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# Comparative Evaluation of Shear Bond Strength and Marginal Leakage of Fuji IX GP Extra GIC And Equia Forte Cement in Primary Teeth: An In Vitro Study

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## ABSTRACT

**Background**: The present study was conducted to evaluate and compare shear bond strength and marginal leakage of Fuji IX GP EXTRA and EQUIA Forte cement in primary teeth.

**Materials and Methods:** Forty non carious extracted primary molars were randomly divided into 2 groups; Group I (shear bond strength) and Group II (marginal leakage) with 20 teeth in each and further sub divided into two groups of 10 each i.e., Group A (Fuji IX GP EXTRA) and Group B (EQUIA Forte). For the shear bond strength, flat dentinal surface was prepared either on buccal or lingual surface of teeth and restored with their respective material. These teeth were then subjected to thermocycling and shear bond strength was determined using a universal testing machine and the values were statistically analyzed. For microleakage, class I cavities were prepared and restored with their respective materials. The teeth were then thermocycle and subjected to 0.5% basic fuchsin dye penetration followed by sectioning which were evaluated under stereomicroscope at 40X magnification to assess dye penetration and the data was statistically analyzed.

**Results:** Results showed that the shear bond strength was highest in Group B (EQUIA Forte) 10.34±4.47 Mpa when compared to Group A (Fuji IX GP EXTRA) 5.50±1.75 Mpa and the difference was statistically significant. The microleakage score was highest in Group A when compared to group B and the difference was statistically not significant.

**Conclusion:** EQUIA Forte cement was significantly better than Fuji IX GP EXTRA in terms of shear bond strength whereas in marginal leakage the difference was found to be statistically not significant.

**Keywords:** Microleakage; Shear bond strength; Thermocycling.

## INTRODUCTION

Dental caries is a microbial infectious disease characterized by a progressive demineralization process that affects the mineralized dental tissues.[1] So, restoration of the decayed teeth is important to prevent further progression of the disease and to maintain esthetics, form and function.[2] The success of restorative material mainly depends on two important factors i.e., marginal adaptation and shear bond strength (SBS). Marginal adaptation can be achieved by proper adaptation of restorative

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material to the cavity walls.[2] Dimensional changes and lack of adaptation of the restoration to cavity walls can lead to marginal leakage with fluid, molecular movement and ingress of the bacteria or bacterial nutrients.[3] Restorative materials also resist various dislodging forces which are acting within the oral cavity. Shear bond strength is the maximum amount of force required to break the interface between a bonded restoration and the tooth surface with the failure occurring in or near the adhesive interface. Clinically, it assumes much importance to the restorative material as the major dislodging forces which are present at the tooth restoration interface have shearing effect. Therefore, higher shear bond strength implies better bonding of the material to tooth.[4]

Glass ionomer cements and composites are the tooth coloured restorative materials which are commonly used for restoration. Glass ionomer cements are easy to place in bulk, fluoride release, have reduced post- operative sensitivity and they are less technique sensitive when compared to composite restorations.[5]

Although these cements have several advantages they have few disadvantages like insufficient strength and toughness. In order to overcome the disadvantages of the mechanical properties of conventional glass ionomer cements Fuji IX GIC EXTRA and EQUIA Forte cements have been introduced.[6]

Fuji IX GP EXTRA and EQUIA Forte cements are the conventional glass ionomer cements which are available as capsules in different forms. These capsules contain pre–measured glass ionomer powder and liquid, which ensures correct ratio, consistency of mix with greater ease and efficiency.[7]

Based on the literature available there are only few studies conducted on shear bond strength and marginal leakage of Fuji IX GP EXTRA GIC and EQUIA Forte cements. Therefore the present study evaluated the shear bond strength and marginal leakage of two different glass ionomer cements GC Fuji IX GP EXTRA and EQUIA Forte in primary teeth.

## MATERIALS AND METHODS

A sample of 40 non carious primary molars with intact buccal or lingual surfaces which were extracted for the reason of over retention or exfoliated due to physiologic resorption were selected for the present study. The teeth were then debrided with ultrasonic scaler and stored in 10% formalin at room temperature until further use. The teeth were randomly divided into two major groups (Group I and II) with 20 teeth in each group to evaluate shear bond strength and marginal leakage. These groups were further divided into two subgroups of 10 teeth in each group (Group A and B) i.e., Fuji IX GP EXTRA and EQUIA Forte cements respectively.

**Methodology for Shear bond strength:**

A total of 20 extracted primary molars were embedded in self-cure acrylic resin with the help of cylindrical moulds of 20mm*12mm dimensions such that the buccal surfaces of all teeth were perpendicular to acrylic resin block surface. The buccal or lingual surface of these teeth were made flat and smoothened using diamond bur (Fig 1) and silicon carbide paper (number 400). Later GC dentin conditioner (i.e., 10% polyacrylic acid) was applied on all the prepared surfaces for 20 seconds with a cotton-tip applicator, rinsed thoroughly with air water syringe for 5 seconds and air dried. The samples were then randomly divided into two groups, group A and B (Fuji IX GP EXTRA and EQUIA Forte) and were color-coded (Fig 2). This step is followed by the placement of hollow plastic straws that simulate the cylindrical mould of 2.5mm diameter and 3mm height over the prepared dentin surface and restored with their respective materials (Fig 3). After restoration plastic straws were cut off from the restoration by using scalpel blade.

Then all the samples were stored in distilled water at room temperature for 1 week and subjected to thermocycling in 5°±2°C and 55°±2°C water baths for 500 cycles with a dwell time of 15 seconds and a transfer time of 10 seconds. The shear bond strength of each specimen was measured using universal testing machine (Dak system Inc, Mumbai, India). A shear load was applied to the glass ionomer interface with a knife- edged rod of 0.5 mm width at a crosshead speed of 0.5mm/min (Fig 4). The bond strength of the cement at failure was calculated in Newton as the recorded failure load divided by the surface area of the bonded surface and expressed in Megapascal. The data obtained was tabulated and statistically analysed.

**Methodology for Marginal leakage:**

Standard class I cavities of depth 1-2mm were prepared on the occlusal surfaces of 20 extracted primary molar. The samples were randomly divided into two groups namely group A ( Fuji IX GP EXTRA) and B (EQUIA Forte) of 10 teeth each and were restored according to the manufacturer's instructions. The samples were then stored in distilled water for 24 hours after which they were subjected to thermocycling for 200 cycles at a temperature of 4°C ± 2°C and 50°C ± 2°C with dwell time of 10 seconds. After thermocycling, two coats of nail varnish was applied to all the tooth surfaces except for 1mm around the restoration margins. The root apices were then sealed with yellow sticky wax to prevent leakage through their apices.

After drying, the teeth were immersed in 0.5% basic fuchsin dye for 24 hours at room temperature. After 24 hours, the samples were removed from the dye and thoroughly cleaned under tap water for 5 minutes to make sure that the superficial dye was removed. The samples were then mounted in self-curing acrylic blocks (Fig 5) and sectioned longitudinally through the center of the restoration in a bucco-lingual plane with a diamond disc and mandrel. Finally, the depth of dye penetration was assessed for sectioned part of each tooth under stereomicroscope (40X magnification) and the highest score obtained for each tooth was recorded. The degree of marginal leakage was determined by scoring criteria given by Prabhakar et al (2003)[8]. The following criteria was used to score dye penetration.

0 - No dye penetration
1 Dye penetration between the restoration and the tooth into enamel only
2 Dye penetration between the restoration and the tooth into enamel and dentin
3 Dye penetration between the restoration and the tooth into the pulp chamber.

The mean amount of leakage was recorded for each group and results were tabulated and statistically analysed.

## RESULTS

Statistical analysis was done using SPSS version 20.0 (SPSS, Inc.chicago, Illinois). A P value of <0.05 was considered to be statistically significant. Mann Whitney test and chi square test was done to compare the outcome between (Group I: Shear bond strength, Group II: Marginal leakage) and within the groups (Group A: Fuji IX GP EXTRA, Group B: EQUIA Forte cement).

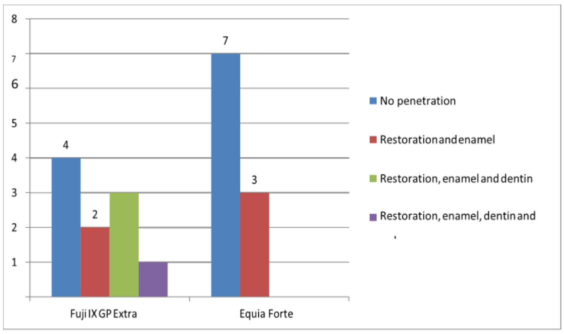
Table 1: shows the mean, standard deviation and comparative evaluation of shear bond strength among the two groups using Mann Whitney test.

| Shear bond strength | N | Minimum | Maximum | Mean | Std.Deviation | P value |
|---|---|---|---|---|---|---|
| Fuji IX (Group A) | 10 | 3.00 | 9.06 | 5.50 | 1.75 | 0.01* (S) |
| EQUIA Forte (Group B) | 10 | 3.92 | 18.21 | 10.34 | 4.47 | |

Table 1 shows the mean, standard deviation and comparative evaluation of shear bond strength among the two groups using Mann Whitney test. When Group A was compared with Group B it was found to be statistically significant with a P value of 0.01.

Table 2: Descriptive statistics of marginal leakage scores of teeth restored with Fuji IX GP Extra cement and Equia Forte Cement.

| Marginal Leakage Score | Fuji IX GP EXTRA (Group A) | | EQUIAForte (Group B) | |
|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent |
| No penetration (Score 0) | 4 | 40.0 | 7 | 70.0 |
| Restoration and enamel(Score 1) | 2 | 20.0 | 3 | 30.0 |
| Restoration, enamel and dentin (Score 2) | 3 | 30.0 | 0 | 0 |
| Restoration, enamel, dentin and pulp (Score 3) | 1 | 10.0 | 0 | 0 |
| Total | 10 | 100.0 | 10 | 100 |




Graph 1: Graph 1 shows comparison of marginal leakage between the two groups using Chi square test. When Group A (Fuxi IX GP Extra) was compared with Group B (Equia Forte) it was found to be statistically not significant with a P value of 0.17.

Figure 1: Tooth preparation for evaluating SBS

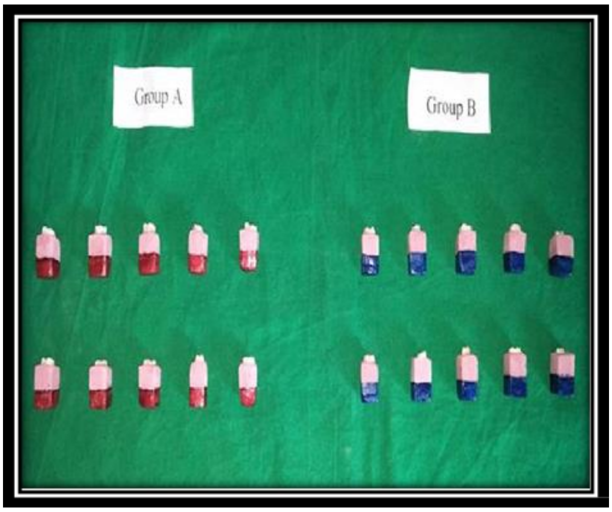



Figure 2: Prepared tooth samples for evaluation of SBS.

Figure 3: GIC mould placed on dentinal surface of tooth.

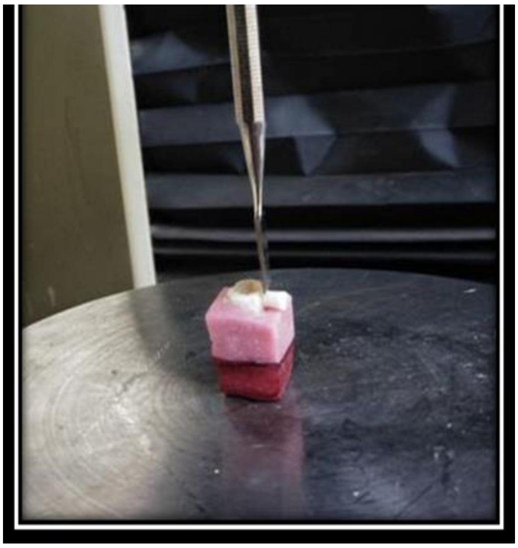


Figure 4: Sample loaded for testing SBS using Universal testing machine.

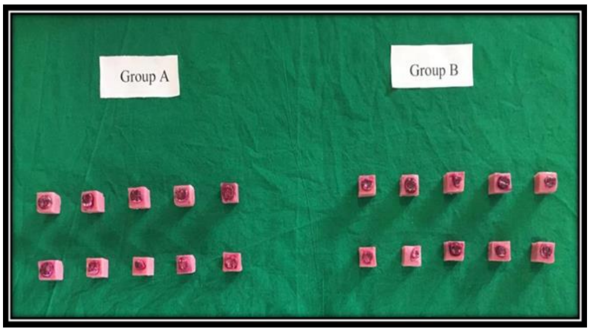



Figure 5: Teeth mounted in acrylic blocks after dye penetration for marginal leakage assessment

## DISCUSSION

Various restorative materials have been used since years to preserve the lost tooth structure and maintain form, function and esthetics. Conventional restorative materials available for restoring posterior primary teeth include amalgam (AM), conventional glass ionomer cement (GIC), resin-modified glass ionomer cement (RMGIC), high-viscosity glass ionomer cement (HVGIC), compomer (CP), and composite resin (CR).[9] There is always a need for restorative materials having superior properties like biocompatibility, fracture resistance, good esthetics and a good adhesion of the restorative material to various tooth surfaces.[10]

GIC has been widely used for restoration of primary teeth because they are easy and practical to use, biocompatible, leach fluoride, adhere to tooth structure and require less or no tooth preparation.[11] Nevertheless, this material presents disadvantages such as low wear resistance and flexural strength. To overcome the brittle nature of GIC and improve its physical properties, modifications on its original composition were made. One such modification is Fuji IX GP EXTRA which is a high strength, packable, high viscous conventional glass ionomer cement with improved physical properties. It has a fast setting time which helps in reducing the chair side time and provides improved stability against water, an important feature in challenging oral environments. It releases fluoride six times more than the previous versions and the presence of smart glass filler shows improved translucency to the cement.[12]

Evolution in the formulation of GIC led to the development of glass hybrids (GH) such as EQUIA Forte cement which is a bulk fill, fluoride releasing, glass hybrid restorative system which shows the presence of ultrafine, highly reactive glass particles, dispersed within the conventional Glass Ionomer (GI) structure.[13] The higher molecular weight polyacrylic acid molecules increases matrix cross-linking and give high strength to the restoration. This type of glass ionomer cement was developed in an attempt to solve the problem of sensitivity to humidity and initial low mechanical resistance associated to conventional GICs. It also have many advantages like high flexural strength, coefficient of thermal expansion similar to dentin, resistance to wear and acid erosion, high fluoride release, improved physical properties and optimal marginal seal.[14]

The present in vitro study was undertaken to evaluate and compare shear bond strength and marginal leakage of two different glass ionomer cements in primary teeth i.e., Fuji IX GP EXTRA and EQUIA Forte cements.

The clinical success of restorative material depends upon good adhesion and tensile strength which are important parameters to be evaluated but in the present study, we have evaluated shear bond strength as it is simple, less technique sensitive and widely used test to assess the bonding performance of restorative materials. This test is particularly used in GICs, where they show low bond strength when compared to the other tests which may offer great difficulty to apply.[15] Another important clinical significance of high shear bond strength is its relation to microleakage. Higher the shear bond strength, lesser the microleakage.[16]

The shear bond strength (SBS) was measured using universal testing machine using a wedge technique. The advantage of this method is that the placement of specimens and loading arrangements are easy. In the present study the shear bond strength values were obtained by using the following formula and expressed in MPa.

Stress=Failure load (N)/surface area (mm2).

In the present study, the mean value of shear bond strength was found to be highest for EQUIA Forte cement i.e.,10.34 Mpa when compared to Fuji IX GP EXTRA cement i.e.,

5.50 Mpa. The intercomparison between two groups was found to be statistically significant. The reason for higher SBS in Equia Forte cement might be due to the presence of ultrafine, more voluminous highly reactive glass particles (<4µm), dispersed within the conventional glass ionomer (GI) structure and higher molecular weight polyacrylic acid in EQUIA Forte Fil component. In addition, the application of EQUIA Forte Coat followed by light curing for 20 seconds helps it in penetrating the surface porosities of the restoration which may finally help in increasing the overall strength of the restoration.

Glass-ionomer surfaces, before being contaminated with water, should be covered with protective coating in order to optimize their mechanical strengths.[17] In the present study, SBS is not only affected by a single factor, other factors associated with it include low P/L ratio which may decrease the ion release process and cross links, irregularly arranged smaller size particles which may increase the risk for local stress concentrations facilitating local crack growth and precision of the operator in inserting the mixture into the tubes may also be responsible for decreased SBS in Fuji IX GP EXTRA cement.[18]

The results were in accordance with the study conducted by Poggio et al [19] (2014) in which the authors evaluated the effects of dentin surface treatments on shear bond strength of Fuji IX GP EXTRA and Fuji II LC and found that the use of 20% polyacrylic acid on dentin showed shear strength values of 3.51 and 10.24Mpa whereas the use of 37 % phosphoric acid, showed shear strength values of 1.86 and 6.53Mpa.

In contrast to the present study, Talip et al [20] (2017) found that GC Fuji IX GP EXTRA with and without Riva Bond LC adhesive showed SBS values of 9.02 and 6.57Mpa respectively. One of the possible explanation, for higher SBS in the Riva Bond LC adhesive is probably due to the existence of the light-activated hydroxyethyl methacrylate (HEMA). HEMA has dual mechanism of adhesion; on one end, it adheres mechanically and chemically to the dentine, and on the other end, it adheres chemically to the GICs. This combination resulted in a significantly higher SBS as compared to GICs without adhesive.

Microleakage is considered as one of the main problems that most of the dentists face. It is used as a measure by which clinicians and researchers can predict the performance of a restorative material.[21] To increase the clinical success rate of any restorative material, the microleakage at the tooth/restoration interface must be in its lower limit. So, there is a constant search for the material and technique that ensures adhesion to the tooth structure in order to minimize the leakage potential.[3] So, the second objective of the present study was to evaluate and compare microleakage of two commercially available glass ionomer cements Fuji IX GP EXTRA and EQUIA Forte cements.

In the current study among the two cements EQUIA forte cement showed less microleakage when compared to Fuji IX GP Extra cement. The intercomparison between these two groups was found to be statistically not significant. The possible explanation for less microleakage in EQUIA Forte cement was due to the presence of highly reactive ultrafine glass filler particles which releases higher amounts of fluoride at tooth restorative interface with recharge capability over time. This helps in maintaining an excellent marginal seal which may offer long-term resistance to microleakage and discoloration and thus resulting in less microleakage.

One of the possible reason for more microleakage in Fuji IX GP EXTRA cement, was that the high viscous nature of the cement did not allow proper wetting of the tooth surface thus preventing the formation of a good seal between tooth-restorative interface. Other possible explanation, could be due to the texture of cement as seen on stereomicroscope photographs which appears to be granulated with many cracks and air voids, which might result in more microleakage.

The results of the present study were in concordance with the study conducted by Singla et al [22] (2012) in which the author found significantly more microleakage with Fuji IX GP when compared to Fuji VII cement. Similar to the results of the present study, Balgi et al [23] (2017) compared the microleakage of SDI Riva Self Cure GIC and GC Fuji IX GP EXTRA in primary molars immersed in sugarcane juice, chocolate milk and mango drink and their findings showed that GC Fuji IX GP EXTRA showed higher microleakage scores when compared to SDI Riva Self Cure GIC.

A study done by Giray et al [12] (2014) evaluated and compared the microleakage of ChemFil™Rock, IonoluxAC, Fuji IX GP Extra and composite Aelite LS in Posterior permanent teeth and concluded that Fuji IX GP Extra had significantly less leakage than other glass ionomer cements ChemFil™Rock and IonoluxAC. However, Fuji IX GP Extra and conventional glass ionomer, behaved similarly to the composite resin. These results were in contrast to the present study.

In contrary to the results of present study, Nurunazra et al [24] (2017) found that high-viscosity variants such as Fuji IX GP Extra and Riva SC exhibited less microleakage when compared to low-viscosity GICs such as Riva Protect and Fuji VII. The results of the present study also matched with the study conducted by Shameera et al [25] (2016) in which microleakage was more with Zirconia reinforced glass ionomer cement (Zirconomer) than conventional glass ionomer cement (GC Fuji IX GP EXTRA). The reason for less microleakage in Fuji IX GP EXTRA cement might be due to the presence of smart glass fillers and six times more initial fluoride release than previous versions help in maintaining a good marginal seal which ultimately reduces the microleakage. Based on the results of the present study, Equia Forte cement has proven to be better both in terms of shear bond strength and microleakage when compared to Fuji IX GP EXTRA cement in primary teeth.

## CONCLUSION

1. The mean shear bond strength of EQUIA Forte cement was higher when compared with Fuji IX GP EXTRA cement and the difference between the values of two groups was found to be statistically significant.

2. The microleakage scores was found to be lowest in EQUIA Forte cement when compared with Fuji IX GP EXTRA cement and the difference between these two cements was found to be statistically not significant.

Within the limitations of the present study, as it was an in vitro study, the exact oral environment could not be simulated. Apart from this, the success of any restoration also depends on the physical and clinical qualities of each material in determining, which material is most suitable for a particular clinical situation. Only long-term clinical trials can determine whether in vitro laboratory study results correlate within in-vivo experience

## CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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