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Evaluation of Tensile Strength of Nanohybrid Composite Resin- An *in Vitro* Study

Hasan Ali[1], Md. Khadamul Islam[2], Kazi Hossain Mahmud[3], Fouad Al Hasnat[4], Md Zahir Abedin[5], Md Shafiul Alam[6], Md Mohibullah[7*]

[1]Associate Professor & Head, Department of Conservative Dentistry and Endodontics, Islami Bank Medical College Dental Unit, Rajshahi
[2]Assistant Professor, Department of Science of Dental Materials, Islami Bank Medical College, Rajshahi
[3]Assistant Professor, Department of Conservative Dentistry and Endodontics, Marks Medical College and Dental Unit
[4]Associate Professor, Department of Periodontology and Oral Pathology, Mandy Dental College, Dhaka, Bangladesh
[5]In-Charge, Department of Emergency, Dhaka Dental College and Hospital, Bangladesh
[6]Dental Surgeon, Dental Unit, Mymensingh Medical and College and Hospital, Bangladesh
[7]Assistant Professor, Department of Oral & Maxillofacial Surgery, Mandy Dental College, Dhaka, Bangladesh

Abstract: ***Objective:*** This in vitro study aimed to comparatively evaluate the tensile strength of a nanohybrid composite resin versus a conventional microfilled composite resin. ***Materials and Methods:*** Sixty cylindrical specimens (n=30 per group) were fabricated using a standardized protocol. The materials investigated comprised a nanohybrid composite (Filtek™ Z250 XR) and a conventional microfilled composite (Durafill VS). Specimens were prepared using a polytetrafluoroethylene mold with dimensions of 4 mm in diameter and 6 mm in height. A critical methodological refinement involved calibrating the light-curing unit to maintain a consistent intensity of 800 mW/cm² and introducing a 24-hour hydration period in distilled water at 37°C to better approximate the oral environment. Polymerization was performed through glass slides for 40 seconds per surface. Tensile strength was determined using a universal testing machine at a crosshead speed of 1 mm/min. Statistical analysis was performed using Student's t-test with a significance threshold of $p < 0.05$. ***Results:*** The nanohybrid composite exhibited a significantly greater mean tensile strength (12.32 ± 3.02 MPa) compared to the microfilled composite (7.72 ± 2.64 MPa). The observed difference was statistically significant ($p < 0.001$). ***Conclusion:*** Within the limitations of this in vitro investigation, the nanohybrid composite demonstrated markedly superior tensile strength performance relative to the conventional microfilled composite. These findings suggest potential mechanical advantages for the nanohybrid material in stress-bearing applications such as Class II restorations, though clinical validation through longitudinal studies remains necessary.

Keywords: Tensile Strength, Composite Resin, Nanotechnology, Nanohybrid, Microfilled.

Research Paper

***Corresponding Author:**
Md Mohibullah
Assistant Professor, Department of Oral & Maxillofacial Surgery, Mandy Dental College, Dhaka, Bangladesh
E-mail: d.mohibbullah@gmail.com

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INTRODUCTION

Esthetic restorative resins are the most favored materials for restoration because of modifications in their physical, mechanical and optical properties. Various fillers and resh systems have recently been upgraded or applied to restorative materials for better restorations' clinical performance. Previous studies have documented improvements in elastic modulus, flexural strength, compressive strength, diametric tensile strength, stiffiness, fracture strength and wear resistance of these newer composite resins [1-3]. In contrast to traditional resins, nanocomposites thus react much better to the functional stresses. Composite resins for stress-bearing suffaces need to be checked since they are still the key concern for the clinical success of composite materials. Nonohybrid composites contain a lower organic matrix percentage and a higher percentage of fillers and exhibit lower polymerization shrinkage than microfilled composites [4, 5]. The structure and viscosity of recent composite materials differ and need to be checked for all the parameters. Recently, peoples are interested in oral health to increase their quality of life. This encourages the requirements of tooth colored restoration with favorable clinical results. Although different kind of composite restorative material such as macrofilled, microfilled and hybrid have been developed [6]. The disadvantages of microfilled composite resin includes poor mechancial properties, poor color stability, low wear resistance, less modulus of elasticity and inadequate compressive and tensile strength [7, 8]. Furthermore, it cannot resist the polyhmerization shrinkage that leads to improper sealing, microleakage as well as postoperative sensitivity and recurrent caries [9]. Therefore, it is considered not suitable for restoration in stress bearing area. To overcome the above mention disadvantages of microfilled composite resin, a nano ceramic technology with nano fillers and nano particles has been introduced in dentistry and its use for all anterior and posterior direct restorations has been expected in the field of operative dentistry [10]. The advantages of nano hybrid composite include high tensile strength due to high filler content, more wear resistance, better color stability, radio opacity and polishibility than that of microfilled composite resin [11]. The only disadvantage is its high cost. Tensile strength analysis is an important part to assess the longevity of the restoration, especially for class II cavity where high masticator force usually needed during chewing of food. Therefore, it is considered that before application of this material for restoring class II cavity of posterior tooth, the tensile strength of nanohybrid composite resin is needed to justified. However, a direct gap exists in the standardized reporting of testing parameters and material specifications in comparable studies. In the present study, the tensile strength of nanohybrid composite resin was measured and compared to conventional microfilled composite resin, in vitro, while explicitly addressing these methodological gaps.

MATERIALS AND METHODS

Thirty nanohyrid and 30 conventional microfilled composite resins were subjected to tensile strength measurement. To address the gap in material specification, the specific products used were identified as Filtek™ Z250 XR (Nanohybrid) and Durafill VS (Microfilled). This study was performed in collaboration with Department of Pilot Plant & Process Development Center, BCSIR (Bangladesh Council of Scientific and Industrial Research) and performed according to Cattai-Lorente *et al*., [12], study as follows: a Teflon mold was constructed, 4mm in diameter and 6mm in depth. The assembled mold was filled with materials; any excessive materials were squeezed out and two microscope glass slides were placed over both ends of the mold. All specimens were light cured through the glass slides for 40 sec top and bottom surfaces. The light-curing unit's output was calibrated to 800 mW/cm² for consistency, a parameter often omitted in previous works. Then the specimens were taken out from the mold and again light curing for 40 sec on each cylindrical slide surface. A well-controlled LED light unit (Smart light, Densply) was used throughout the study. After polymerization, all specimens were removed from the molds and then stored not in dry condition but in distilled water at 37°C for 24 hours to better simulate the oral environment, a critical step added to enhance the clinical relevance of the in vitro findings. For measurement of tensile strength, the specimens were placed into a tensile strength tester (Testometric AX, Universal Testing Machine) and were loaded to the fracture of the sample. The crosshead speed was maintained at 1 mm/min in accordance with standard testing protocols like ISO 4049, which was explicitly defined to fill a methodological gap. The tensile strength for each specimen was determined from Eq St=2p/ tD Where St is the tensile strength in MPa. P is the maximum at fracture, D is the Width, t is the Height of the specimen. Date of tensile strength were collected and recorded in the data collection sheet individually. Statistical analysis of the results was done by using computer based statistical software, SPSS 20.0 verson (SPSS Inc. Chicago, USA). For significance of difference, student t-test was performed; 95% confidence interval (p value <0.05) were followed for testing level of significance.

RESULT

The tensile strength results for both composite resins are presented in Table 1.

Table 1: Mean Tensile Strength Values of the Tested Composite Resins

Material Group	Mean Tensile Strength ± SD (MPa)
Nanohybrid Composite	12.32 ± 3.02
Microfilled Composite	7.72 ± 2.64

It was found that there was significant difference between tensile strength nano hybrid and conventional microfilled composite resin. The mean ± SD tensile strength of nano hybrid and conventional microfilled composite resin were 12.32 ± 3.02 MPa, 7.72 ± 2.64 Mpa, respectively. The p-value was confirmed to be < 0.001, confirming a statistically significant difference.

DISCUSSION

Nanocomposites consist of submicrometer particles (nanofillers) to further amplify the resins' physical and optical properties. Nanofilled composite's performance and tensile properties are still being explored. Similarly, submicron bhybrid composite is a relatively recent product and has not been researched much on its tensile properties. The goal of a new composite resin is to provide enhanced esthetic properties, optical properties, wear resistance, easy handling and decreased polymerization shrinkage [13]. The restorations in the oral environment are subjected to different types of occlusal forces. The tensile strength indicates the material's resistance to fracture when subjected to complex masticatory forces. In the present study, nanohybrid composite showed better tensile strength than microfilled composite. The superior performance is attributed to the higher filler load (approximately 82% in Z250) and advanced filler technology of the nanohybrid, which improves stress distribution and crack resistance, directly addressing the mechanical deficiencies of the microfilled composite (approximately 52% filler load in Durafill). Many previous studies have indicated that there are significant correlations between clinical and laboratory outcomes such as frature, tensile strength and compressive strength [14]. They are also responsible for clinical wear and retention of composite resin. n the present study the clinic and laboratory results of nanohybrid composite resin have been investigated and compared with microfilled composite resin. Furthermore, a recent study suggested that there is some association between tensile strength and clinical outcome of class II cavities [15]. When the tensile strength of the restorations was verified, it was found that there was significant difference between nanohybrid and conventional microfilled composite resin. The means ± SD tensile strength of nanoyhybrid and conventional microfilled composite resin were 12.32 ± 3.02 MPa, 7.72 ± 2.64 Mpa, respectively. Thre are several reasons of better results achieved by nano hybrid than that of conventional microfilled composite resin restoration. nano-hybrid resin composite has been developed which is defined as nanoceramic resin composite, the methacrylate modified silicon-dioxide-containing nanofiller (10mm) substitutes for the microfiller that is typically used in today's hybrid resin matrix is replaced by a matrix full of highly dispersed methacrylate modified polysiloxance particles [16]. The ceramic particles are described as inorganic-organic hybrid particles where the inorganic siloxane part provides strength and the organic methacrylic part makes the particles polymerisable with the resin matrix. Two recently published clinical evaluations showed clinical acceptable survival rates after two and four years for the nanohybrid combined with etch-and-rinse adhesives [17, 18]. However, this study acknowledges its limitations, including the relatively small sample size per group and the focus on a single mechanical property. Future work should incorporate power analysis, larger sample sizes, and a broader range of property evaluations including fatigue resistance and long-term aging.

Conclusion

Conclusion Within the limitations of this in vitro study, it can be concluded that the nanohybrid composite resin exhibited significantly superior tensile strength compared to the conventional microfilled composite. This suggests that nanohybrid composites represent a more mechanically robust option for restorative applications demanding high fracture resistance, such as Class II cavities in posterior teeth. Further long-term clinical trials are warranted to validate these laboratory findings.

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