



FRACTURE RESISTANCE OF MAXILLARY PREMOLARS WITH MOD CAVITIES RESTORED WITH CAPSULATED RESTORATIVE MATERIALS: AN IN VITRO COMPARATIVE STUDY

Dental Science

Dr Shrishail Totad	Reader Department of Conservative Dentistry and Endodontics PMNM Dental College and Hospital, Bagalkot
Dr Raghu H*	Post Graduate Student Department of Conservative Dentistry and Endodontics PMNM Dental College and Hospital, Bagalkot *Corresponding Author
Dr B.S. Patil	Reader Department of Conservative Dentistry and Endodontics PMNM Dental College and Hospital, Bagalkot
Dr Jayaprakash D Patil	Professor and Head of Department Department of Conservative Dentistry and Endodontics PMNM Dental College and Hospital, Bagalkot
Dr Saritha.v	Professor Department of Conservative Dentistry and Endodontics PMNM Dental College and Hospital, Bagalkot
Dr Sandhya Khasnis	Reader Department of Conservative Dentistry and Endodontics PMNM Dental College and Hospital, Bagalkot

ABSTRACT

Aim: To test the fracture resistance of maxillary premolars with MOD cavities restored with a capsulated restorative materials, GC miracle mix, GC Equia Forte Fil and GC Fuji IX Extra.

Materials and Methodology: Freshly extracted forty intact, human maxillary premolars were collected and stored in distilled water. The teeth were randomly divided into 2 Control groups with 5 teeth each (n=5) and 3 experimental groups with 10 teeth each (n=10). Group I: No cavities were prepared (Positive control). Group II : Class II MOD cavities were prepared but not restored (Negative control). Group III: Cavities were restored with miracle mix capsule (GC). Group IV: Cavities were restored with Equia Forte Fil(GC). Group V: Cavities were restored with Fuji IX posterior extra (GC). Fracture resistance was tested with Universal Testing Machine. Statistical analysis was done using One-Way Analysis of Variance (ANOVA) and Tukey test.

Results and conclusion: Teeth restored with GC Equia Forte Fil were most resistant to fracture load followed by GC Fuji IX extra (p<0.05) and GC miracle mix Capsule (p<0.05), suggesting GC Equia Forte Fil can be used as a potential restorative material among capsulated materials in posterior teeth.

KEYWORDS

Fracture Resistance, Gc Equia Forte Fil, Gc Fujiix Extra, Gc Miracle Mix

INTRODUCTION

Removal of tooth structure via cavity preparation has been shown to weaken teeth and increase their susceptibility to fracture.^[1] It has been claimed that the strength of a tooth decreases in proportion to the amount of tooth tissue removed, particularly in relation to the width of the occlusal section of the preparation.^[2]

According to a study conducted by Joynt et al, in 1987, preparation of an occlusal cavity reduces the tooth stiffness by 20%. proximal cavity preparation leads to 46% reduction in tooth stiffness. If both marginal ridges are included in the cavity preparation design, the stiffness decreases by 63%^[2]. Posterior teeth, particularly maxillary premolars are more likely to fracture the cusps under occlusal load because of their anatomic shape^[3].

Glass ionomer cement introduced by Wilson and Kent in 1972 is a popular direct restorative material in dental practice. It has certain advantages like physical/chemical bonding to tooth structure, anticariogenic property due to fluoride release, aesthetics, biocompatibility and low coefficient of thermal expansion. On the other hand, poor mechanical properties, such as slow fracture strength, toughness, and wear resistance, limit its use as a filling material to low stress bearing areas^[4].

Glass-ionomer luting cements have traditionally been presented in two ways, i.e. hand mixing, in which powder and liquid are proportioned with a spoon and dropper and mechanical mixing, in which the powder and liquid are pre-proportioned in capsules.

Setting rate and mechanical strength of GICs can increase by increasing the powder/liquid ratio. Smaller particles reduce the setting time, and improve wear resistance, compressive strength and surface hardness^[5]. It is imperative that the correct liquid powder relationship is maintained for GIC materials since the material has to resist the stresses that occur in posterior teeth^[6].

Pre dosed capsules were introduced to overcome the problems associated with manual mixing due to improper ratio and consistency.

This study had been performed to compare some of the modifications of GIC in capsulated form, namely GC FUJI IX™ EXTRA, EQUIA FORTE™ FIL AND GC MIRACLE MIX.

GC America's new Fuji IX™ GP EXTRA is a self-curing glass ionomer restorative material, features the excellent handling and high physical properties, which includes improved translucency and better shade matching to the natural tooth structure. This product also have a rapid set, which significantly reduces early moisture sensitivity.^[7,8]

GC MIRACLE MIX capsule is a metal reinforced crown and core build-up material formed by the combination of glass ionomer and spherical amalgam alloy powder with fluoride release and chemical bonding.

EQUIA FORTE™ Fil is a new glass hybrid restorative material achieved through the introduction of ultrafine, highly reactive glass particles, dispersed within the conventional Glass Ionomer (GI) Structure. With the addition of a higher molecular weight polyacrylic acid, the new glass hybrid formulates a high strength restorative^[9].

The aim of this study is to test the fracture resistance of maxillary premolars with MOD cavities restored with a capsulated restorative materials namely, GC miracle mix Capsule, GC Equia Forte Fil and GC Fuji IX extra.

MATERIALS AND METHODS:

A total of 40 intact human maxillary premolars extracted for orthodontic purposes were selected. Ten intact premolars served as the control group and 40 premolars received MOD cavity preparation and were divided into four groups (n = 10). Any calculus deposits and soft

tissue were removed from the selected teeth using a hand scaler. The teeth were cleaned with pumice and examined under $\times 10$ magnification to detect any pre-existing defects. Following post-extraction storage in 10% neutral buffered formalin for at least four days, the teeth were stored in tap water at room temperature until used. Each tooth was fixed, with the crown uppermost and long axis vertical in polyvinyl chloride (PVC) rings with a length of 25mm and a diameter of 10mm, using auto-cured acrylic resin. The level of the resin was limited to 1.0 mm below the cemento - enamel junction. The teeth were divided into 5 groups: 3 experimental groups (n=10) and 2 control groups (n=5). Standardized class II MOD cavities were prepared in all teeth except the positive controls with the dimensions : 2 ± 0.2 mm pulpal width, 2 ± 0.2 mm gingival width, 3 ± 0.2 mm buccolingual width and are verified using a periodontal probe. The facial and lingual walls of the occlusal segment were prepared parallel to each other with the cavosurface angle at 90° .

Group I: Class II MOD cavities were prepared, matrix band & retainer were adapted and were restored with GC miracle mix Capsule.

Group II: Class II MOD cavities were prepared, matrix band & retainer were adapted and were restored with GC Fuji IX Extra.

Group III: Class II MOD cavities were prepared, matrix band & retainer were adapted and were restored with GC Equia Forte Fil.

Group IV: The positive control with unprepared teeth.

Group V: The negative control. This consisted of teeth in which cavity preparations have been done but were left unrestored.

The specimens were stored in distilled water and thermo cyler for 5,000 cycles at 5°C and 55°C with each cycle corresponding to a 15 sec bath at each temperature. The specimens were tested individually in a universal testing machine (Hounsfield Universal Tester). Each specimen was subjected to compressive loading using a rounded stainless steel testing probe, 5mm in cross section, at a cross head speed of 1mm/min until the cusp is fractured.

The probe should contact the inclined planes of the facial and palatal cups beyond the margins of the restorations. Peak load to fracture was recorded in kilogram force/millimeter² (Kg/mm²) for each specimen and the mean was calculated for each group. Statistical analysis was done using One Way Analysis of Variance and Tukey test. A p – value less than 0.05 is considered significant.

Results:

All samples failed with a buccal or lingual cuspal fracture after compression. Mean values of the compression force required for cuspal fracture (Kg/mm²) and standard deviations for each experimental group are shown in Table 1. Statistically significant results obtained (Table 2). Statistical analysis revealed that the mean fracture load for group 4 (intact teeth) was significantly higher than that of the other groups (Figure 1). Among the experimental groups, Group 3 (GC Equia Forte Fil) had highest fracture loads, followed by Groups 2 (GC Fuji IX extra) and Group 1 (GC Miracle Mix).

TABLE 2: Multiple comparison of the mean difference in the fracture resistance between the groups using Tukey's Post hoc Analysis

Group (i)	Group (j)	Mean Diff	95% CI of the Diff		P-Value
			Lower	Upper	
Group 1	Group 2	-13.77	-22.92	-4.61	0.001*
	Group 3	-39.60	-48.75	-30.44	<0.001*
	Group 4	-65.70	-76.91	-54.49	<0.001*
	Group 5	21.35	10.13	32.56	<0.001*
Group 2	Group 3	-25.83	-34.98	-16.68	<0.001*
	Group 4	-51.93	-63.15	-40.72	<0.001*
	Group 5	35.11	23.90	46.33	<0.001*
Group 3	Group 4	-26.10	-37.32	-14.89	<0.001*
	Group 5	60.94	49.73	72.16	<0.001*
Group 4	Group 5	87.05	74.10	99.99	<0.001*

* - Statistically Significant

Note: Group 1 - GC Miracle Mix, Group 2 - GC Fuji IX Extra, Group 3 - GC Equiaforte fil, Group 4 - Positive Control, Group 5 - Negative Control

FIGURE 1 : comparison of mean fracture resistance between the groups

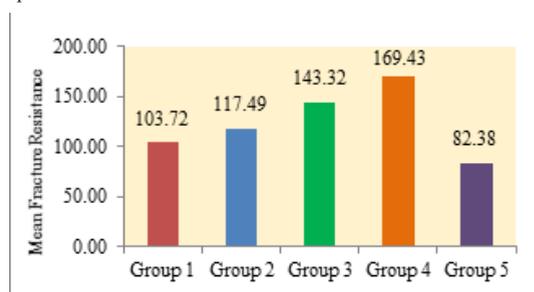


TABLE 1: Result shows mean fracture resistance of each groups Comparison of mean Fracture Resistance between the groups using one-way ANOVA followed by Tukey's post hoc Analysis

Groups	N	Mean	SD	Std. Error	Min	Max	F	P-Value
Group 1	10	103.72	3.92	1.24	98.14	109.22	133.993	<0.001*
Group 2	10	117.49	7.25	2.29	104.49	127.71		
Group 3	10	143.32	5.84	1.85	134.14	151.38		
Group 4	5	169.43	10.06	4.50	159.31	185.14		
Group 5	5	82.38	10.61	4.75	67.85	92.97		

* - Statistically Significant

DISCUSSION

The application of excessive force leads to complete or incomplete break in a material called as fracture [10].

Ideally any material that is used to restore missing tooth structure should reinforce the tooth and minimize risk of cuspal fracture. This study shows significant difference in resistance to catastrophic fracture between the sound (unprepared) teeth and restored teeth. This supports previous findings that demonstrate the deleterious effect that cavity preparation has on the fracture resistance of posterior teeth [11]. According to Santos and others, teeth with large MOD cavities are severely weakened due to the loss of reinforcing structures and become more susceptible to fractures [12].

The liquid to powder ratio and variability will affect the clinical handling and physical properties of the GIC. The literature has shown that capsular GIC stay superior to hand mixing due to a decrease in operator variability and ease of application into the cavity preparation[13]. Capsule GIC provides an increased compressive fracture strength and elastic modulus compared with hand mix materials[14].

In this study, comparison of the failure load between the negative control group and the other experimental groups including Miracle Mix showed statistically significant difference in better reinforcement. The poor capability of Miracle Mix in reinforcing undermined occlusal enamel was not a surprise. The absence of interfacial bonding in Miracle Mix provides a reason why this material in spite of metal addition has not proved to be any stronger or more durable than their metal free counterparts. Studies have shown complete de-cohesion of the matrix-metal particle interface under rapid fracture conditions^[15].

Our experience with Fuji IX GP Extra and Miracle Mix was very similar to that of Yap et al^[16], who have shown that the properties of Fuji IX GP were significantly better than that of Miracle Mix. Hence they recommended the substitution of Miracle Mix by Fuji IX GP whenever possible.

GC Fuji IX GP Extra, is the new and improved incarnation of GC Fuji family has several significant improvements over the previous version. It utilizes a new "Smart Glass" filler that results in a more aesthetically pleasing appearance for the restoration by providing improved translucency and better shade matching to the natural tooth structure. Fuji IX GP Extra has a six times higher initial level of fluoride release than the earlier version of this product. This helps to

promote and increase enamel remineralisation and it also aids in maintaining an excellent marginal seal. Fuji IX GP Extra is the fastest setting glass ionomer currently available to dental professionals. This quicker final setting time shortens chair time needed to place the restoration and improves the materials ability to work within a moist field. Fuji IX GP Extra also exhibits significantly higher strength and durability than the previous versions^[7,8].

However, the studies are still ongoing to improve the mechanical properties of GIC to use it as posterior restorative material for stress bearing areas.

EQUIA is established as a long-term glass ionomer restorative solution which is proven by numerous clinician studies in stress-bearing Class I and limited-size stress-bearing Class II cavities.

Gustavo et al showed that encapsulated high-viscosity glass ionomers, EQUIA system has significantly higher test values for diametral tensile, compressive and flexural strength compare to the

In 2011, Retrospective cohort study was conducted by FRIEDL et al. After 2 years by evaluation of about 150 restorations they concluded that EQUIA may be used as a permanent restoration material for any size of Class I and in smaller Class II cavities^[18].

In 2015, GC takes glass ionomer technology to the next level by introducing glass hybrid technology with its latest material, EQUIA Forte.

EQUIA Forte Fil, a novel Glass Hybrid technology introduced with fast setting, aesthetic restorative and increase in physical properties. To accelerate and enhance matrix formation after mixing, a new, ultrafine, and highly reactive glass is dispersed within the glass hybrid fillers This new glass hybrid technology increases the ion availability and builds a stronger matrix structure with greater physical properties, wear resistance and fluoride release^[19].

EQUIA Forte is indicated ideal for Class I, II and V restorations. The key benefits of EQUIA Forte includes, it is Bulk-fill restorative, Easy and quick to use, not technique sensitive, Non sticky and packable, No polymerization shrinkage or shrinkage stress, provides Optimal marginal seal, High fluoride release at tooth restorative interface with recharge capability, Outstanding resistance to wear and acid erosion^[9].

EQUIA Forte extends its indications to include stress bearing Class II Restorations in comparison to original EQUIA.

Our study results are in agreement with the results of Glavina D et al^[20] Who have concluded that Equia Forte(GC) showed significantly better fracture resistance comparing to Equia (GC); KetacMolar (3M ESPE) and IonostarMolar (VOCO).

The results of this study have shown that the material of choice for premolars with MOD cavities include the newly introduced Equia Forte Fil, as it is nearly as strong as the control group and shows significantly higher fracture resistance compared to GC Fuji IX Extra and GC Miracle Mix.

Conclusion:

Equia Forte Fil is found to have better strength among the capsulated restorative materials. Within the limits of this study it can be concluded that Equia Forte Fil can be used as posterior direct tooth coloured restoration. Further research has to be carried out to determine the clinical efficiency and longevity of Equia Forte fil restorative material.

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