture toughness [20, 21]. As result nanocomposite (filtek Z350) and microhybrid (Filtek Z 250) their compressive strength is higher than that of Herculitexrv and ceram x mono that used in this study in which their higher strength can be explained by their higher filler loadings.

Many Studies have been reported this relationship between mechanical properties and volume fraction of fillers(Braem, et al, 1989; Chung, and Greener1990) [22, 23]. [24].

Conclusions

It can be concluded, within the limitations of this in vitro study; that Nanocomposites and microhybrid composite statistically non different but nonocomposite have shown higher compressive strength value. Filtek Z 350 has shown the highest compressive strength and Ceram X Mono shown the least compressive strength among the tested materials.

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تقييم مقارن للقوة الضاغطة لمركب الراتنجات المتناهيه في الصغر والمركبات المجهرية (دراسة في المختبر)

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المستخلص

أهداف هذه الدراسة في المختبر هوتقييم ومقارنة قوة الضغط لمركب الراتنجات المتناهيه في الصغر (Filtek Z350, Ceram X Mono, Herculite XRV Ultra) مع المجهرية (Filtek Z250) وتقييم الفرق في قوة الضغط لمركب الراتنجات المتناهيه في الصغر.

المواد والطرق: تم عمل أربعون عينة من مركب الراتنج باستخدام قالب من البلاستيك قياس (5ملم × 5ملم) وتم تجميعها مع عشرة من العينات في كل مجموعه وكالتالي، المجموعة الأولى (فلتك 250)، المجموعة الثانية (فلتك 350)، المجموعة الثالثة: (هركيليتاكسارفيالترا)، المجموعةالرابعة :(سيراماكس مونو) توضع الراتنجات في قالب من البلاستيك اسطواني ومغطاة بشريط سليليويدي وثم علاجه عن طريق جهازعلاج الضوء. وسجلت قوة الضغط للكومبوزت باستخدام آلة عالمية للاختبار. ويتم تحليلا لنتائج إحصائيا باستخدام طريقة أنوفا و(ال اس دي).

النتائج: المركبات المتناهيه في الصغرلديها أفضل قيمة لقوة الضغط من المركبات المجهرية لكن الفرق غيرملحوظ بينها مع المجهرية، ليس كل من الراتنجات المتناهيه في الصغرالمستخدمة كانت أعلى من المجهرية.

الاستنتاج: المركبات المتناهيه في الصغر (فلتك 350) لديها قوة ضاغطة مقارنة مع راتنجات المجهرية (فلتك 250) التي تستخدم كل منهم افي المناطق الأمامية وكذلك

المناطق الخلفية حيث قوة الضغط والحمل أعلى وتحتاج خصائص فائقة الميكانيكية على تحمل هذه القوات.

الكلمات الرئيسية: القوة الضاغطة، مركب متناهي في الصغر، المركبات المجهرية.