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Original Article

Dentistry Section

Comparative Evaluation of Fracture Resistance of Maxillary Premolars with Class II Cavities Restored with Glass Hybrid Restorative System and Nanohybrid Composite Resin: An In-vitro Study

KRUSHN SAVALIYA[1], KARKALA VENKAPPA KISHAN[2], MANAN GAURANG SHROFF[3], PURNIMA SAKLECHA[4], HARSHIT TUSHAR MAVANI[5], SUPREET KAUR[6], SHREYA VOLETY[7]

ABSTRACT

Introduction: Maxillary premolars are the most susceptible teeth to fracture if both marginal ridges are compromised. Composite restorations have performed remarkably in restoring the marginal ridges. However, it has certain disadvantages, thus to overcome this, modified glass ionomer based restorative materials with improved mechanical properties were introduced.

Aim: To compare and evaluate the fracture resistance of maxillary premolars with class II Mesio-Occluso-Distal (MOD) cavities which received Glass hybrid restorative system and Nanohybrid Composite resin.

Materials and Methods: The present study was an in-vitro study conducted at KM Shah Dental College and Hospital, Vadodara, Gujarat from December 2019 to June 2020, on 30 Extracted Maxillary premolars. Total samples were divided into group A (n=15) restored by glass hybrid restorative system and group B (n=15) restored by nanohybrid composite resin. Standardised class II MOD Cavity preparation was done in all the samples. The samples were subjected to a thermocycling procedure, and a universal testing machine measured the fracture resistance. Data obtained from all the samples was analysed by Independent sample t-test with a p-value set at less than 0.05.

Results: In group A, mean fracture resistance (at mean force 947.07±236.41) was found to be greater than in Group B. However, the difference among the groups was not statistically significant with a p-value of 0.555.

Conclusion: Glass Hybrid restorative system showed better fracture resistance than Nanohybrid Composite Resin in maxillary premolars with class II MOD Cavities.

Keywords: EQUIA forte, Fracture resistance, Thermocycling procedure

INTRODUCTION

In the past decade, posterior teeth have been extensively restored using dental restorative composites. Secondary caries and wearing of the occlusal surfaces are the most common failures in direct posterior composite fillings. However, it has been shown that fracture is also a common reason for replacement [1]. One of the most important characteristic features of any dental material is its fracture resistance which means the resistance of the material to prevent crack propagation [2].

After the preparation of large MOD cavities, a significant amount of reduction in tooth structure occurs due to loss of marginal ridges, leading to an increased risk of tooth fracture, which is one of the most common problems in restorative dentistry. Therefore, to avoid such tooth fractures providing the resistance form when preparing a cavity is essential. The stiffness is reduced by 63% if the cavity preparation design incorporates both marginal ridges [3].

It is considered that because composite resins can adhere to the remaining tooth structure, they can transmit and distribute functional stress, but they have certain disadvantages. Glass Ionomer Cements (GICs) are frequently employed in many different dental specialties. When opposed to other restorative materials, one benefit of glass ionomers is that they can be inserted into cavities without the use of bonding agents, however it has less flexural strength and lack of fracture toughness [4]. To overcome these disadvantages, EQUIA was introduced. EQUIA is a new glass ionomer restorative system. Chemically cured, self-adhesive, highly filled GIC and light-cured, self-adhesive, filled resin surface sealant are combined in this restorative material [5].

EQUIA Forte was set upon the exceptional clinical performance of the existing EQUIA system [6]. Manufacturers claim that EQUIA Forte Fil (GC America) is a restorative material with a significant increase in flexural energy (fracture toughness). EQUIA Forte Fil is stronger because the glass fillers' matrix is strong which is attributed to the new Hybrid glass technology. Besides the original glass particles (fluoro-alumino-silicate (FAS)), innovative ultrafine, highly reactive glass (FAS) fillers (<4 μm) are dispersed into EQUIA Forte Fil. In addition, the set cement's physical, chemical, and acid resistance qualities are enhanced by polyacrylic acid which has a relatively higher molecular weight. It extends recommended indication to include stress-bearing class II restorations [7].

With the help of single dispersion nano-fillers, the EQUIA Forte Coat's innovative cross-linking monomer chemistry and more effective polymerisation capabilities provide a stronger resin matrix [8]. Scarce literature is available comparing fracture resistance of glass hybrid restorative system and nanohybrid composite resin. Also, the testing parameters used in those studies were mainly in non carious cervical lesions. Hence, there is a need of testing these materials in the high-stress bearing areas of marginal ridges before it can be used in the clinical scenario [6-9]. Thus, the present study aimed to evaluate and compare the fracture resistance of maxillary premolars with class II MOD Cavities restored with Glass Hybrid restorative system (Equia Forte, GC) and Nanohybrid Composite (FiltekTMZ350XT, 3M/ESPE). The null hypothesis was that there is

no difference in fracture resistance in maxillary premolars restored with Glass Hybrid restorative system (Equia Forte, GC) and Nanohybrid Composite (FiltekTMZ350XT, 3M/ESPE).

MATERIALS AND METHODS

The present study was an in-vitro study conducted at the Department of Conservative Dentistry and Endodontics at KM Shah Dental College and Hospital, Vadodara, Gujarat, India, from December 2019 to June 2020. After taking approval from the Ethical Committee (SVIEC/ Dent/ON/SRP/20028).

Sample size calculation: G*Power 3.1 (Heinrich Heine University, Germany) was used to calculate the sample size, and it had a power of 80% and an alpha type error of 0.05. The calculated sample size was 15 per group.

Inclusion criteria: Adult maxillary premolars which were extracted for orthodontic purpose were included in the study.

Exclusion criteria: Carious, attrited, cracked, and teeth with hypoplastic defects or restored teeth were excluded from the study.

Study Procedure

The samples were disinfected with a 0.5% chloramine T. Then, using an ultrasonic scaler, all teeth were cleansed of periodontal tissue and calculus. The samples were kept in normal saline solution at 4 degrees.

Class II (MOD) type cavity preparation was done with a pulpal depth of 2±0.2 mm, axial height of 2±0.2 mm, 1.5±0.2 mm gingival width. Proximally, 3±0.2 mm buccolingual width and one-third of the inter-cuspal distance at occlusal isthmus. After proper measurement of the cavity, the samples were randomly (Flip coin method) divided into two experimental groups of 15 samples each, and restoration was carried out. The details of the restorative materials used are listed in [Table/Fig-1].

Group	Composition	Company
EQUIA forte	**Liquid:** Water, polybasic carboxylic acid **Powder:** Flouro-alumino-silicate glass, iron (III) oxide.	GC
Nanohybrid composite (Filtek™ Z 350 XT).	• Organic Phases (UDMA, Bis-GMA, Bis-EMA, TEGDMA). • Inorganic matrix (Silica 920 nm non-agglomerated/ aggregated), Zirconia (4-11 nm nonagglomerated/ aggregated and agglomerated), Clusters, Zirconia/ Silica aggregated particles 920 nm silica particles combined with 4-11 nm Zirconia 3).	3M/ESPE

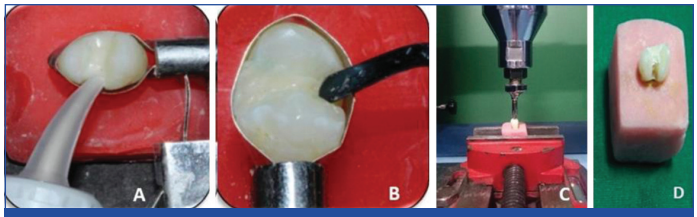
[Table/Fig-1]: The details of the restorative materials used in this study.

- For Group A (n=15), teeth were restored with EQUIA Forte,
- For Group B (n=15), teeth were restored with nanohybrid composite resin (FiltekTMZ350XT, 3M/ESPE).

In Group A, 20% Polyacrylic acid was applied for 10 seconds, rinsed and the cavity was dried using a cotton pellet. After that, EQUIA Forte (GC) Capsule was activated just before the mixing. After that, the capsule was mixed for 10 seconds using an amalgamator. It was directly then placed within 10 seconds after mixing. The self-curing restoration was finished after 2 minutes 30 seconds from the start of mixing, as per the manufacturers' instructions [8].

In Group B all conventional protocols of composite restoration placement were followed, and finishing and polishing were performed.

After that, thermocycling of the samples of both groups was done (500 cycles) at 5°C ± 2° C to 55 °C±2°C. To replicate the periodontal ligament, polyvinyl siloxane was applied around the root surfaces after a layer of light body elastomeric impression material. Next, a block of cold-cure acrylic resin was used to mount the teeth upto 1.5 mm apical to the Cemento-Enamel Junction (CEJ). Using a universal testing machine (Instron testing machine), a compressive force at a strain rate of 1 mm/min was applied to measure fracture resistance. The force necessary to fracture each tooth was measured in Newton's (N). As shown in [Table/Fig-2].



[Table/Fig-2]: Clinical Images of the study procedure.
A: Insertion of EquiaForte into the cavity B: Insertion of Nanohybrid Composite C: Load application on the teeth through the Instron testing machine to check the fracture resistance D: Fracture of the restoration

STATISTICAL ANALYSIS

Statistical significance was set at p-value <0.05 in Statistical Package for Social Sciences (SPSS) software (version 20.0.1; International Business Management (IBM) Corp, Armonk, NY). The data obtained were tabulated and subjected to Independent sample t-test, and the difference in fracture resistance will be evaluated between the two groups.

RESULTS

The mean force that caused the fracture of the teeth in each group and the standard deviation are presented in [Table/Fig-3]. For EQUIA Forte, the mean force was 947.07 Newton with a standard deviation of 236.41, whereas for Nanohybrid Composite, it was 895.23 Newton with a standard deviation of 238.17. Statistical analysis was first made by independent sample t-test, which showed that Group A had more fracture resistance among both the groups but the difference was statistically non significant with p-value 0.555.

Group	N	Mean force (Newton)	Standard deviation (Newton)	Standard error mean	Mean difference (Newton)	p-value
EQUIA forte	15	947.07	236.41	61.042	51.83	0.555
Nanohybrid composite	15	895.23	238.17	61.495		

[Table/Fig-3]: Mean force that caused fracture of the teeth in each group and the standard deviation (Total samples N=30).

DISCUSSION

One of the challenges with restoring large cavities is the remaining tooth structure's resistance to fracture under masticatory stresses. However, by employing different restorative materials, it might be possible to reinforce the tooth structure that is still present. The physical characteristics of restorative materials may have an impact on tooth reinforcement. Thus, the mechanical properties of the restorative material are a primary concern when selecting any restorative material. Restoration of teeth also depends on many parameters, like tooth type, remaining tooth structure, and position of the teeth in the arch [1].

In the oral cavity, maxillary premolars tend to fracture due to their morphology (crown root ratio and crown shape) and cuspal inclination, making them more susceptible to fracture under occlusal load. Thus, in the present study, maxillary premolars were selected to check fracture resistance [10]. The removal of dental structure is directly correlated with a decrease in fracture resistance. There is a significant amount of reduction in the strength of the tooth after the preparation of Class II MOD cavities due to the loss of both marginal ridges. Thus, in the present study, Class II MOD cavities were prepared to simulate a similar condition often seen in routine clinical practice [11].

Various studies have found that nanohybrid composite has higher fracture resistance, and composite resin can reinforce and restore teeth weakened by wide class II MOD Cavity preparation [5,12]. The physical and mechanical properties of nanohybrid composites made of nanofillers have a significantly higher filler content, have improved considerably. Thus, in the present study, nanohybrid composite (Filtek Z350 XT) was selected as a control [13,14].

According to a study conducted by Mostafa S and Mohamed A [2] nanohybrid composite resin group showed an acceptable fracture resistance. The major drawback of direct resin composite restoration

is high polymerisation shrinkage, resulting in microleakage. GIC has been used in restorative dentistry for a long time as it has anticariogenic properties but has poor mechanical properties such as low fracture strength and low fracture toughness [15].

To overcome the poor mechanical properties of conventional GIC, high-strength GIC restoration with improved physical properties was introduced. This led to the introduction of EQUIA, a combination of self-adhesive, chemically cured, highly filled GIC and self-adhesive light-cured filled resin surface sealants [16]. It has been claimed by manufacturers that the material has increased fracture toughness, flexural strength, and flexural fatigue resistance.

The present study's results showed no statistically significant difference in fracture resistance between Glass Hybrid restorative system (Equia Forte, GC) group and nanohybrid composite group. However, Glass Hybrid restorative system (Equia Forte, GC) group showed comparatively better results than the Nanohybrid group, in accordance with the previous study done by Kutuk ZB et al., [9], which concluded that glass hybrid restorative material exhibited sufficient mechanical properties and could be used for extensive carious lesion in posterior teeth. Similar results were found in the study done by Moshaverinia M et al., wherein the glass hybrid restorative materials showed superior flexural strength and surface hardness [17].

The differences between Glass Hybrid restorative system (Equia Forte, GC) and nanohybrid composite may be explained by the novel hybrid glass technology of EQUIA Forte in which, apart from the glass particles, a novel ultra-fine, highly reactive glass is incorporated into EQUIA Forte Fil [17]. This innovative hybrid glass formulation boosts ion availability, improves matrix formation, and creates a significantly stronger matrix structure when combined with a higher molecular weight polyacrylic acid. The material's micron-sized filler particles release more metal ions, which enhances the matrix's cross-linking of polyacrylic acid and its general physical qualities. In addition, the coating agent (EQUIA Forte Coat) applied on the surface of the EQUIA Forte restorations contains a nano-filled resin and multifunctional monomer that may significantly increase the surface hardness and fracture resistance of the material to withstand masticatory forces [18].

Limitation(s)

One of the limitations of this in-vitro study was that some differences exist between induced fracture variables like the speed of force application and direction of forces. Thus, it does not simulate the functional environment of the oral cavity.

CONCLUSION(S)

The fracture resistance of the Glass Hybrid restorative system was found to be insignificantly better than that of Nanohybrid Composite Resin in maxillary premolars with class II MOD Cavities. However, clinical research with long follow-up will give us a better validity of the Glass Hybrid restorative system for clinical usage.

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PARTICULARS OF CONTRIBUTORS:
1. Ex-postgraduate Student, Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College and Hospital, Surat, Gujarat, India.
2. Professor, Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College and Hospital, Vadodara, Gujarat, India.
3. Postgraduate Student, Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College and Hospital, Vadodara, Gujarat, India.
4. Ex-postgraduate Student, Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College and Hospital, Mumbai, Maharashtra, India.
5. Postgraduate Student, Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College and Hospital, Vadodara, Gujarat, India.
6. Ex-postgraduate Student, Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College and Hospital, Vadodara, Gujarat, India.
7. Postgraduate Student, Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College and Hospital, Vadodara, Gujarat, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Karkala Venkappa Kishan,
Professor, Department of Conservative Dentistry and Endodontics, Room No. 8, K.M. Shah Dental College and Hospital, Sumandeep Vidyapeeth, Waghodia, Vadodara-391760, Gujarat, India.
E-mail: drkishankv@yahoo.co.in

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