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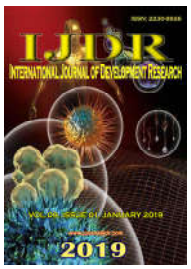

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

# A COMPARATIVE EVALUATION OF FLEXURAL STRENGTH OF COMPOSITE RESINS ON GLASS FIBRE REINFORCEMENT

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**ABSTRACT**

**Aim:** To evaluated the effects of glass fibre layering on the flexural strength of hybrid and microfill composites. **Methodology:** A stainless steel mold of dimension (25x2x2 mm) was used to fabricate a total of 90 speimens of corresponding dimensions according to the groups-control and experimental groups. A 3-point bending test was carried out to assess the flexural strength. Load was applied on the specimens by using a universal testing machine, at crosshead speed of 1 mm/min. The fracture load was recorded in kilo Newton which then converted to mega Pascal. *RESULT*- Stastitical analysis was performed by using analysis of variance (ANOVA) and student 't' test. Glass fibre reinforcement improved the flexural properties of the composite resin significantly ($p<0.001$). Placement of a layer of glass fibre at the bottom of the specimens significantly ($p<0.001$) resists tensile failure as compared to the placement in the middle of the specimens. *CONCLUSION*- Glass fibre reinforcement of the hybrid and microfill composites improves the flexural properties of the composite resin materials significantly.



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## INTRODUCTION

The demand for esthetics has shifted the focus of clinicians to the resin composites (Smith, 1962; Daniel Fortin, 2000). Variations in the basic chemistry of the resin materials can produce a range of composites with distinct properties. But the mechanics of composites are deficient to use in heavy load areas (Leinfelder *et al*., 1999). So this study was aimed to improve the mechanics of most commonly used esthetic material, resin based composite materials in order to use composite in stress bearing conditions (Williems, 1993). Hence, the search began for a better and more reliable reinforced composite restorations. To strengthen the composites, preimpregnated glass-fibres are preferred due to their mechanical properties, esthetic qualities as well as their ability to chemically bond to dental composite resin materials (Pereira *et al*., 2003; Freilich *et al*., 2000). It increases resistance of material to fracture especially in high load bearing areas.

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Fracture resistance is an indicator of strength and structural performance for brittle dental materials including composites and flexural strength test has been used to measure fracture resistance and mechanical properties namely compression and tension (Pereira *et al*., 2003). Composite restorations are subjected to flexural stresses, especially in stress bearing cavities (Classes I, II, and IV). So to resist the higher flexural stresses, flexural strength should be higher. The highest flexural strength was achieved when the fibre framework are placed on the tensile side (base) of the composite materials according to previous studies. Pre-impregnated glass fibres consists of glass fibres impregnated with light-curing monomers which crosslink during polymerization of the overlying composite and forms a multi-phase polymer network (Freilich *et al*., 2000; Goldberg *et al*., 1998; Freilich *et al*., 1998). Multiphase structure is called a semi-inter-penetrating polymer network structure (semi-IPN) (Goldberg *et al*., 1998). The advantages of the semi-IPN are said to be high strength, reduced water sorption, high flexural strength, and improved adhesion between FRC framework and veneering composite after polymerization (Hamza *et al*., 2004).

Present study was designed to evaluate the efficacy of glass fibre layering on the flexural strength of hybrid and microfill composites and also evaluated that whether placement of glass fibres in the composite resins at the bottom of the restoration or in between the layers of composite resins makes any differences on the flexural strength.

## METHODS AND MATERIALS

Two light polymerizing restorative materials and glass fibres (Interwined pre-impregnated glass fibre-Interlig) were chosen.

**Materials used in this study includes**

- Hybrid composite (Prime-Dent, Made in U.S.A., Lot No. NB28K)
- Microfill composite (Prodigy, Kerr Corp. 1717 West Collins, Orange, CA 92867, Made in U.S.A., Lot No. 2929142)

Glass fibres, Interlig(Angelus Industries Dental Products, CEP 86031-218-Londrina-PR- Brazil, Lot No.15221 )(informations are according to the manufacturer).

**Distribution of Specimens was as follows**

**Control Groups**

- Group CI comprised of hybrid composite specimens without reinforcement
- Group CII contained microfill composite specimens without reinforcement

**Experimental groups**

- Group EI was formed of glass fibre reinforcing the hybrid composite at the bottom;
- Group EII was made up of microfill composite and Glass fibre at the bottom;
- Group EIII glass fibre layer was sandwiched between two layers of hybrid composite;
- Group EIV glass fibre layer was incorporated between two layers of microfill composite.

**Preparation of the specimens:** The specimens (n=90) were prepared by placing the composite into a standard stainless steel split mould (25x2x2 mm) according to ISO 4049 specifications.

**In control group C 1:** Lubricated mould was taken and placed over a mylar strip on a glass slab. The mould was filled with hybrid composite material in imcrementsby using plastic instrument and the resin was condensed till it was filled up to the brim of the mould and then covered with a mylar strip. The mould was gently pressed with another glass slab for the excess material to extrude. Photo-polymerization of the specimens were performed, from top of the mould (only from one side) by a blue light-emitting diode (ULTRA-LITE, Unicorn Medident Pvt. Ltd, New Delhi, INDIA), with the light intensity of 500E W and the wavelength range of 440 to 480 nm. The radius of the tip of the curing light was measured as 11.5 mm.

**In control group C II:** Same procedure was carried out to fill the mould with microfill composite material. The resin was condensed in mould by plastic instruments till it filled the entire mould and covered with a mylar strip. Mould was gently pressed with another glass slab for extrusion of excess material. Photo-polymerization of the each specimen was performed, from top of the mould, by a blue light-emitting diode.

**In experimental group E I:** Lubricated mould was placed on a glass slab. Mylar strip was used in between mould and glass slab for smooth surface of the samples. Interwined preimpregnated glass fibre (Interlig) (0.02 mmin thickness,2 mm in width and 25 mm in length) cut from a 87.5 mm long strip and was placed with a tweezer to the bottom of the mould (tensile side). Rest of the mould was filled with hybrid composite onto the fibre and condensed thoroughly. A mylar strip was placed over composite filled mould and covered with another glass slab to extrude excess material. Photo-polymerization of the specimens was performed from top of the mould, by a blue light-emitting diode.

**To make specimens for experimental group E II:** Same procedure was performed as in experimental group I and the mould was filled with microfill composite onto the fibre and composite material condensed in mould by plastic instruments. Rest procedure was same.

**To prepare specimens for experimental group E III:** After placing the mylar strip on the glass slab, a layer of hybrid composite material was condensed on to the base of the lubricated mould and covered with a strip of glass fibre (Interlig) (0.02 mm in thickness, 2 mm in width) in 25 mm length. After placing the glass fibre, rest of the mould was filled with hybrid composite onto the fibre. Rest procedure was same.

**To prepare specimens for experimental group E IV:** Whole procedure was same as for experimental group III and composite material used was microfill composites. After polymerization, the specimens were trimmed with BP knife but not polished. The specimens were removed from the mould, and stored for 24 hours at 37˚C in distilled water. After that specimen were subjected to thermal cycling 3000 times in between 5 to 55˚C temperature with dwell time 30 seconds, to simulate clinical conditions. Transfer time was 5 second. All the specimens were weighted before and after storage to measure thickness and width of the specimens by using a digital micrometer (Digimatic, Mitutoyo Corp., Niles, IL, USA), with an accuracy of 0.01 mm at three locations along the rectangular bar specimens. A three-point bending test was carried out to assess the flexural strength of the specimens. The distance between the supports was 20 mm. Load application was performed by using a universal testing machine (UNITEK 9450, Fuel Instruments & Engineers Pvt. Ltd., Yadrav 146-145, Maharashtra, INDIA). Load was applied at the middle of the specimens at 90° to the long axis of the specimen, at a crosshead speed of 1 mm/min. The specimens were loaded until the first sound of crack was heard and the load was recorded in kilo Newton. Fractured parts of specimens were observed under scanning electron microscope. The specimens of control groups (hybrid and microfill composites) fractured in two parts whereas specimens of experimental groups III and IV (containing glass fibres) did

not detach, they showed meshy glass fibres at the location where anvil of the universal testing machine touched during load application. The specimens of experimental group V and VI (hybrid and microfill composite containing glass fibre at middle of the specimen) also fractured in two parts.

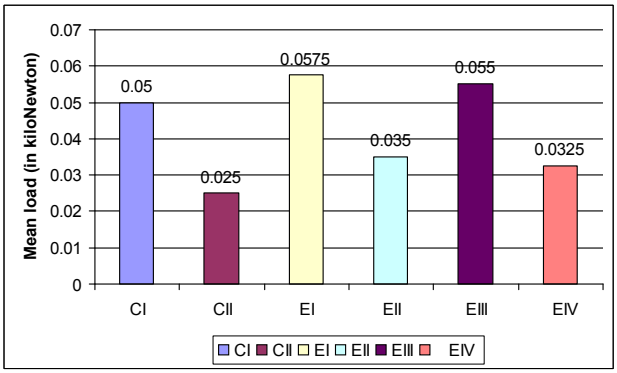
Flexural strength was calculated by using the following equation:

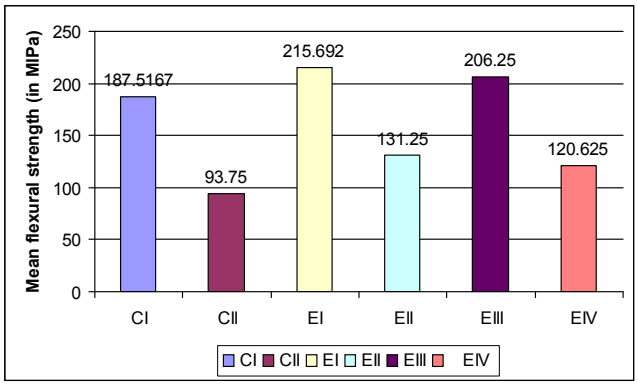
Flexural strength MPa= 3Fl/2bh2

where F is the maximum load in kiloNewton exerted on the specimen, l is the distance between the supports (20 mm) and b and h are the width and thickness of the specimen (2 mm). All the dimension were taken in meters. The flexural strength values obtained were in Pascal which then converted to Megapscal (MPa) by dividing to 10 (Freilich, 2000). Statistical analysis was performed by using analysis of variance (ANOVA) to measure variance within group and among the groups. For pairwise comparison of flexural strengths between two groups, the student 't' test was used.

## RESULTS

Mean fracture load was maximum for group E I 0.0575 kiloNewton whereas minimum for group C II 0.0250 kiloNewton. Mean score for flexural strength was maximum 215.692 MPa in group E I of hybrid composite containing glass fibre layering at the tensile side of the specimens. Whereas, minimum 93.75 MPa for group C II of microfill composite without glass fibre layering. Flexural strength was calculated from fracture load by following formula




Flexural strength= 3Fl/2bh2

**Conclusion of analysis**

- Load in MPa differ significant in the different groups ($p<0.001$).
- The flexural strength was found maximum in the experimental group E I (215.69±7.92 MPa).
- The load was found minimum in control group C II 93.75±7.09 MPa.
- Load was found maximum in experimental group E I (215.69±7.92 MPa), than in experimental group E III (206.25±9.38 MPa), than in control group C I (187.52±8.72 MPa), than in experimental group E II (131.25±6.14 MPa) , than in experimental group E IV 120.63±7.82 MPa and minimum in control group C II (93.75±7.09 MPa).

**Result load:** Group E I > Group E III >GroupC I > Group E II > Group E IV > Group C II

## DISCUSSION

For increasing demand for esthetic material, the present study was chosen to evaluate the mechanical properties of most commonly used esthetic restorative material, composites resins and also how to improve its most important mechanical property that is flexural strength. The present study effect of Glass Fibre Layering on The Flexural Strength of Hybrid and Micro fill Composites. Was undertaken to evaluate the mechanical properties of resin based composite materials. The study included evaluation of flexure strength of two types of composite materials, hybrid and microfill along with and without glass fibre reinforcement. Microfill composites with finer particle fillers allowed better polish retention while enhancing esthetics, but offered less strength (Smith, 1962; Daniel Fortin, 2000; Johnson, 1993; John, 1981). Thus, they are chosen primarily for esthetic-driven anterior restorations (John, 1981). Hybrid composites blended in larger particle fillers to improve strength but were less polishable, resulting in more of a matte rather than gloss finish. They were chosen for their durability for posterior restorations in which strength was essential (Karl Lyons, 2003). Hybrid resin, originally introduced as esthetic restorative material to restore posterior region (Leinfelder *et al*., 1999; Karl, 1995; Burgess, 2002), but mechanical properties were still inferior as compared to other non-esthetic restorative materials. So the present study was intended to improve the mechanical properties of esthetic restorative materials. Of late, beware of, increasing demands for esthetic restorations, glass fibres are likewise widely used for reinforcement of dental restorative materials.18 This is because glass fibres have excellent transparency and can bond chemically to dental polymers —such as methyl methacrylate, Bis-GMA, or UDMA —by silanization. Materials used in the study were Hybrid composite, Microfill composite and Glass fibres for reinforcement.

Distribution of Specimens was as follows;

**Control Groups:**

- Group CI -hybrid composite specimens without reinforcement
- Group CII -microfill composite specimens without reinforcement

**Experimental groups**

- Group EI -glass fibre reinforcing the hybrid composite at the bottom;

- Group EII -microfill composite and Glass fibre at the bottom;
- Group EIII -glass fibre layer was sandwiched between two layers of hybrid composite;
- Group EIV- glass fibre layer was incorporated between two layers of microfill composite.

Hybrid composites are formulated to provide better strength, wear resistance, polishability and coefficient of thermal expansion of hybrid composite, is close to that of tooth structure (Burgess, 2002). So that posterior teeth can also be restored with resin based composites (Burgess, 2002). Mechanical and physical properties of reinforced composite resins are comparable to the enamel and dentin which makes it materials of choice for restoring posterior cavities (Williems, 1993). In the present study, it was hypothesized that use of reinforcing fibres will improve the load bearing properties of hybrid and microfill composites. Fibre reinforcement is currently a popular approach in aesthetic dentistry, since the composite resin itself fails to maintain an adequate retention to supporting structures (Alfredo de Aquino Gaspar Junior, 2009; Takahito, 2006). For reinforcement, glass fibres are taken because of excellent transparency and can bond chemically to dental polymers such as methyl methacrylate, Bis-GMA, or UDMA by silanization. The strength of the fibre reinforced composite structure is dependent on the adhesion between the FRC framework and veneering composite (Lassila *et al*., 2005). In cases where composites are reinforced with glass fibre, position of the fibres may affect the initial and final failures of composite. So the reinforcing capacity of fibres is dependent on their adhesion to the resin, on the orientation of the fibres, and on preimpregnation with the resin (Freilich *et al*., 1998; Takahito, 2006; Bae *et al*., 2004). Glass reinforcement fibres are made of silicon oxide, aluminum and magnesium (Vistasp. 2007). So in this study, pre-impregnated unidirectional braided glass fibres were used as a reinforcement to improve the mechanical properties of hybrid and microfill composites. According to the methodology used, fracture load was applied vertical to the glass fibre layering.

In the present study, hybrid and microfill composite resins were compared, with and without glass fibre layering at different locations. The specimens (n=90) were prepared by placing the composite into a standard stainless steel split mould (25x2x2 mm) (International Organization for Standardization, 1992; Ellakwa, 2002). Mould was prepared by stainless steel metal because it is non-reactive and maintains the dimensional stability of the test materials. Resin mould may react with resin based polymerizing composite materials and Teflon coated mould may fail to maintain the dimensions of the experimental specimens. Light activation is the most common method of initiating the polymerization process in resin composites for use in restorative dentistry. Light emitting diode (LED) was used to polymerize specimens because the use of LED is preferred over halogen light and plasma argon laser due to no heat production. Multiple overlapping curing was used to polymerize the specimens because the exit window of clinical light cure units is smaller than 25 mm (Chung, 2004). After curing, the specimens were removed from the mould, and were trimmed with BP knife, finished but not polished on the surfaces before testing. All applications were performed in our department, in order to standardize laboratory procedures. The specimen were subjected to thermal cycling to simulate clinical conditions prior to flexural strength test (Queiroz *et al*., 2012).

Three point bending test was perfomed to test flexural strength of the specimens by using Instron, Universal Testing Machine to apply fracture load at crosshead speed 1 mm/min (Ellakwa *et al*., 2002). Test was done in collaboration with Research and Design of Standard Organization (RDSO), Lucknow. Crosshead speed may be from 0.75 to 1.00 mm/min (International Organization for Standardization, 1992). 3-point bending test is reliable in evaluation of flexural strength of resin-based dental composites (Ellakwa *et al*., 2002; Chung *et al*., 2004; Manhart *et al*., 2000; Xu *et al*., 2003). All the specimens were fractured at fracture load. All specimens without glass fibres,were fractured in two parts after application of fracture load whereas groups containing glass fibres at tensile surface, remained in one part despite of fracture of superficial composite materials. Reading of fracture load was collected in KiloNewton. Flexural strength of individual specimen, was calculated in MegaPascal. The flexural strength and elasticity modulus are the most important mechanical properties for the evaluation of fibre reinforcement systems (Ellakwa *et al*., 2002; Chung *et al*., 2004; Manhart *et al*., 2000; Xu *et al*., 2003; Chung *et al*., 1990). The results obtained from this study can be summarized in order of merits and their performance

**Group E I > Group E III > GroupC I > Group E II > Group E IV > Group C II**

From the result, it was concluded that flexural strength of hybrid composite without fibre reinforcement, was significantly higher than microfill composite ($p<0.001$), whether microfill composite specimens were reinforced or not. Glass fibre reinforcement significantly improved the flexural strength of both hybrid as well as microfill composites either it was placed at tensile side or inside the specimens. But tensile side placement of glass fibre improved the flexural strength more significantly as compared to inside placement of glass fibres ($p<0.001$). Glass fibres at both two different locations, significantly improved the flexural strength of unreinforced hybrid and microfill composite resins. Observations were statistically analyzed by analysis of variance (ANOVA) and student 't' test. Fibre reinforcement significantly improved the mechanical properties of composite materials (International Organization for Standardization, 1992).The fibre-reinfocement characterized by its length (Vallittu, 1996). Chopped fibres when randomly mixed into composite, presumably some fibres oriented to produce beneficial effects and others little or no effect (Carlos, 1997).

Thus the fibres were not used in either the chopped or woven form but in the braided parallel form. In continuous fibre composite the bundle fibres are called as roving and consist of thousands to two lacs single fibres. Braided fibres do not separate from each other and resist fracture load more as compared to unidirectional fibre bundle. Braided fibres does not spread and fall apart during manipulation (Premnath) and resist flexure load. This study was in agreement with the previous studies where addition of glass fibre layer placed in the tensile side (base), improved the flexural strength of both microfill and hybrid composites. When three-point flexural test was conducted, the greatest tension occurred at the outermost position of the fibre reinforced polymer so the reinforcement should be placed at tensile side of the restoration (Takahito, 2006). Whilst moving the fibre reinforcement away from the tensile side by up to 1·5 mm led to a significant reduction in flexural strength (Ellakwa, 2003; Nayereh Rashidan *et al*.,

2010) Clinically, axial forces in addition to lateral forces and fatigue loading should be considered (Garoushi *et al*., 2006). Many differences exist between fractures occurring clinically and those induced by universal testing machine. Force generated intraorally during function vary in magnitude, speed of application and direction whereas the force applied on the specimens in this study, were at a constant direction and speed and they were increased continually until the fracture occurred. The result of the present study that the flexural strength of hybrid composite was found higher than microfill composite, are in agreement with previous studies (Yap *et al*., 2003; Chung, 1990).

The flexural strength hybid and microfill composite presented significant improvement in association with glass fibre layering. The resistance to fracture of microfill composite improved without diminishing esthetics. The flexural strength and fracture resistance of the restoration increased by the addition of reinforced fibres as concluded in their studied by (Takahito, 2006; Jang, 2005; Douglas, 2006).

In the present study, fibres placed at tensile side showed more significant improvement as compared to fibres placed within the composite materials. Further developments in fibre reinforcement systems and various applications such as using flowable composites under fibre-reinforced resin restorations may enhance better results in the fracture resistance of the restorations and could be examined in future studies. The result of the present study indicated that the use of a fibres under or inside the restoration significantly increases fracture strength. However the clinical conditions and complexity of forces generated described in this study must be evaluated further in vivo.

**Conclusion**

Within the limitations of the experimental design, the present study conclude that:

- Glass fibre reinforcement of the hybrid and microfill composites improves the flexural properties of the composite resin materials significantly. Thus, fibresreinforced composites may offer an better alternative in high stress-bearing areas
- Glass fibres placed at bottom of composites provide greater reinforcement compared to fibres placed at middle of resin composites.

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