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FRACTURE RESISTANCE OF MOLARS WITH MOD CAVITES RESTORED WITH DIFFERENT COMPOSITE RESTORATIONS - AN INVITRO STUDY

Dental Science

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ABSTRACT

The present study aimed to compare and assess the fracture resistance of fiber reinforced and nanohybrid composite in extensive class II (MOD) cavities. Sixty molar teeth were divided into four groups of fifteen teeth each. Except for the control group (Group1), MOD cavities were prepared on the other groups (Groups 2,3,4) and the prepared cavities were restored in groups 3 and 4 with fiber reinforced and nanohybrid composites respectively. Teeth from all four groups were subjected to a shear load test and their fracture resistance was recorded. Cavities restored with fiber reinforced composites had significantly higher fracture resistance when compared to those with nanohybrid composites. Teeth without any preparation (Group 1) had the highest fracture resistance among the four groups, followed by the teeth restored with fiber reinforced composite. When used to restore MOD cavity preparation, the fiber reinforced composite could resist fracture better than the nanohybrid composite.

KEYWORDS

Fracture resistance, Fiber reinforced composites, Nanohybrid composites, MOD- mesio-occluso-distal

INTRODUCTION

Cavity preparation, viz removal or modification of the compromised portion of the tooth, arguably weakens the tooth structure, thereby increasing the tooth's susceptibility to fracture. MOD (mesio-occluso-distal) preparation is one such extensive cavity preparation. It involves the removal of tooth structure from mesial, occlusal, and distal surfaces, leading to the elimination of marginal ridge, which plays an important role in the fracture resistance of a tooth [1]. Although metal restorations like Amalgam and gold have been the material of choice, they are no longer in use due to various concerns such as mercury toxicity[2], aesthetics[3], etc. Thus, MODs present a significant challenge to the clinician in terms of susceptibility to mechanical failure under functional loads and the choice of restorative material.

The increased demand for durable and resilient dental restorations has led to significant advancements in materials science, particularly with the development of dental composites, which addressed both aesthetic and functional shortcomings of traditional restorative materials. The advent of composites involved the formulation of a resin matrix augmented with inorganic fillers, such as silica or glass, which impart high mechanical strength and desirable translucency. These fillers contribute to the material's ability to withstand masticatory forces and maintain structural integrity. In addition, incorporating bonding agents enhanced the adhesion to enamel and dentin at a microscopic level, leading to a conservative cavity preparation system. Fiber-reinforced and nano-hybrid are novel variants of dental composites, known to optimize both functional performance and aesthetic outcome.

Fiber-reinforced composites (FRCs) constitute the matrix (continuous phase), the fibers (dispersed phase), and the zone in between (interphase). The function of the fibers is to transfer loads from polymer phase to the more durable reinforcing fibers. Also, glass fibers impart aesthetic properties. Functionally, fiber-reinforced composites provide enhanced resistance to masticatory forces and stress distribution within the dental structure. The fibers within these composites act as reinforcements that mitigate the risk of fracture and improve the overall mechanical strength of restorations[4,5]. This makes them particularly useful in areas subjected to high stress, such as posterior teeth. Additionally, their improved adhesive properties ensure better integration with the tooth structure leading to minimally invasive procedures, contributing to the durability and success of restorations.

On the contrary, Nanohybrid composites utilize a blend of nanometer-sized and micrometer-sized fillers, achieving a balance between enhanced strength and superior aesthetic properties. Nano-scale fillers contribute to greater wear resistance and polishability, which results in smoother surfaces and reduced plaque accumulation[6]. The improved mechanical properties of nano-hybrid composites include higher flexural strength and better resistance to deformation under load, making them highly effective for both anterior and posterior restorations[7]. Their ability to closely mimic the optical properties of natural teeth ensures excellent aesthetic integration, enhancing the overall success of dental restorations.

Considering the significant properties of fiber-reinforced and nanohybrid composites in terms of functionality, the present study aimed to compare the fracture resistance of intact teeth and MOD cavities restored by fiber reinforced and nanohybrid composites.

Methodology:

Collection And Storage Of Specimen:

Sixty human permanent molar teeth extracted for periodontal reasons that were free from caries, restorations, cracks, attrition and abrasion were collected from the Department of Oral and Maxillofacial Surgery, S.V.S. Institute of Dental Sciences, Telangana. As per the CDC & OSHA guidelines, teeth were washed thoroughly under running tap water to remove blood & saliva. Soft tissue and other debris covering the tooth surface were removed using an ultrasonic scaler and stored in distilled water.

Grouping Of The Specimen:

The teeth were randomly divided into 4 groups (n=15) based on the surface treatment of dentin as follows
Group-1 – No cavity preparation or restoration
Group-2 - MOD cavity preparation
Group-3 – MOD preparation & restoration [Fiber reinforced composite (GC ever X posterior)]
Group-4 – MOD preparation & restoration [Nano filled composite (Tetric N Ceram)]

Preparation Of Specimens (fig 1- 6):

All the specimens were embedded in resin blocks until CEJ using auto polymerizing acrylic resin.

- **Cavity Preparation**

Standardized MOD cavities were prepared in groups 2,3,4 by a single trained dentist. The cavities were prepared to a 2.0 mm pulpal depth, 1.5 mm gingival depth, 2.0 mm axial height, parallel walls with 3.0 mm buccolingual width across the groups 2,3,4 for standardization. The access to the cavity was created using a high speed aerotor with a spherical bur, while the rest of the cavity was prepared using a 245 bur. Each bur was used to prepare four teeth, after which it was replaced. Care was taken to prevent thermal changes while preparing the cavity using cooling methods. Cavities were rinsed and dried post preparation.

- **Bonding And Restorative Protocol**

The specimens from groups 3 and 4 were acid-etched with 37% orthophosphoric acid for 15 seconds, rinsed with water, and blot dried. Total etch adhesive (Tetric N Bond) was applied onto the etched cavities and excess solvent was removed using a gentle stream of air. Light curing was done with a light emitting diode curing light for 20 seconds at an intensity of 1200 mW/cm^2. Following this, the specimens were restored with a specific cement assigned to its group. The specimens were light cured for 20 seconds using light emitting diode.


Fig 1: Cavity preparation


Fig 2: Acid etching


Fig 3: Application of bonding agent


Fig 4: Curing the bonding agent


Fig 5: Restoring the cavity with composite


Fig 6: Curing the composite

Fracture Resistance Testing:

The 60 specimens were subjected to shear load by a Universal testing machine (Fig 7) at a 0.5 mm/min crosshead speed. The load was applied until restoration failure occurred.

Fig 7: Universal Testing Machine

Sample Analysis: The point of shear load at which the tooth fracture occurred was calculated in Newton (N), as the fracture resistance.

Statistical Analysis:

The data was analyzed using Statistical Package for Social Sciences 20.0 (IBM SPSS 20.0). The mean, standard deviation, minimum, and maximum values of the sample were calculated. The difference in fracture resistance among and between the groups was tested using Kruskal Wallis and Mann Whitney U tests, respectively. The level of significance was set at p<0.05.

RESULTS:

Specimen from Group 1 (intact teeth) had the highest mean fracture resistance (4096.46±668.11) followed by the teeth restored with fiber reinforced composite (2918.06±560.63). Teeth with cavity preparation and without restoration had the least mean fracture resistance (1656±20±274.35). The mean values were significant(p<0.05) **(Table 1)** When the mean values of the Groups 2,3,4 were compared against Group 1, the difference between the fracture resistance values was significant(p<0.05) **(Table 2)**

Table 1: Mean, Standard Deviation, Minimum and Maximum values of fracture resistance of the sample

Groups	Z score	P value
Group 2 vs Group 1	4.64	**0.0000***
Group 3vs Group 1	3.87	**0.0001***
Group 4 vs Group1	4.64	**0.0000***
Group 3 vs Group 4	3.85	**0.0001***

*p<0.05 is significant

Table 2: Inter group comparison of fracture resistance

Group	N	Mean	SD	Minimum	Maximum	Test statistic (H)	P value
Positive control	15	4096.46	668.11	3120	5023	50.24	**<0.0000***
Negative control	15	1656.20	274.35	1043	2010		
Fibre reinforced	15	2918.06	560.63	2066	3860		
Nanohybrid	15	2159.80	287.19	1789	2760		

*p<0.05 is significant

DISCUSSION:

Maintaining structural integrity is crucial for the natural resistance of teeth against fractures. The loss of tooth structure, whether due to extensive cavity preparation, restorative treatments, or endodontic interventions, impacts the tooth's biomechanical properties and load distribution. Therefore, restorative techniques and the careful selection of materials should not only restore anatomical function and aesthetic appearance but also strengthen the remaining tooth structure.

As per the results of the present study, the control group of sound teeth demonstrated the highest fracture resistance compared to fiber-reinforced composite restorations, nanohybrids, and MOD cavities, similar to a study by Escobar et al[8]. These results highlight the significance of preventive oral health measures in maintaining the structural strength of healthy teeth and underscore the principles of minimally invasive conservative dentistry.

The group exhibiting fracture resistance most akin to healthy teeth employed fiber-reinforced composite (FRC) restorations. These FRCs are made up of an organic resin matrix, inorganic glass fibers, and various filler particles. The resin matrix contains Bis-MEPP, TEGDMA, and UDMA, while the fillers comprise short E-glass fibers alongside predominantly barium glass particle fillers. This enhanced performance can be explained by the effective transfer of stress from the polymer matrix to the fibers, reinforcing the overall material. The addition of fibers enhances the flexural strength of composite resins, and the elastic modulus of these composites is closely aligned with that of dentin, potentially serving as a stress alleviator at the interface between the composite and dentin. The fibers also act as reinforcements to prevent crack propagation by supporting the outer layer of the composite. Furthermore, by partially substituting the composite material, fibers can diminish overall volumetric contraction and function as barriers against crack growth, thereby reducing shrinkage stress. Additionally, a study by Khan et al. (2018)[9] reported that E-glass fibers exhibited the greatest fracture resistance among various fiber types used in composites, which may help explain the findings observed in this research.

Nanohybrid composites could not outperform fiber reinforced composite's fracture resistance in this study. This result concurs with studies by Kurniawati et al[10] & Solanki et al[11]. The random arrangement of E glass fibers in a resin matrix consisting of barium glass fillers of FRCs leads to an isotropic reinforcement effect not just in a single, but multiple directions[12,13]. This could be one of the underlying reasons for the trailing of nanohybrids in this study.

However, it is agreeable that the results of the present study are to be well thought out before generalizing them, as it was in vitro in nature. Further research in vivo might strengthen the evidence gathered through this study.

CONCLUSION:

Fiber reinforced composite can resist fracture in large MOD cavities, only secondary to the intact tooth, emphasizing the importance of the preventive approach in maintaining oral health.

REFERENCES

1. Covey, D., Schulein, T. M., & Kohout, F. J. (1989). Marginal ridge strength of restored teeth with modified Class II cavity preparations. Journal of the American Dental Association (1939), 118(2), 199-202.
2. Mackert Jr, J. R., & Berglund, A. (1997). Mercury exposure from dental amalgam fillings: absorbed dose and the potential for adverse health effects. Critical Reviews in Oral Biology & Medicine, 8(4), 410-436.
3. Schmalz, G., Schwendicke, F., Hickel, R., & Platt, J. A. (2023). Alternative direct restorative materials for dental amalgam: A concise review based on an FDI policy statement. International dental journal.
4. Scribante, A., Vallittu, P. K., & Özcan, M. (2018). Fiber-reinforced composites for dental applications. BioMed Research International, 2018, 4734986.
5. Vallittu, P. K. (2013). Fibre-reinforced composites (FRCs) as dental materials. In Non-Metallic Biomaterials for Tooth Repair and Replacement (pp. 352-374). Woodhead Publishing.
6. Angerame, D., & De Biasi, M. (2018). Do nanofilled/nanohybrid composites allow for better clinical performance of direct restorations than traditional microhybrid composites? A systematic review. Operative dentistry, 43(4), E191-E209.
7. Alzraikat, H., Burrow, M. F., Maghaireh, G. A., & Taha, N. A. (2018). Nanofilled resin composite properties and clinical performance: a review. Operative dentistry, 43(4), E173-E190.
8. Escobar, L. B., Pereira da Silva, L., & Manarte-Monteiro, P. (2023). Fracture resistance of Fiber-Reinforced Composite restorations: a systematic review and Meta-analysis. Polymers, 15(18), 3802.
9. Khan, S. I. R., Ramachandran, A., Alfadley, A., & Baskaradoss, J. K. (2018). Ex vivo fracture resistance of teeth restored with glass and fiber reinforced composite resin. Journal of the Mechanical Behavior of Biomedical Materials, 82, 235-238.
10. Kurniawati, C. S., Rachmawati, D., & Mas'Adah, D. (2018, August). The fracture resistance of fiber reinforced composite restorative material has higher yield than nanohybrid resin composite. In Journal of Physics: Conference Series (Vol. 1073, No. 5, p. 052019). IOP Publishing.
11. Solanki, N., Kishan, K. V., Saklecha, P., & Parikh, M. (2021). Comparison of fiber-reinforced composite and nanohybrid resin impregnated with glass fibers as postendodontic restoration in molars–a clinical study. Journal of Conservative Dentistry and Endodontics, 24(5), 514-518.
12. Oskoee, P. A., Ajami, A. A., Navimipour, E. J., Oskoee, S. S., & Sadjadi, J. (2009). The effect of three composite fiber insertion techniques on fracture resistance of root-filled teeth. Journal of endodontics, 35(3), 413-416.
13. Spyrides, S. M. M., & Bastian, F. L. (2004). In vitro comparative study of the mechanical behavior of a composite matrix reinforced by two types of fibers (polyethylene and glass). Materials Science and Engineering: C, 24(5), 671-677.