

**Comparative Evaluation of fracture resistance of Endodontically treated teeth when restored with Ever X Posterior, Paracore and filtek Z350 XT.**

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**Introduction**

The restoration of endodontically treated teeth offers many challenges for the restorative dentist because of the large percentage of failures.<sup>1,2</sup> This high incidence of failure has led to the development of a magnitude of restorative alternatives for endodontically treated teeth.<sup>3</sup>

Advancements in the adhesive restorations have significantly contributed to improved fracture resistance of teeth by creating conservative aesthetic restorations bonded to the teeth.<sup>4,5</sup>

Dual-cure composites have been developed as core build-up materials that help in overcoming the limitations of extended chair-side time, reduced interlayer strength, increased interfacial porosity and the depth of cure.<sup>6</sup>

Composites reinforced with fibres have shown significant improvements in the marginal integrity and fracture strength of composite resins by the application of the fibre layer beneath the restoration.<sup>7</sup>

The Ever X Posterior, a short fibre-reinforced composite resin, is used in high stress-bearing areas. Composed of randomly oriented short glass fibre fillers made of a combination of barium glass and silanated E-glass fibres. It is claimed to provide an isotropic reinforcement effect in the multiple directions.<sup>8</sup>

No previous studies have compared the Fracture resistance of Endodontically treated teeth Restored with Ever X posterior, Paracore and Filtek Z 350 XT.

## **Clinical Significance**

In contrast to the conventional methods to reinforce endodontically treated teeth, short fibre-reinforced composite resin, a minimally invasive direct core build-up material seems to be the material of choice.

## **Methodology**

### **Selection of Sample**

Fifty intact, noncarious, unrestored human maxillary premolars of similar dimensions (verified using a digital caliper) devoid of pulpal aberrations and that were freshly extracted for orthodontic reasons were selected for the study. The teeth were cleaned and stored in physiological saline at 4 °C for 3 days. They were randomly assigned to five groups of 10 teeth each. Group 2 was the negative control (NC); the teeth were intact and were not subjected to cavity preparation or root canal treatment.

### **Sample Preparation**

Mesio-occluso-distal (MOD) cavities were prepared in the remaining forty teeth using a straight fissure bur and a high-speed airtoror handpiece (NSK Pana Air, Placentia, CA) with water coolant. The intercuspal distance and buccopalatal dimensions were recorded using a digital caliper. The dimensions of the cavity were : Buccopalatal width: 2.5mm, Depth: 1.5mm from the cemento-enamel junction.

Endodontic access cavities were then prepared using a #2 round diamond bur (Mani, Utsunomiya, Japan). The teeth were selected with a minimal apical diameter corresponding to a size 15 K-file. The working length was determined using a size 15 K-file (Mani) and set as the initial apical file. Biomechanical preparation was done using ProTaper rotary files; upto apical size F2. Irrigation was performed with 5.25% sodium hypochlorite (Merck Specialties Private Limited, Mumbai, India) between each file usage during cleaning

and shaping and finally with distilled water. The canals were dried with paper points (DiaDent, Burnaby, BC, Canada) and obturated by cold lateral condensation with ISO standardized 2% gutta-percha (Dentsply Maillefer, Ballaigues, Switzerland) and AH Plus Root Canal Sealer (Dentsply Maillefer, Ballaigues, Switzerland). The gutta-percha was removed below the level of the CEJ, and the canal orifices were sealed with GC Fuji II. Of the forty teeth, 10 teeth that served as the positive control (group 1) did not undergo further procedures. The remaining thirty teeth received Ever X Posterior composite (group 3), ParaCore composite (group 4) and Filtek Z350 XT (group 5) composite resin as coronal restorations according to the manufacturers' specifications.

A thin metal matrix band (0.00100) held by a Tofflemire (GDC, India) retainer was placed around each tooth before restoration. All the materials were restored using an incremental technique and cured with a quartz-tungsten-halogen light-curing unit at a power intensity of 600 mW/cm<sup>2</sup> (Curing Light 2500, 3M ESPE).

After the procedure, the matrix bands were removed, and the restorations were contoured, finished, and polished with a series of abrasive disks (Super-Snap; Shofu Inc, Kyoto, Japan). The teeth were stored in distilled water for 24 hours at 37 °C before being subjected to fracture testing. The roots of the teeth were mounted in self-cure acrylic resin of 3 cm X 2.5 cm up to the level of 1 mm apical to the CEJ.

### **Push-Out Bond Strength Test**

The push-out bond strength was evaluated using Universal Testing Machine. The prepared specimens were placed on a holder slot that was fixed to the lower arm. Loading was applied on the post-endodontic composite filling material by using a custom stainless steel cylindrical plunger. A metal indenter with a 6-mm

diameter that was fixed to the upper arm of a Lloyd LRX universal testing machine (Lloyd Instruments Ltd, Fareham, UK) that was set to deliver increasing loads until fracture occurred. The load was applied to the occlusal inclines of the buccal and lingual cusps vertically along the long axis of the tooth at a crosshead speed of 1 mm/min. The push-out bond strength at failure was calculated in Mega-pascals (MPa) and later converted to the SI unit i.e. Newton (N), by dividing the force by the surface area of test material.

The area in each section was calculated by using the following formula:

$$Area = 2\pi r \times h$$

where,  $\pi$  = constant value of 3.14,

r = radius of the intra-radicular space (root canal radius), and

h = height (thickness of the root dentin slice) in mm.

### Statistical Analysis

Data were analysed using Statistical Package for Social Sciences (SPSS) version 11.5 (SPSS Inc, Chicago IL). The mean fracture resistance values were statistically analysed using 1-way analysis of variance (ANOVA). These data provide a statistically significant difference ( $p < 0.05$ ) that can be clinically correlated.

### Result

On applying One-way ANOVA test, for inter-group comparison we found that the mean push-out bond strength in Group III, IV, V was lower than that of Positive Control.

Overall ranking for the fracture resistance evaluated in the study at all levels used was: Positive > Ever X Posterior > Paracore > Filtek Z350 XT > Negative

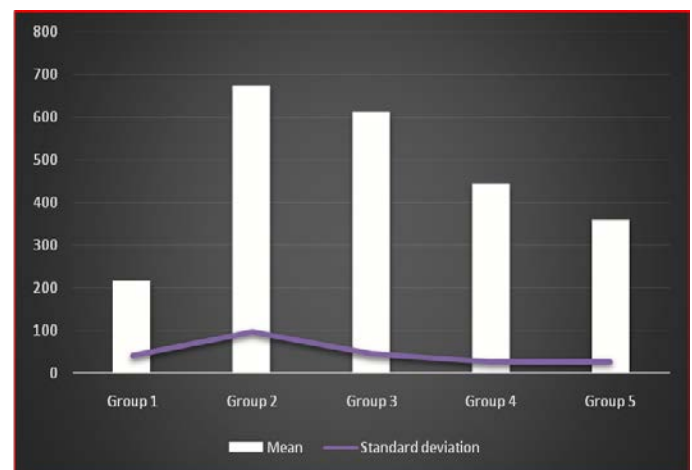
There was significant difference between the fracture resistance of Ever X Posterior and that of Filtek Z350 XT. No statistical difference between the fracture

resistance of Positive control group and that of the Ever X Posterior.

Hence, the null hypothesis were rejected.

Table 1 and Graph 2: The mean fracture resistance values and standard deviation of the groups

Sn.	Groups	Mean	Standard deviation
1	Group I	216.19	39.82
2	Group II	672.54	95.53
3	Group III	612.70	43.82
4	Group IV	443.19	26.03
5	Group V	359.61	27.98



Group I = Negative Control

Group II = Positive Control

Group III = Ever X Posterior

Group IV = Paracore

Group V = Filtek Z350 XT

### Discussion

The selection of an ideal restorative modality to compensate for the loss of coronal tooth structure is considered as the key for success of post endodontic restorations. The traditional attempts for reinforcing such teeth vary from the usage of pins, cast restorations, and full crown coverage procedures to post placement.<sup>9</sup> Unfortunately, most of these weaken the minimal

remaining tooth structure, leading to fracture disposition of the root and/or crown structure.

Despite advancements in material sciences and with the concept of minimally invasive procedures, composite resins are still not commonly used for extensive restorations or in high stress-bearing areas because of their relatively high brittleness, low fracture toughness, and formation of microcracks in the tooth structure caused by polymerization shrinkage. Hence, composite resins are reinforced with microglass fibers, a fiber-reinforced substructure, whiskers, and particulate ceramic fillers to improve their mechanical properties.<sup>10</sup>

Composite resin reinforced with polyethylene fibers and glass fibers (Interlig Fibers) have been shown to have a better effect on the resistance and durability of endodontically treated teeth, but these reinforced fibers create a discontinuous phase with the continuous polymer resin matrix leading to delamination and thus failure at the interface.<sup>11</sup> It can be stated that the effectiveness of fiber reinforcement depends on many factors including the resins used; the quantity, length, form, and orientation of the fibers; and the adhesion and impregnation of the fibers to the resin matrix.<sup>12</sup> Our study compared the recently introduced everX Posterior, which is intended to be used as a bulk substructure covered with a layer of particulate composite resin, with the other available core buildup materials.

Maxillary premolar teeth were used in this study because during mastication the anatomic shape of premolars creates a tendency for the separation of cusps. Post placement in these teeth is also not usually recommended because of their delicate root morphology. Siso et al reported that unrestored teeth with MOD preparation leads to a significant reduction (50%) in tooth strength because of the loss of marginal ridges compared with unaltered premolar teeth.<sup>13</sup> Hence, in this study, the MOD cavity

was prepared, and each preparation was proportional to the tooth dimension in order to simulate the worst clinical situation.

Burke and Watts proved that when the cylindric indenter makes contact with the tooth, it acts as a wedge between the buccal and lingual cusps and decreases the mean fracture resistance values while promoting more catastrophic types of fracture.<sup>14</sup> Similarly, in our study, the application of force was on the cuspal inclines vertically because it was found to be appropriate to simulate the clinical intraoral conditions.

In this study, Group I (Negative Control) showed the lowest resistance to fracture, whereas Group II (Positive Control) showed the highest fracture resistance, proving the deleterious effects of the loss of vital tooth structure because of MOD and access cavity preparations. This is in accordance with many previous studies.

All the experimental groups showed improved fracture resistance when compared with the Group I. However, significant differences were found among Group III, IV and V.

The least fracture resistance value was observed in Group V resin among the experimental groups. This is in concurrence with the results of previous studies. Group V resin showed less fracture resistance compared with Group III resin, which was statistically significant. The reasons may be manifold including that the fibers in Group III resin (E-glass Fibres) are preincorporated with resin. Furthermore, glass fibers present in Group V are more rigid and cannot easily adapt closely to the teeth, which may result in uneven thickness of the composite material, thus resulting in decreased functionality of the reinforced composite in clinical conditions.<sup>15</sup>

Among the experimental groups, Group III resin showed a no significant difference in fracture resistance comparable with the Positive Control. The reason may be attributed to

the support of the bulk Group III resin substructure to the overlying conventional composite resin by transferring the stresses from the polymer matrix to the fibers, the individual fibers acting as crack stoppers.

The mechanical properties are enhanced and achieved by having a fiber length equal to or greater than the critical fiber length. The critical fiber length is the minimum length at which the center of the fiber reaches its ultimate tensile strength when the matrix reaches its maximum shear strength (ie, a minimum of 0.5–1.6 mm should exist to exhibit enhanced properties).<sup>16</sup> Because the length of the E-glass fibers in the bisphenol A glycol dimethacrylate polymer matrix is 3 mm, this could have also influenced the results obtained in this study, showing higher fracture resistance of the tooth.<sup>17</sup>

According to the Krenchel factor, short randomly arranged fibers (E-glass fibers) when incorporated in the resin matrix provide an isotropic reinforcement effect in multiple directions instead of just 1 or 2 directions.<sup>18</sup> With continuous bidirectional fibers, the reinforcing effect is provided in 2 directions with a reinforcement efficiency of 50%, whereas multidirectional random fibers will render a reinforcement efficiency of 38% in 1 plane and 20% in 3 dimensions.<sup>19</sup>

According to the results of the study, resin composite core build up materials showed better mechanical properties FiltekZ350 XT, which is similar to the results of study done by previous studies. This could be due to the micromechanical bonding (monoblock effect) of resins to the tooth structure and resin composites behaving like stress breakers as well as complete curing of material with dual cure technology.<sup>20</sup> Results of our study were consistent with the results of study done by Agrawal et al and others who found that some resin composites exhibited compressive strengths more than that of amalgam and could be used as alternatives to amalgam. In

our study, ParaCore composite resin material showed excellent physical properties because it is reinforced with glass fibers; it is a dual cure material that will ensure complete cure, thereby improve the strength of the material.<sup>21</sup> The macroscopic size of the unidirectional fiber bundles used in fiber reinforces the resins and improves their mechanical properties. The presence of fibers affects the fracture process that results in interrupting crack growth progression and thus enhances the fracture toughness of the fiber-reinforced composite material.<sup>22</sup> The present study is in agreement with the study done by Peterson *et al.*

Filtek Z350 XT had the least fracture resistance as compared to the Ever X Posterior and that of Paracore. The high filler loading enables nanocomposites to demonstrate good physical and mechanical properties and reinforce the tooth structure well but the lack of reinforced fibre particle results in decreased strength.<sup>23</sup> The results of the study were similar to that of Eapen et al (2017), who reported better results with ever X Posterior and MultiCore Flow, rather than Filtek Z350 XT.<sup>24</sup>

Based on the results on this in-vitro study, the use of short-fibre reinforced composite material for endodontically treated teeth, using the advantage of bilayered restorations may mimic the natural behavior of the enamel and dentin<sup>25</sup>.

This combination could provide better reinforcing effect, without delamination under higher stress.

### Conclusion

A short fibre-reinforced composite can be used as direct core build-up material that can effectively resist heavy occlusal forces against fracture and may reinforce the remaining tooth structure in endodontically treated teeth.

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