The Fracture Resistance of Fiber Reinforced Composite Restorative Material has Higher Yield than Nanohybrid Resin Composite

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The Fracture Resistance of Fiber Reinforced Composite Restorative Material has Higher Yield than Nanohybrid Resin Composite

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Abstract. Restorative materials used in dentistry should have aesthetic appeal and good strength for use in restorations on anterior and posterior teeth. Nanohybrid resin composite is a composite resin with nano-filler particles having both aesthetic appeal and good durability against fracture. The newest composite resin, fiber-reinforced composite, comprises resin matrix, E-glass fiber and organic particulate filler. Composite resins with E-glass fibers are expected to have higher fracture toughness values than composite resins without E-glass fibers. This research aimed to study the difference in the fracture toughness between nanohybrid resin composite and fiber-reinforced composite. Twenty samples were divided into 2 groups: Group I- nanohybrid resin composite and group II- fiber-reinforced composite. Each sample was applied incrementally on a glass mould and individually exposed to light for cure stiffening for 20 s. Before polymerisation of the second layer, the central part of the sample was given a sharp crack. The sample was then maintained at 37°C for 48 h, followed by testing for fracture toughness by the universal testing machine specification. Independent t-test revealed significant differences in fracture toughness values between the two groups (p = 0,000).

1. Introduction
Dental caries is a process of tooth structure decay that initiates from the enamel and progresses into the dentine. One of the treatment for dental caries is restoration. To achieve successful restoration, selection of proper restorative materials is essential [1].

The mechanical properties of a material influence its selection as a restoration material. Fracture resistance is a mechanical property that determines the resistance of a material to cracks that spread because of pressure on the restored tooth area. Fracture resistance is one of the standard and recommended tests for assessing the fragility of a restorative material because it determines the maximum strength and pressure that a restorative material can bear before any damage occurs [2].

Composite resin is a dentistry material that continues to grow as a nanotechnology ingredient. Composite resin has a particle size of nano filler (1–100 nm). Nanohybrid resin composite is a type of hybrid composite resin containing glass-filler particles and nanoparticle resin matrix (40–50-nm). Nanohybrid composite resins possess good aesthetic properties (e.g. microfiller composite resins) and durability (e.g. macrohybrid composite resins) [3]. Nanohybrid resin composites can be used for
restoration on the anterior and posterior teeth because it has better resistance to fracture and greater resistance to abrasion [4].

One of the latest composite reinforced concretes containing short fiber (fiber-reinforced composite resin, FRC) comprises a combination of resin matrix, E-glass fiber or electrical glass and inorganic particulate filler [5]. This composite possesses high flexure and fatigue strength, a modulus of elasticity close to that of dentine, good aesthetic properties, non-corrosive capabilities, biocompatible components and the ability to distribute pressure uniformly to prevent fracture [6].

Composite resins with E-glass fibers are expected to possess a higher fracture resistance value than a composite resin without E-glass fibers. Based on the above data, we examined the difference in fracture resistance of fiber-reinforced composite and reinforced composite nanohybrid resin materials. The results of this study are expected to provide an overview to the fracture resistance in fiber restoration-reinforced composites and nanohybrid resin composites.

2. Methods
In this study, 20 beam samples were used after dividing them into two groups of 10 samples each: group I (fiber-reinforced composite) and group II (nanohybrid resin composite). The characteristics of the sample beams were 25-mm length, 2.5-mm width, 5-mm thickness and no porous restoration.

The composite resin used was a universal shade of fiber-reinforced composite and nanohybrid resin composite shade P-A3. Sampling was performed using a glass mould of 2-mm thickness. The inside of the mould was vigorously applied, after which a composite resin material was applied with an incremental technique to the mould, followed by curing for 20 s on each layer up to the last layer. However, prior to the second-layer polymerisation, the central part of the specimen was given a sharp crack using a straight cutter into the specimen. After hardening, the sample was removed from the mould and excess materials were disposed and the sample was cleaned.

All samples were stored at 37°C for 48 h in a sterile incubator [8]. Fracture endurance testing was performed on the sample using the universal testing machine. The specimens were tested by a 3-point bending test method with a crosshead speed of 0.5–1 mm/min. The occurrence of a fracture in the sample was ascertained by the sound of a crack, and the value showing on the machine at the time of the occurrence of the sound was recorded as the time of fracture (which is the force (F) on the Newton scale). Next, Mpa scale conversion is performed using the following formula: Fracture Toughness (KIC) = (P L / B W1.5) f(x).

The collected data were first tested for normality using the Saphiro–Wilk test. A homogeneity test was conducted using the Levene’s test. If the data was normally distributed and showed a homogeneous variation, then it was statistically analysed parametrically using the independent t-test (P < 0.05) to determine the difference in fracture resistance between both types of composite resin.

3. Results
The mean fracture resistance value in both the sample groups is given in table 1 and as a bar chart in Figure 1.

| Sample (20) | Fracture toughness value (MPa.m½) | Group I | Group II |
|-------------|----------------------------------|---------|---------|
|             |                                   | Fiber-reinforced composite | Nanohybrid resin composite |
| Mean        | 23.256                            | 10.532  |
Parametric statistical analysis was performed using an independent t-test; the average value of fracture resistance in group I was higher than that in group II (p < 0.05). The difference in the mean values of fracture resistance between the two groups is depicted in the bar chart of Figure 1.

![Bar chart showing the difference in mean values of fracture resistance between group I and group II.](image)

**Figure 1.** The difference in the mean values of fracture resistance between the two groups is depicted in the bar chart.

### 4. Discussion

Our test results revealed that the average value of fracture resilience of group I fiber-reinforced composite (23,256 MPa.m1/2) was higher than that of group II nanohybrid resin composite (10,532 MPa.m1/2). This difference can be attributed to the fact that group I includes a component of fiber embedded in a polymer resin matrix that acts as an amplifier, and the matrix serves to channel the pressure between the fibers and protect the fiber from mechanical and environmental damages. The increase in the material properties can also be attributed to the fiber’s ability to stop crack propagation.

Fiber-reinforced composites comprise short glass containing a combination of resin matrix, randomly distributed E-glass fibers and inorganic particulate filler. Based on its chemical composition, a glass fiber can be classified into A, C, D, E, R and S fibers, which differ in their mechanical and chemical properties. Type E-glass fibers is the main fiber type that uses plastic reinforcement and comprises calcium alumino borosilicate, which has tensile strength, compressive strength, elastic modulus and good density required for high fracture resistance. The diameter of filler short E-glass fibers is 17 μm and it has a length ranging from 1.3 to 2 mm.

The resin matrix comprising BisGMA, TEGDMA and PMMA forms semi-IPN during polymerisation of the material, which can improve the bonding properties and hardness of a composite resin. Semi-IPN possess the ability to re-activate fiber-reinforced composite surface structure such that the restoration material has a durable bond and can improve the restoration of fiber-reinforced composite in case of damage. Unlike in nanohybrid resin composite restorative materials, millimetre-scale fibers and semi-IPN structures are the two main factors that fortify fiber-reinforced composites.

Nanohybrid composite resins contain filler particles composed of zirconia, measuring 0.1–10 μm, 20-nm sized silica, nanocluster of zirconia and silica. These filler particles contribute to the high charge on a nanohybrid resin composite. No significant association was noted between the fracture resistance value and the percentage of particle filler size. Although the filler charge on composite resin was high in this study, the composite resin nanohybrid showed low tensile and shear stress values in the enamel and dentin.

Therefore, based on the outcomes of this comparative study, it is suggested that the fracture resistance value of a composite nanohybrid resin is lower than that of reinforced composite fiber.
5. Conclusion
It can be concluded that the fracture resistance value of fiber-reinforced composite restorative material is higher than that of nanohybrid resin composite.

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