



## **In-vitro Shear Bond Strength of a Nano-composite Resin in Comparison with Microfilled and Microhybrid Composite Resins**

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### **Authors' contributions**

This work was carried out in collaboration between all authors. Authors MS and NS designed the study, wrote the protocol and wrote the first draft of the manuscript. Author AS managed the literature searches. Authors PKS, TT and CT wrote the final draft of manuscript. All authors read and approved the final manuscript.

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### **ABSTRACT**

**Background:** Nanotechnology has revolutionized all aspects of research and development, and dentistry has not been an exception. Nanocomposites are a gift of this nanotechnology. Extensive work has been done on its various physical properties, but few studies have been conducted on its shear bond strength.

**Aims:** The present study was undertaken to determine the shear bond strength of nanocomposites and to compare it with that of the microfilled composites and the microhybrid composites.

**Materials and Methods:** The study specimen consisted of 45 extracted human teeth which were divided into 3 groups [A, B and C] of 15 specimens each. The teeth were embedded in resin blocks

and a flat dentin surface was prepared on buccal aspect. Bonding agent was applied and light cured. The specimens of group A, B and C were restored by using microfilled, nanofilled and microhybrid composites respectively. The cured samples were placed in distilled water and stored in incubator at 37 degree Celsius for 48 hrs. Shear bond strength was measured using Universal Testing Machine (Unitek No 9450).

**Statistical Analysis:** ANOVA was used and  $p \leq 0.05$  was considered to be statistically significant.

**Results and Conclusion:** Mean Shear bond strength of nanocomposites was less than that of microhybrid composites, but the difference was not statistically significant. The Mean shear bond strength of the nanocomposites was more than that of microfilled composites and the difference was statistically significant.

*Keywords: Nanocomposites; microfilled; microhybrid; shear bond strength.*

## 1. INTRODUCTION

A vast variety of restorative materials are available in the market today with composites in the lead. The composites are available in great variety of forms like microfilled, macrofilled, hybrids, microhybrids etc. Until recently, research was on to develop a composite which could satisfy both the requisites of an ideal restorative material *i.e.* usage in highly stress bearing areas in the posterior region as well as in esthetically demanding anterior region [1].

Nanotechnology, molecular nanotechnology or molecular engineering is the science dealing with the production of substances on a nanometric scale with the particle size ranging from 0.1 nm to 100 nm [2]. Hence, the properties and the structure of materials can be altered at the nanometer level to bring about dramatic improvements [3]. In keeping pace with this novel nanotechnology, dentistry has maintained a contemporary outlook and has applied this technology in the development of nanocomposites.

In oral cavity, compressive, tensile and shear forces are constantly present, influencing the dental restorations during mastication and parafunctional activities which may fracture or debond them. The nanocomposites have vowed to be the savior in this area as claimed by different authors [4-9]. These materials have excellent esthetics, durability and strength with a combination of scientific principles for increased longevity. The improved properties may be owed to increased interfacial interaction between resin and fillers [10].

Shear stresses produced by functional and parafunctional forces lead to breakdown of bonds between hydroxyapatite crystals and may result in bulk enamel loss, similarly this can lead to the bond fracture between the enamel and composite restoration.

Although ample amount of work has been done on the compressive strength, tensile strength and fracture resistance of nanocomposites [5,8,9,11-15], but little research has been done to assess their shear bond strength that plays a significant role in the longevity of these restorations [16-18].

Therefore, a study was designed to examine the shear bond strength of nanocomposites and later compared to those of microfilled and microhybrid composites to validate the clinical applicability of these materials.

## 2. MATERIALS AND METHODS

The study specimen consisted of 45 extracted human permanent upper and lower molars. The patients were selected from the outpatient department of Oral & Maxillofacial surgery and department of Periodontics, King George's Medical College, Lucknow, India.

The sample teeth were chosen based on the following inclusion criteria: the teeth were freshly extracted; the teeth had sound enamel and dentin; the teeth were caries free and unrestored. The study was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2000 [19].

Teeth were cleaned thoroughly and stored in physiological saline solution [16]. Each tooth was held in 30 mm x 8 mm x 10 mm block of autopolymerizing acrylic resin.

A flat surface was prepared in dentin on buccal surface of teeth by grinding with carborundum disc under water spray followed by smoothing of the prepared surface with carborundum paper no. 200 and finally with paper no. 1000. A mylar strip with a round hole of 3.2 mm diameter was centered on the dentin surface to standardize the exposed area.

The Primer, **Unifil bond** (Light cured bonding system, GC Corporation, Tokyo, Japan) was applied on to the dentin surface of the prepared tooth with the applicator. It was left undisturbed for 20 seconds and then gently dried with an air syringe for 5 seconds followed by the application of bonding agent, **Unifil bond** (Light cured bonding system, GC Corporation, Tokyo, Japan) to the primed dentin surface. It was blown gently with an air syringe to form a thin film and light cured for 10 seconds with curing tip distance of 2 mm from the specimen.

Specimens were divided into 3 groups of 15 each on the basis of type of composite used:

- Group A: Microfilled composite (Durafill VS, Heraus-Kulzer, Wehrheim, Germany) Shade A2
- Group B: Nanofilled composite (Ceram X, Dentsply Caulk) Shade A2
- Group C: Microhybrid composite (EsthetX, Dentsply Caulk) Shade A2

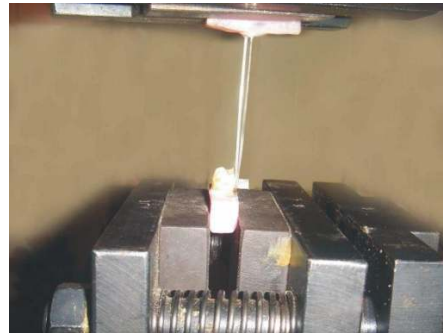
A translucent plastic cylinder of 3.2 mm diameter and 6 mm height was used to build the composite. Three layers of composite approximately 2 mm in height were applied and individually light cured so as to simulate the incremental technique that is followed in a clinically large composite restoration [20] (Fig. 1). The curing time was as per the specifications of the manufacturer. The cured samples were placed in distilled water and stored in an incubator at 37 degree centigrade for 48 hours.



**Fig. 1. Prepared sample**

Shear Bond strength was tested with the help of Universal testing machine (Unitek No. 9450, PC, FIE, India) at Research, Design and Standard Organization (RDSO) Lucknow, India. A portion of the specimen block was attached to a specially formed jig, which was affixed to the holding arm of the machine. Shear force was applied with the help of wire loop perpendicular

to the vertical axis of the composite cylinder at a distance of 0.2 mm from the bond interface (Fig. 2). The crosshead speed was 1 mm/min. The load at which the sample got debonded was recorded and shear bond strength was calculated (Fig. 3).



**Fig. 2. Sample clamped in Universal Testing Machine**



**Fig. 3. Debonded sample**

## 2.1 Statistical Analysis

ANOVA was applied to the data to calculate the level of significance. Data was represented in the form of Mean $\pm$ SD and 'p'  $\leq$ 0.05 was taken as the level of statistical significance.

## 3. RESULTS

Shear bond strength of nanocomposites was higher (18.97 $\pm$ 1.73 MPa) than that of microfilled composites (15.56 $\pm$ 1.77MPa) and the difference was found to be statistically significant (p < 0.001) [Table 1].

The comparison of nanofilled and microhybrid composites revealed insignificant differences (p > 0.05). The mean shear bond strength of microhybrid composite was slightly higher

(20.02±1.07 MPa) than that of nanofilled composite (18.97±1.73MPa) [Table 2].

#### 4. DISCUSSION

The functional and parafunctional forces produce shear stresses which may lead to debonding of composite restoration in a manner similar to the tensile and shear stresses generated in the cervical region of a tooth that cause breakdown of the bonds between the hydroxyapatite crystals. This can be explained on the basis of a biomechanical theory postulated by Levitch et al [21], which states that the mechanical overloading of cervical enamel caused by cuspal flexure may contribute to non-carious cervical tooth loss. As the tooth flexes, the cusps are subjected to axial compressive load, resulting in tensile and shear stresses acting at right angles to the axial load in a manner similar to a diametral compression test [22]. This causes breakdown of the bonds between the hydroxyapatite crystals leading to crack initiation, and the resultant crack growth resulting in bulk enamel loss [23,24].

Therefore, it becomes imperative for an apt clinician to know which composite material can suitably tolerate the shear forces acting against them and be esthetic at the same time.

Nanotechnology has a significant contribution in resin composite research. Due to the reduced dimension of particle size and a variable size distribution, an increased filler load can be achieved with the consequence of reducing the polymerization shrinkage and improving the mechanical properties such as tensile strength, compressive strength and resistance to fracture. These may be equivalent to or higher than those of universal composites and significantly higher than those of microfilled composites [8].

In the present study, caries free, unrestored human permanent molars were used as per the guidelines of the International Standards Organization (ISO/technical committee 106/ SC1/ WGII, 1991) [25]. Durafill VS, Ceram X and Esthet X were used as the microfilled, nanofilled and microhybrid composites respectively as these materials are easily available in the local market and are manufactured by companies of international repute. The shear bond strength testing was done with the help of computerized Universal Testing Machine (Unitek No. 9450, PC, FIE, India) using wire loop method at a crosshead speed of 1 millimeter per minute. This is similar to the method employed in previous studies [16].

**Table 1. Analysis of variance of shear bond strength in various groups**

Source of variation	Degree of freedom	Sum of square	Mean sum of square	'f' ratio	'p' value
Between the groups	2	163.237	81.618	44.235	< 0.001
Within the groups	42	77.495	1.845	-	-
Total	44	240.732	-	-	-

**Table 2. Comparison of Shear Bond strength of Group-A & B**

	Group-A	Group-B
Number of sample	15	15
Mean shear bond strength (in MPa)	15.56	18.97
Standard Deviation (S.D.)	1.772	1.7327
Standard Error (S.E.)	0.2402	0.3536
Range (in MPa)	13.68 - 17.67	16.06 – 21.65

( $t' = 6.31$ ,  $p' < 0.001$ )

**Table 3. Comparison of Shear Bond Strength of Group-B & C**

	Group-B	Group-C
Number of sample	15	15
Mean shear bond strength (in MPa)	18.97	20.02
Standard Deviation (S.D.)	1.7327	1.0712
Standard Error (S.E.)	0.3536	0.2186
Range (in MPa)	16.06 – 21.65	18.04 – 21.77

( $t' = 1.99$   $p' = 0.08$ )

The investigations revealed that the mean shear bond strength of microfilled composite was  $15.56 \pm 1.77$  MPa approximating the results of Roh and Chung [16] and Almuammar et al. [26]. The mean Shear Bond strengths of nanocomposites was  $18.96 \pm 1.73$  MPa and that of microhybrid was  $20.02 \pm 1.07$  MPa.

Every effort to minimize the formation smear layer was taken such as the preparation of the facial surface of crown was done under water cooling, as smear layer has an impact on bond strength.

Absence of thermocycling can be a drawback of the present study, however there is a question that arises over the validity of this procedure since the temperatures used to stress restorations may not be the real temperatures of cold and hot food/beverage tolerated by patients [27].

Mode of failure during bond strength determination was also not determined, which was another drawback of the study.

Therefore, based on the results of the study, it can be said that nanocomposites are ideal for both anterior and posterior restorations as they possess excellent esthetic and mechanical properties. This is analogous to the investigations done by previous researchers who demonstrated that microfilled composite resin exhibited the lowest mechanical properties and nanofilled resin composites showed mechanical properties as good as those of universal hybrids and therefore can be used in similar clinical situations [8].

Unfortunately, restorations are often done in conditions that are far from ideal i.e., in a complex oral environment. Hence, the physical and mechanical properties of composite restorations may practically differ in a clinical environment.

## 5. CONCLUSION

Within the limitations of the study it can be concluded that Microfilled composite resin exhibited the lowest mechanical properties. Nanofilled resin composites showed mechanical properties atleast as good as those of the universal hybrids. So based on the strength and esthetic properties of the resin based nanocomposites should allow the clinician to use it for both anterior and posterior restorations.

Further studies to test the clinical performance of these new generation composites should to be conducted for universal acceptance.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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