Assessment of compressive and diametric tensile strength of nano and hybrid composites

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Abstract:

Background: To assess the comprehensive and diametric tensile strength of nano and hybrid composites. **Materials & methods:** In each group, there were 10 samples included. The Universal Testing Machine was utilized to perform the compressive strength test, with a crosshead speed of 1 mm/min. Data was collected and subsequently analyzed using SPSS software. A p-value of 0.05 was considered statistically significant. **Results:** The average value for hybrid composites and nano composites was found to be 255.24 and 265.7 MPa, respectively. In the case of nexcomp, the mean value was 278.6 MPa. Notably, the obtained P-value did not reach statistical significance. **Conclusion:** Compressive strengths of various composites are about the same, but DTS of some nanofilled composites may be lower than the other nanofilled or hybrid composites.

Keywords: Hybrid composites, tensile strength, nano composites.

Introduction:

Tooth-colored restorative resins are the most preferred restorations due to improvements in their physical, mechanical, and optical properties and ease in clinical handling. Different fillers and monomer systems are modified or added to restorative materials recently for the success of restorations clinically. Restorative resins are modified from past to present from macrofilled composites, microfilled composites, hybrid composites, microhybrid composites, and flowable composites to recent bulk fill composites and nanocomposites. Improvements are mainly aimed at reducing polymerization shrinkage and increasing hardness, compressive strength, flexural strength, and flexural modulus by introduction of newer resin formulations and filler concentration. [1,2]Improvements in higher modulus of elasticity, greater flexural strength, compressive strength, diametrical tensile strengths, hardness, fracture toughness, and wear resistance of these newer composite resins have been reported in previous studies. [3]Nanocomposites thereby respond much better to the functional stresses of mastication as compared to the conventional resins. Restorative materials used in stress-bearing areas have to be tested for physical and mechanical properties such as high strength, fracture toughness, surface hardness, optimized modulus of elasticity, low wear, low water sorption and solubility, low polymerization shrinkage, low fatigue and degradation, high radiopacity, and optical properties as these are still the major concern of composite materials' success clinically. Nanohybrid composites contain the least amount of organic matrix and greater percentage of fillers and demonstrate lesser polymerization shrinkage than the nanofill composites.[4,5]

Nanotechnology is the production of functional materials and structures in the range of 0.1 -100 nanometers – nanoscale – by various physical and chemical methods. The usage of nanomaterials stems from the idea that they may be used to manipulate the structure of materials to provide dramatic improvements in the electrical, chemical, mechanical and optical properties. [6,7]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. [8,9] Hence, this study was conducted to assess the comprehensive and diametric tensile strength of nano and hybrid composites.

Materials & methods:

In each group, there were 10 samples included. The Universal Testing Machine was utilized to perform the compressive strength test, with a crosshead speed of 1 mm/min. To conduct the diametric tensile strength test, a nickel-chromium split mold with dimensions of 3 mm in depth and 6 mm in diameter was employed to prepare the cylindrical specimens. The remaining steps of the procedure were identical to the compressive testing method, except for the positioning of the samples in the instron testing machine. Data was collected and subsequently analyzed using SPSS software. A p-value of 0.05 was considered statistically significant.

Results:

Each group consisted of 10 samples. The evaluation focused on the compressive strength. The average value for hybrid composites and nano composites was found to be 255.24 and 265.7 MPa, respectively. In the case of nexcomp, the mean value was 278.6 MPa. Notably, the obtained P-value did not reach statistical significance. The mean diametric tensile strength (DTS) for nexcomp was 22.42 MPa. In hybrid composites, the mean tensile strength was 34.16 MPa. The p-value shows 0.01. The nexcomp depicted the p- value with significance of 0.005. Nanofilled composites may have lower DTS than the other composite resins.

Table 1: Compressive strength values (MPa) of composite types

Types of composites	Mean	P- value
Spectrum	240.8	0.4
Hybrid	255.24	0.4
Nano	265.7	
Nexcomp	278.6	0.1

Table 2: Diametric tensile strength values (MPa) of composite types

Types of composites	Mean	P- value
Spectrum	28.12	0.1
Nexcomp	22.42	0.005
Synergy nano	34.08	0.01
Hybrid	34.16	

Discussion:

A core build-up is a restoration placed to provide the foundation for a restoration that will endure the masticatory stress that occurs in the oral cavity for prolonged periods and to provide satisfactory strength and resistance to fracture before and after crown preparation.[10] The selection of materials is based primarily on ease of handling with due consideration being given for mechanical properties and manipulative variables. Among mechanical properties compressive strength of core materials is important because cores usually replace a large bulk of tooth structure and they should provide sufficient strength to resist intraoral compressive and tensile forces that are produced in function and parafunction. Flexural strength is used to evaluate the strength of the material and the amount of the distortion expected under bending stress. [11] Hence, this study was conducted to assess the comprehensive and diametric tensile strength of nano and hybrid composites.

In the present study, each group consisted of 10 samples. The evaluation focused on the compressive strength. The average value for hybrid composites and nano composites was found to be 255.24 and 265.7 MPa, respectively. In the case of nexcomp, the mean value was 278.6 MPa. Notably, the obtained P-value did not reach statistical significance. A study by Meenakumari C et al, there was significant differences among composites restorative resins tested. CFM Nano hybrid composite exhibited highest hardness values. Flexural strength, flexural modulous and hardness properties of Ever X and Z350 were almost similar. Compressive strength value of Ever X was high compared with other four composites. SDR exhibited least values when compared with other composites.Differences in compressive strength, hardness, flexural strength and modulous is due to differences in percentage and type of filler particles in all composite resin material tested.[12]

In the present study, the mean diametric tensile strength (DTS) for nexcomp was 22.42 MPa. In hybrid composites, the mean tensile strength was 34.16 MPa. The p-value shows 0.01. The nexcomp depicted the p- value with significance of 0.005. Nanofilled composites may have lower DTS than the other composite resins. Another study by Jayanthi N et al, the results of the study showed that Fluorocore had the highest compressive strength and flexural strength followed by Filtek Z350 [nanocomposite] Amalgam had the least flexural strength and Vitremer GIC had the least compressive strength. Thus flurocore and nanocomposite are stronger than other core build up materials and hence should be preferred over other conventional core build up materials in extensively damaged teeth.[13] Hegde MN et al, forty eight specimens of composite were fabricated using customized biparpite brass mold measuring 5mm x 5mm and were grouped with twelve specimens in each Group I : Tetric Ceram, Group II: Filtek Z 350, Group III : Ceram X Mono, Group IV : Ceram X Duo. Composite resins are placed in cylindrical recesses and covered with mylar strip and are cured using QHL light curing unit. They concluded that nanocomposites have better compressive strength than microhybrid composite and nanocomposite showed optimal compressive strength of 312 - 417 Mpa.[14]Nano filled materials are believed to offer excellent wear resistance, strength and ultimate esthetics due to their excellent polishability, polish retention and lustrous appearance. Nano filled resin composites show mechanical properties at least as good as those of universal hybrids and could thus be used for the same clinical indications along with anterior restorations due to their high esthetic properties. Mechanical properties of a material describe its response to loading. Although most clinical situations involve complicated three-dimensional loading situations, it is common to simply describe the external load in terms of a simple dimension as compression. Compressive strength is particularly important because of chewing forces. It is one of the measures of strength of material in different force conditions, increased value represents increased strength of the material.[15]Compressive strength test evaluates the masticatory forces of restorative material especially posterior composites. According to Kim et al. [16] the larger size of filler particle and high percentage of fillers reduces the crack formation and deflection in composites making the material resistant to fracture, this might be the reason for better compressive strength results with CFM. The TEC is a nano hybrid composite consisting of monomer Bis-GMA, UDMA and Bis -EMA and different type of isofillers 61% filler volume. These isofillers are specially designed to reduce polymerisation shrinkage and improve other mechanical properties. The reason for better compressive strength could be because of decrease in inter-particle distance between the nanofiller which reduces the tendency for crack formation and propagation and the smooth and rounded edges of the spherical nanoparticles tends to distribute stress more evenly throughout the composite resin which is almost similar to study concluded by De Moraes et al.[17]

Diametric tensile strength is a mechanical property used to understand the behavior of brittle materials when exposed to tensile stress. DTS is an acceptable and common test for dental composites. [18] The DTS mean values of the composites tested in the present study are in the DTS range of dental composites, 3 0-50 5 MPa. [19] Cho GC et al, compressive strengths varied widely from 61.1 MPa for a polyurethane to 250 MPa for a resin composite. Diametral tensile strengths ranged widely from 18.3 MPa for a glass ionomer cermet to 55.1 MPa for a resin composite. Some resin composites had compressive and tensile strengths equal to those of amalgam. Light-cured hybrid resin composites were stronger than autocured

titanium containing composites. The strengths of glass ionomer-based materials and of a polyurethane material were considerably lower than for resin composites or amalgam.[20]

Conclusion:

Compressive strengths of various composites are about the same, but DTS of some nanofilled composites may be lower than the other nanofilled or hybrid composites.

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