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Original Article

Comparative Evaluation of Fracture Resistance of GC Fuji Type IX GIC, Composite Z-350, Cention N, and Zirconomer Restorations in Class II MOD Cavity: An *In-Vitro* Study

Kavita Kavita[1] Kamal Kishor Gupta[1] Vasundhara Pathania[1] Amit Kumar Sharma[1] Vinay Bal Singh Thakur[1] Ishant Sood[1]

[1]Department of Pedodontics and Preventive Dentistry, Himachal Dental College, Sunder Nagar, India

Address for correspondence: Kavita Kavita, MDS, Department of Pedodontics and Preventive Dentistry, Himachal Dental College, Sunder Nagar, India
E-mail: kvardhan95@gmail.com

Abstract

Objective: An in vitro study was designed to evaluate the fracture resistance of premolars with class II MOD cavities restored with GC Fuji Type IX GIC, Composite Z-350, Cention N, and Zirconomer restorations in comparison with intact teeth and unrestored teeth.

Materials and Methods: Sixty freshly extracted premolars were randomly divided into six groups: two control groups and four experimental groups of 10 teeth each. Group I: Positive Control Group; Group II: Negative Control Group; Group III: Class II MOD cavity restored with GC Fuji Type IX GIC; Group IV: Class II MOD cavity restored with Composite Z-350; Group V: Class II MOD cavity restored with Cention N; and Group VI: Class II MOD cavity restored with Zirconomer. Fracture resistance was tested in a Universal Testing Machine with a cross-head speed of about 1mm/min. The data were statistically analyzed.

Results: Maximum fracture resistance was recorded for the intact tooth (2299.3±64.1 N) followed by Cention N (1797.8±81.1 N), GC Fuji IX GIC (1508.4±79.2 N), Zirconomer (1399.2±38.1 N), Composite Z-350 (1157.8±55.9 N), and least in the Unrestored tooth (311.1±38.8 N).

Conclusion: Among the experimental groups, Cention N showed the highest fracture resistance. Cention N is the material of choice for posterior restorations.

Keywords: Cention N, composite Z-350, GC Fuji Type IX GIC, universal testing machine, zirconomer

Introduction

Removal of tooth structure by cavity preparation can cause the weakening of the tooth and increased susceptibility to fracture.[1,2] It has been claimed that the strength of a tooth decreases in proportion to the amount of tooth tissue removed, particularly the width of the occlusal section of preparation.[3] According to Geistfeld, an occlusal cavity preparation reduces tooth strength by 14–44% and a MOD cavity by 20–63%.[4] Depending on the extent of the cavity, restorative treatment is a predisposing factor for an incomplete or complete tooth fracture.[5] Teeth weakened by restorative procedures should be reinforced by restorative materials to strength-

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en the remaining tooth structure.[3] The ideal restorative material should have good compressive strength, tensile strength, shear bond strength, and the least microleakage for the success and longevity of a restoration.[6] When a restorative material tends to have lower compressive strength than the tooth material, most often it will lead to fracture and failure of the restoration.[7,8] Hence, a material needs to exhibit good compressive strength.[9] This study evaluated and compared the fracture resistance of GC Fuji Type IX, Composite Z-350, Cention N, and Zirconomer restorations in class II MOD cavities.

Materials and Methods

Important properties of the materials used in the study are like this (Table 1).

Sixty extracted teeth were washed under running water and any soft tissue was scraped from the root surfaces using an ultrasonic scaler, after which they were autoclaved for infection control and stored in a 10% buffered formalin solution. Samples were checked for any signs of fracture lines. The teeth were divided into 2 control groups (Group I; Group II) and 4 experimental groups (Group III; Group IV; Group V, and Group VI) with 10 teeth each. Class II MOD cavities were prepared with standardized dimensions using a high-speed handpiece and a No. 330 bur with continuous water cooling and verified using William's periodontal probe. The occlusal preparation was 2 mm deep, with a width of one-third the intercuspal distance (Fig. 1). The proximal boxes were prepared at a width of one-third the buccolingual distance and a depth of 1.5 mm axially with a cavosurface angle of 90° (Fig. 2).

The teeth were randomly divided into 6 groups:

Group I: Intact teeth (+ve control group): Sound teeth without restorations.

Group II: Unrestored teeth (-ve control group): Class II MOD cavities were prepared and left unrestored.

Group III: Class II MOD cavity restored with GC FUJI Type IX: Class II MOD cavities were prepared. The prepared cavities were restored with GC Fuji Type IX GIC using the Tofflemire matrix system for creating the proximal contours.

Group IV: Class II MOD cavity restored with Composite Z-350: Class II MOD cavities were prepared. A matrix band and retainer were tightly adapted to the tooth. Acid etching was done with 37% phosphoric acid gel for 15 seconds, which was then rinsed off with water and gently air-dried. 3M ESPE Single Bond Universal bonding agent was applied and cured for 20 seconds. Composite Z-350 was placed by incremental technique and cured for 20 seconds.

Group V: Class II MOD cavity restored with Cention N: Class II MOD cavities were prepared. A matrix band and retainer were tightly adapted to the tooth and then the teeth were restored with Cention N (Ivoclar Vivadent).

Group VI: Class II MOD cavity restored with Zirconomer: Class II MOD cavities were prepared. A matrix band and retainer were tightly adapted to the tooth and then the teeth were restored with Zirconomer (Shofu). All specimens were stored in distilled water for 24 hours before testing. All the samples were positioned individually on a universal testing machine (G50KS Tinus Olsen) with the help of a rectangular gauge (Fig. 3), crosshead speed of 1mm/minute till the restorations were fractured (Fig. 4). The load at which the restorations fractured was recorded and expressed in Newton (N).

Results

The statistical analysis was done using SPSS (Statistical Package for the Social Sciences, SPSS Inc., v.16). The descriptive statistics were calculated as mean and standard deviation. The fracture resistance among the study groups was compared using Analysis of Variance (ANOVA), followed by post hoc Tukey's test for multiple comparisons. The level of significance for the present study was fixed at a P-value of less than 0.05. The maximum value of mean fracture resistance was recorded for the intact tooth (2299.3±64.1 N) and the least for the unrestored tooth (311.1±38.8 N). Among the experimental groups, Cention N (1797.8±81.1 N) showed the highest fracture resistance followed by GC Fuji IX GIC (1508.4±79.2 N), Zirconomer (1399.2±38.1 N), composite Z-350 (1157.8±55.9 N) (Fig. 5).

Discussion

A fracture is a complete or incomplete break in a material resulting from the application of excessive force. It is an important property directly related to cracking.[5] Fracture resistance is a material's inherent property by which it resists plastic deformation under a particular load. Masticatory forces on restored or unrestored teeth tend to deflect the cusps under stress.[18] In the present study, sixty single-rooted human-extracted premolar

Table 1. Properties of the materials used in the study

GC Fuji Type IX	Composite Z-350	Cention N	Zirconomer
The new restorative materials need to have physical and chemical properties that are superior to our gold standard conventional GIC to be accepted as a permanent restorative material, especially in pediatric dentistry GIC type IX.[10]	Composite Z-350 is a visible light-activated composite designed for use in anterior and posterior restorations. It has excellent polish, a wide range of shades and opacities improved fluorescence unique nanofiller technology. Nanofillers allow increased filler volume and reduce polymerization shrinkage. [11]	Cention N is an "alkasite" restorative material which is essentially a subgroup of the composite material class. [12] It is a tooth-colored, basic filling material for direct restorations as it is self-curing with the additional option of light curing.[13] It also includes a special patented filler (isofiller) which acts as a shrinkage stress reliever.[14]	Zirconomer is a new class of restorative GIC that claims to have the strength and durability of amalgam and eliminate mercury hazards as well as issues related to polymerization shrinkage. [15] Its structural integrity has been attributed to the inclusion of zirconia fillers in the glass component thereby imparting better strength.[16] The high flexural modulus and compressive strength.[17]

Figure 1. Occlusal box preparation

Figure 2. Proximal box preparation

teeth were selected. Premolars are prone to masticatory loading, more due to their position in the arch, and the anatomy of premolars with deep cuspal inclination makes them more susceptible to fracture.[19,20] They are more susceptible to compressive and shear stresses, thus making them ideal candidates for testing fracture resistance under load.[21] The present *in vitro* study was conducted to compare and evaluate the fracture resistance of GC Fuji Type IX GIC, Composite Z-350, Cention N, and Zirconomer in Class II MOD cavities. According to Mondelli and others, teeth with large MOD cavities are severely weakened due to the loss of reinforcing structures and become more susceptible to fractures.[22,23] Reeh et al[24] reported MOD preparation results in a loss of 63% relative cusp rigidity. Thus, the restorative material used must not only replace the tooth structure but also increase the fracture resistance of the tooth and promote effective marginal sealing.[25] Ideally, any material that is used to restore the missing tooth structure should reinforce the tooth and minimize the risk of cuspal fracture.[17]

In the present study, when the fracture resistance of intact teeth was compared with all other groups of teeth, it was found that the fracture resistance of intact teeth was significantly higher than that of teeth restored with any of the filling materials. The fracture resistance of unrestored teeth was found to be significantly lower than any of the restored teeth and intact teeth. Similar results were found in the study done by Hood (1991),[25] Assif D. and Gorfil C. (1994),[26] Cobankara et al[27] (2008), Rajaraman et al[28] (2022)

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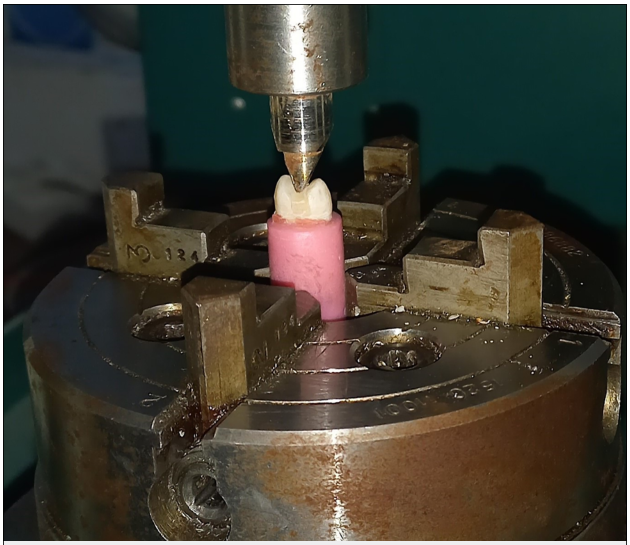

Figure 3. Sample loaded on universal testing machine

who analyzed the biomechanics of the intact, prepared, and restored teeth and concluded that the degree of cuspal deflection increases with an increase in the depth of the preparation. Soares and colleagues (2008)[29] also claimed that the application of a load on unrestored teeth produces a wedge effect between buccal and palatal/lingual cusps, leading to reduced fracture resistance and a more catastrophic fracture of the teeth. Teeth with a MOD cavity suffer a significant reduction in fracture resistance due to the loss of the marginal ridge and the occurrence of micro-fractures caused by occlusal forces. Occlusal load tends to force the cusps in opposite directions, causing cuspal fracture from fatigue. Thus, the restorative material used must not only replace the tooth structure but also increase the fracture resistance of the tooth and promote effective marginal sealing.

In our study, when the fracture resistance of Cention N and GC Fuji Type IX GIC was compared, the fracture resistance of Alkasite was significantly higher than that of High Strength GIC. Similar results were found in the studies performed by Naz T, Singh DJ, Somani R, and Jaidka S (2019),[10] and Balagopal S, Nekkanti S, and Kaur K (2021),[30] and Adsul SP, Dhawan P, Tuli A, Khanduri N, Singh A (2022).[31] They concluded that the compressive strength and flexural strength of Cention were higher because of the presence of UDMA particles in the monomer matrix which is less elastic and provides stiffness to the matrix, thus becoming highly resistant to stresses generated in the oral cavity. The cyclic aliphatic structure of aromatic aliphatic UDMA ensures stability and increased mechanical strength. Kaur M, Mann NS,

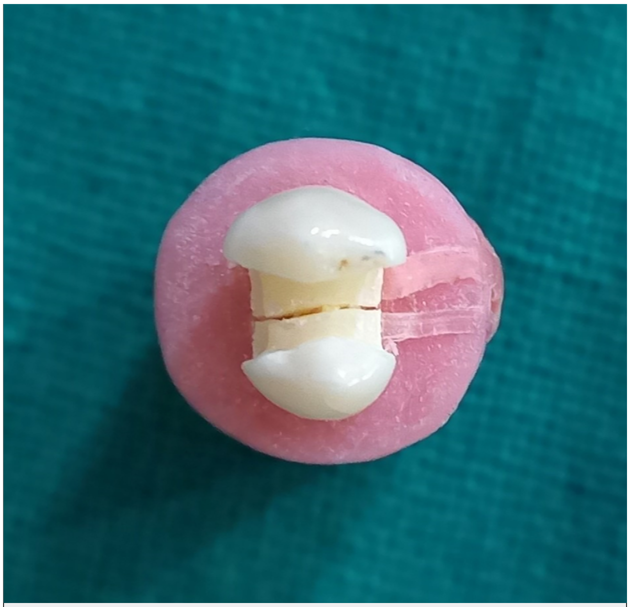

Figure 4. Sample after fracture

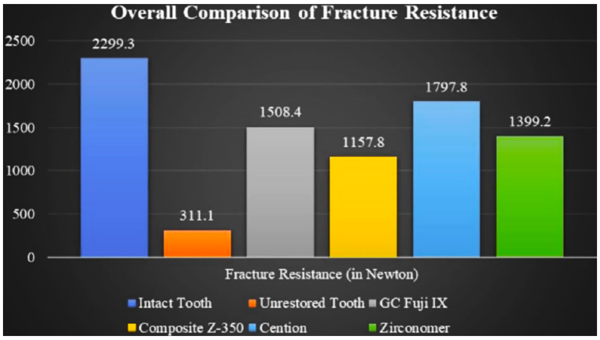

Figure 5. Fracture resistance (in Newton)

Jhamb A, and Bhatra D (2019)[32] also concluded in their study that the compressive strength of alkasite was significantly higher than that of GC Fuji Type IX GIC. The reason for the higher compressive strength of Cention N can be attributed to a special patented isofiller (partially functionalized by silanes) which is also used in Tetric N-Ceram Bulk Fill. This acts as a shrinkage stress reliever that minimizes shrinkage force. In contrast, the organic/inorganic ratio as well as the monomer composition of the material is responsible for the low volumetric shrinkage.

When the fracture resistance of High Strength GIC was compared with zirconia-reinforced GIC, it was found that High Strength GIC had a higher fracture resistance than that of zirconia-reinforced GIC. Similar results were found in the studies performed by Patel et al[33] (2018), Dheeraj M, Johar S, Jandial T, Sahi H, and Verma S (2019).[34] They found that High-strength GIC had a higher compressive strength. The possible reasons to explain these results could be the increased alumina content of high-strength GIC (Wilson).

When the fracture resistance of composite and zirconia-reinforced GIC was compared, it was found that the fracture resistance of zirconia-reinforced GIC was significantly higher than that of composite. These results are in agreement with the results of Swati UB, Ramesh S, and S Pradeep (2020).[17] They concluded that the zirconia-reinforced GIC had higher fracture resistance. This is because of the presence of Yttria-stabilized Zirconia particles in the material that increased the compressive strength. However, the studies done by Mohanty S and Ramesh S (2017),[35] and Gudugunta et al[36] (2020) concluded that composite showed higher compressive strength and Zirconia-reinforced GIC to be the weakest, which was in contrast to our study. Composite, with its content of Nanomers using nanotechnology as well as hybrid technology, enables high filler loading for increased strength hence enhancing the longevity of a composite.

In the present study, while comparing all the study groups, the maximum value of mean fracture resistance was recorded for the intact tooth (2299.3±64.1 N) followed by Cention N (1797.8±81.1 N), GC Fuji IX GIC (1508.4±79.2 N), Zirconomer (1399.2±38.1 N), composite Z-350 (1157.8±55.9 N), and least in the unrestored tooth (311.1±38.8 N).

Conclusion

Within the limitations of this study, it is concluded that the mean fracture resistance of intact teeth was found to be highest, followed by Cention N, GC Fuji Type IX GIC, Zirconomer, Composite Z-350, and least in the unrestored tooth. Cention N is the material of choice for posterior restorations because of its high compressive strength and high fracture resistance.

From a Pedodontist's point of view, this study is important because:

- To restore esthetic and retain adequate function (mastication and speech).
- To protect and preserve the remaining pulp and tooth structure; thereby managing and preventing symptoms and pain.
- To maintain arch length and space for the developing permanent dentition.

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