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In Vitro Comparison of the flexural strength of 3 commercially available composite resin based restorative materials

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Abstract:

Objective:- The aim of this study is to comparatively evaluate the flexural strength of 3 commercially available bulk fill composites. **Materials & Methods:-** The study compared and evaluated the flexural strengths of three different types of dental restorative materials: Te-Econom Plus (manufactured by Ivoclar Vivadent AG, located in Liechtenstein), Titric-Power-Fill (manufactured by Ivoclar Vivadent AG, located in Liechtenstein) and Tetric N-Ceram Bulk Fill (manufactured by Ivoclar Vivadent AG, located in Liechtenstein). The flexural strength was assessed following the ISO (International Organization for Standardization) Standard 4049. To conduct the study, 10 specimens were fabricated for each material group. Statistical analysis was performed using one-way ANOVA with a Tukey post-hoc test to determine any significant differences among the groups ($p < 0.05$).**Results:-** The results of the study indicate that Group 1 showed the highest mean flexural strength value (143.40 ± 0.31 MPa), followed by Group 3 with a mean flexural strength value of 129.20 ± 0.39 MPa. Group 2 displayed the lowest mean flexural strength value of 120.70 ± 0.45 MPa.**Conclusion:-** Tetric Power fill composite exhibited notably higher flexural strength values in comparison to Tetric N-Ceram and Te Econom plus alternatives.

Keywords:- Flexural strength , Tetric-N-Ceram, Te-Econom, Tetric power Fill

Introduction:- A core build-up is a dental procedure used to rebuild the foundation of a severely damaged tooth, preparing it for further restoration. This process strengthens the remaining structure of the tooth, providing a stable base for subsequent restorative treatments, typically involving extra-coronal restorations. Advancements in materials science and clinical techniques have expanded the applications of resin-based composites (RBCs), now encompassing substantial posterior stress-bearing restorations that were traditionally treated with amalgam.[1] Flexural strength is a crucial material property that gauges a material's ability to resist fracture when subjected to bending stress. It serves as an indicator of any inherent flaws within the material that could lead to failure under load [2,3]. This property is pivotal for assessing both the strength of the material and the degree of deformation anticipated under bending stress. Due to their enhanced mechanical properties, increased wear resistance, and cost-effectiveness, resin composites have emerged as the preferred material for numerous dentists, not just for dentin replacement but also for comprehensive posterior tooth restoration. Composite restorations are frequently exposed to substantial flexural stresses in both anterior and posterior teeth in clinical practice. Therefore, it is crucial for clinicians and material scientists to characterize the flexural properties, including strength and modulus. Flexural strength refers to the stress at which a material fails under bending, making it a critical parameter for assessment.[4] Studies have demonstrated that flexural strength serves as a more discerning test compared to compressive strength, showcasing greater sensitivity to subtle alterations in a material's substructure.[5] Advancements in evolutionary research have predominantly centered on minimizing stresses and enhancing physico-mechanical properties, particularly flexural and compressive strengths, through the manipulation of filler characteristics such as size, shape, and concentration of filler particles.[6]

Materials and Methods:-

Sample preparation involved categorizing the bulk-fill composites into three distinct groups:

Group 1: Tetric-Power-Fill (manufactured by Ivoclar Vivadent AG, located in Liechtenstein).

Group 2: Tetric-N-Ceram (manufactured by Ivoclar Vivadent AG, located in Liechtenstein).

Group 3: Te-Econom Plus (manufactured by Ivoclar Vivadent AG, located in Liechtenstein).

Flexural Strength:-

In accordance with ISO 4049 specifications for flexural strength testing, ten samples of each test material were prepared using custom-made stainless steel split molds with dimensions measuring 25 mm in length, 2 mm in width, and 2 mm in height. The test materials were dispensed from their respective containers and carefully packed into the molds until uniformly filled, with excess material trimmed away. Polymerization was carried out using a blue light-emitting diode light source, following the manufacturer's instructions, ensuring exposure from both sides of the mold. Following polymerization, the samples were demolded and immersed in distilled water at 37°C for 24 hours to ensure thorough polymerization prior to testing.

Sample evaluation:-

The fabricated samples were affixed onto a 3-point bending test apparatus, with a span length of 20 mm between the supporting rods. These samples were then subjected to loading in a Universal Testing Machine (specifically, an Instron 3366) at a crosshead speed of 1 mm/min, with a loading force of 2 kN. The maximum fracture load (F in Newtons) of each sample was meticulously recorded.

Flexural strength was automatically computed utilizing a computerized program, applying the formula specified below:

$$\sigma = 3Fl/2bh^2$$

- σ denotes flexural strength (in Mpa)
- F represents the maximum fracture load (in Newtons)
- L signifies the span length between the supporting rods (in mm)
- b denotes the width of the sample (in mm)
- h signifies the height of the sample (in mm)

Statistical methods:-

The data collected from the flexural and compressive strength tests underwent rigorous statistical analysis. To assess the significance of variations between groups, a one-way ANOVA was employed, followed by the Tukey test for post-hoc comparison. The predetermined threshold for significance was set at a p-value of less than 0.05.

Results:-

Flexural Strength:

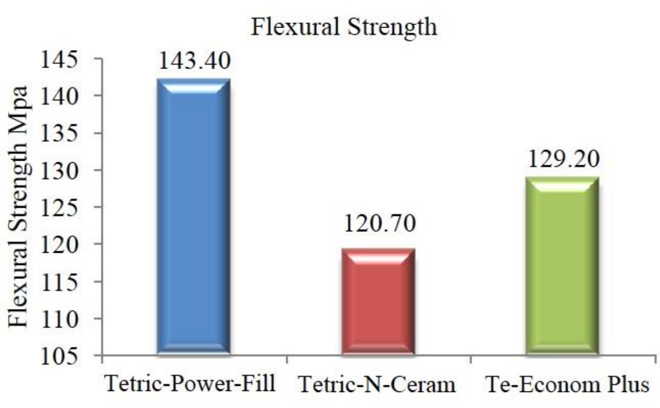

Figure 1: Mean values of flexural strength (MPa) of the all groups.

TABLE 1:
One way ANOVA comparison of Flexural Strength (MPa) between the study groups

	N	Mean	Standard Deviation	Minimum	Maximum
Group 1	10	143.40	0.31	141.20	144.26
Group 2	10	120.70	0.45	118.80	121.22
Group 3	10	129.20	0.39	128.10	129.80
ANOVA	**F = 8755.048 p-value = 0.001**				

*p<0.05 statistically significant

The results of the study indicate that Group 1 showed the highest mean flexural strength value (143.40 ± 0.31 MPa), followed by Group 3 with a mean flexural strength value of 129.20 ± 0.39 MPa. Group 2 displayed the lowest mean flexural strength value of 120.70 ± 0.45 MPa. The obtained p-value, which was 0.001, indicates a statistically significant difference among the groups.

Discussion:-

The newly developed bulk-fill resin composites feature advanced proprietary resins, supplemented with additional modifiers, innovative photoinitiators, and distinctive fillers. Utilizing nano-sized filler particles, these bulk-fill composites can be densely packed within the resin matrix, leading to enhancements in various physical properties such as wear resistance, compressive strength, and tensile strength of the material. Flexural strength refers to the maximum stress that Resin based Composites can withstand before failing, while flexural modulus describes the stiffness of these materials. Resin based composites with high flexural properties are often selected for use in Class I, II, III, and IV cavities to mitigate fracture or deformation under substantial occlusal forces. Conversely, Resin based composites with lower flexural modulus are favored in Class V cavities, as they can flex alongside the natural movements of the teeth during both function and parafunction. This flexibility helps reduce stresses at the adhesive interface, thereby decreasing the likelihood of debonding.[7,8,9] It is generally assumed that the higher the filler loading, the higher the composite mechanical properties.[10]

To evaluate and screen the diverse properties of materials, the flexural strength test is a crucial parameter chosen. According to Heintze et al., research indicates that flexural strength testing serves as an indicator for assessing the durability of materials under masticatory conditions. Several studies have demonstrated a direct correlation between the volume of filler and the filler weight level of composites with the strength of the material. In this investigation, specimens were fabricated and examined for flexural strength based on the specifications outlined in ISO 4049.[11,12] Tetric PowerFill is a sculptable posterior 4-mm composite with light-curing times starting from 3 seconds.

Bulk-fill resin composites expedite the restoration process by allowing for curing in up to 4 mm increments in a single step, minimizing polymerization shrinkage and maintaining macro mechanical properties. Flury et al. have indicated that bulk-fill composites enhance the efficiency of clinical procedures when compared to traditional composites.[13] Additionally, as noted in Chesterman et al.'s review, bulk-fill composites mitigate the risk of voids between composite layers and prevent inter-layer contamination, addressing a common issue associated with conventionally placed composites.[14]

In this study the Tetric power Fill with the highest flexural strength value of 143.40 MPa. Tetric power fill allowing for curing up to 4mm increment so there are less risk for voids between layers. Tetric N cerem and Te econom allowing for lesser curing depth so there are more chances of voids between layers.

In this study Te econom plus has higher flexural strength than Tetric N cerem. Te econom is a microhybrid resin based composite material and Tetric N cerem is a nanohybrid resin based composite material. Tetric power fill composite material is less sticky and its handing properties are better than Te econom and Tetric N cerem composite materials.

Conclusion:-

All examined resin composite materials demonstrated satisfactory flexural strengths, meeting the requirements outlined in ISO 4049 and ADA 27 specifications. Notably, Tetric Power fill composite exhibited notably higher flexural strength values in comparison to Tetric N-Ceram and Te Econom plus alternatives.

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