Review Article

# Comparative Evaluation of Fracture Strength of Endocrown Restorations using Different Composite Materials – An *In vitro* Study

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## Abstract

The aim of this study is to evaluate the fracture resistance and failure mode of endodontically treated teeth (ETT) restored with different composite materials. A total of 40 mandibular first molars were selected and divided into four groups ($n$ = 10). Group I was control group, Group II samples were restored with glass fiber post combined with convention Filtek Z 350, Group III samples were restored with bulk-fill composite resin, and Group IV samples were restored with polyethylene reinforced fiber with alternate layers of conventional composite. The samples were subjected to fracture strength testing until failure. The compressive strength and the failure mode were recorded. Statistical analysis was performed using one-way analysis of variance. A statistically significant difference was found in the fracture resistance between the four groups with the highest fracture resistance in the control group followed by Group II samples restored with bulk-fill composite, then Group III samples restored with glass fiber post and conventional composite, and then Group IV samples restored with alternate layers of polyethylene fiber reinforced composite and conventional composite. It can be concluded that the use of bulk-fill composite for the restoration of ETT may be an alternative treatment modality as it provokes a more conservative and cost-effective treatment.

**Keywords:** CAD/CAM, Endocrown, Endodontically treated teeth.

## Introduction

Restoration of endodontically treated teeth (ETT) may depend on many factors, the amount of remaining intact tooth structure, the clinician's understanding of the potentials and limitations of the restorative technique, biocompatibility of restorative materials, and the expectations of the patients.[1] Severely damaged ETT teeth should be restored with the materials which can mimic the natural biomechanical characteristics of dental substrates. The restoration of ETT with severe damage remains a clinical challenge. ETT teeth become fragile and more prone to fracture due to moisture loss.[2]

However, conventional treatment using intraradicular posts and full-coverage crowns proposed to be very significant in clinical success, one disadvantage of this method is the extra removal of intact tooth structure needed for fitting the post-retained restoration. Since adhesive dentistry evolved, a promising treatment modality as an alternative to post and core is endocrown restorations.[3,4]

Endocrown, which can be considered as a monoblock type of restoration, combines the intraradicular post, the core, and the crown in single unit, and was first introduced as an alternative treatment modality in 1995 by Pissis. In endocrowns preparation using adhesive restorations, subgingival margin placement is not needed unlike conventional complete crown.[2,5]

Endocrown is a type of partial crown which is commonly made from ceramic material or composite resin which is applied with resin cement to the ETT. Commonly, endocrowns are prepared according to the criteria of 90° butt margin, 6–10° internal taper, 2–3 mm cuspal reduction, and smooth internal transition.[6-8] The advantage of endocrown restoration is that it takes full occlusal coverage, along with pulp chamber to increase the adhesive substrate area. Materials used for the manufacture of endocrown

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are feldsphatic and glass-ceramic, hybrid composite resins, and computer-aided design and computer-aided manufacturing ceramics and composite resins. Endocrown indications include loss of extensive tooth structure, small intermaxillary spaces, where rehabilitation using pegs and crowns is not possible due to insufficient thickness of ceramic material, and cases, where post use is contraindicated because there are anatomic variations of the roots.

ETT with reduced clinical crown length are difficult to restored using a full coverage crown; thus, an endocrown may be an appropriate treatment modality. Recently, various materials have been described that may be useful in endocrown restoration rather than conventional ceramic materials. The bulk-fill resin composite is the proven material which can be used for endocrown. Advantage of this material is being less viscous than conventional composites would improve cohesiveness within the restoration.[9]

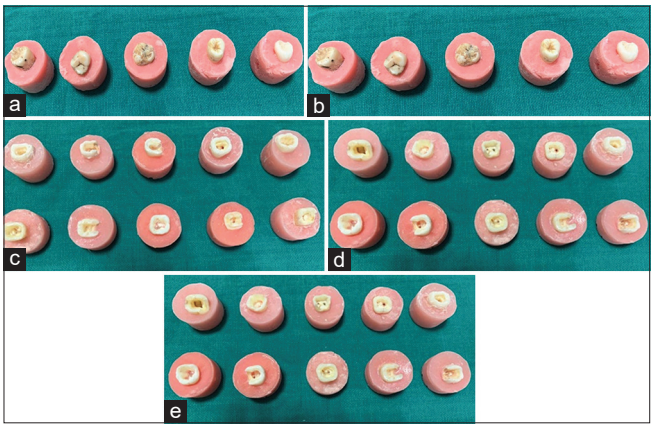



**Figure 1:** (a)&(b) Group I control group, (c) GroupII, (d) Group III, (e) Group IV

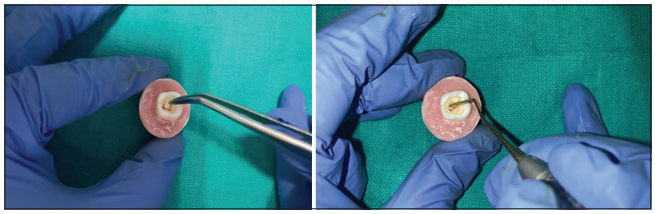


**Figure 2:** Endocrown using Ribbond Fibre ,endocrown using Conventional Filtek Z 350 composite


**Figure 3:** Endocrown restoration using bulk-fill composite

**Figure 4:** Different restorative materials(Ribbond fibre, Bulk-Fill Filtek Z 350 composite, and conventional composite)


**Figure 5:** Sample testing for fracture resistance under universal testing machine

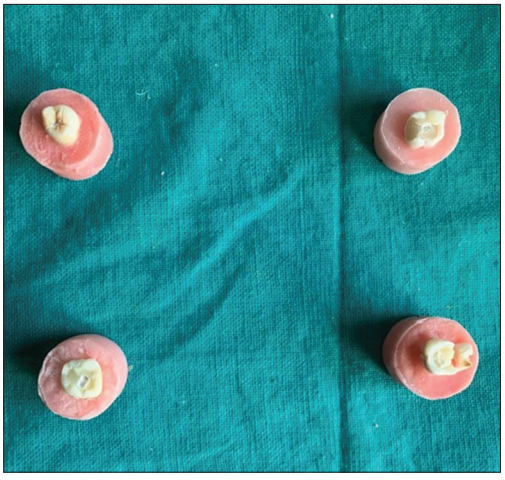


**Figure 6:** Fractured teeth samples

## Materials and Methods

In this *in vitro* study, 40 mandibular first molars were collected according to the following inclusion criteria: The presence of enamel on the crown margins, the wide pulp chamber an intact tooth structure minimum of 2 mm above CEJ, and the samples were divided in four subgroups ($n = 40$) (Figure 1). The teeth were mounted in acrylic resin holder for sample preparation. Then, the access opening was done, and root canals were instrumented using stainless steel K-files number, 15, 20, 25, and 30, followed by thorough cleaning and shaping using ProTaper Gold. The samples were irrigated using 2% sodium hypochlorite solution. Then, the samples were obturated using standardized seal apex root canal sealer (Figures 2 and 3). Then, post space preparation was done in the root canal treated teeth after 48 h, samples were then randomly divided into four group ($n = 10$) according to restorative materials used for making endocrowns (Figure 4).

1. Group I ($n = 10$): Control group
2. Group II ($n = 10$): Glass fiber post-retained with conventional filtek z350
3. Group III ($n = 10$): Bulk-fill composites
4. Group IV ($n = 10$): Polyethylene fiber reinforced composite (Ribbond) with alternate layer of conventional composite.

Group I which was the control group no treatment was done. Group II endocrown was made by placing glass fiber post along with conventional Filtek Z350 composite, Group III endocrown was made by restoring completely with bulk-fill composite, and Group IV endocrown was made by placing polyethylene fiber reinforced composite in alternate layers with conventional composite. Then, the samples were tested for detecting the fracture strength of each endocrown (Figures 5 and 6).

## Results

Data obtained were analyzed using statistical package for social sciences version 23.0 IBM Chicago and the following results were obtained. Results were interpreted in tables. $P \leq 0.05$ considered significant.

Mean fracture resistance scores assessed for different groups are shown in Table 1. Highest fracture resistance was observed in control group with 2246.39 ± 177 followed by bulk-fill with a mean fracture resistance of 2035.63 ± 68. Conventional Filtek Z350 showed fracture resistance with a mean value of 1131.32 ± 55. Polyethylene fiber reinforced composite showed least fracture resistance with a mean of 591.60 ± 38 (Graph 1).

**Table 1: Mean fracture resistance for different groups**

| Group | Mean±SD | Lower bound | Upper bound |
|---|---|---|---|
| Control | 2246.39±177 | 1844.39 | 2648.40 |
| Bulk-fill | 2035.63±68 | 1543.67 | 2527.58 |
| Conventional Filtek Z350 | 1131.32±55 | 736.80 | 1525.83 |
| Polyethylene fiber reinforced composite | 591.60±38 | 314.81 | 868.38 |

SD: Standard deviation

Inter group comparisons for the four different groups were done using Bonferroni *post hoc* test (Table 2). There was no significant difference observed between control group and bulk-fill group ($P = 1.00$). A significant difference was observed between control group and conventional Filtek Z350 and also with polyethylene fiber reinforced composite ($P \leq 0.05$).

Results from the above study suggest the fracture resistance among the study groups are as follows from highest resistance to lowest: Control >bulk-fill >conventional Filtek Z350 >polyethylene fiber reinforced composite.

## Discussion

Endocrown has been considered a reliable alternative in the restoration of extensively damaged ETT. In general, endocrowns are prepared using glass-ceramics.[10] The primary disadvantage of this restorative material compared with other systems (e.g., conventional crowns combined with intraradicular posts) is that glass-ceramics are brittle, showing on the one hand high stiffness but on the other hand little elastic behavior, which, thereby, favors the occurrence of catastrophic failures such as fractures extending to the root. Hence, it appears that the use of more compliant materials would produce a better biomechanical match between restoration and tooth. Work-of-fracture is a mechanical property that is commonly used to predict the interfacial fracture toughness of materials, involving the ability of a material containing a crack to resist fracture. In simple words, work-of-fracture corresponds to the total energy required to grow a thin crack, and restorations with greater work-of.

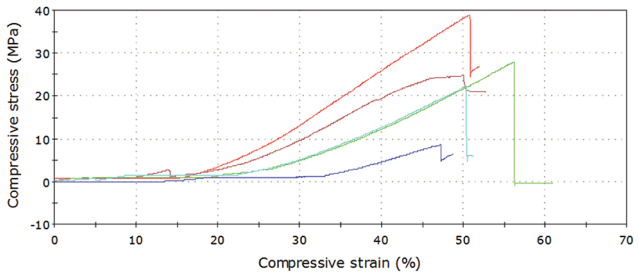
In this study, a total of four groups were used with resin composites; control group, bulk-fill composites, glass fiber post combined with conventional composites (Filek z 350), and polyethylene fiber reinforced composites with alternate layers of conventional composites.

Regarding the control group as per the study, they exhibited the highest fracture resistance (2246.39 ± 177). They exhibit the natural resistance of the tooth against the load and stresses occurred. The bulk-fill composite endocrown was Group II exhibit one of the highest fracture resistance among other (2035.63 ± 68). It can be inferred that a sound tooth possesses a work-of-fracture behavior that may not be completely restored using current restorative materials, although a better match may be obtained by bulk-fill resin composite tested here (Z350). Group III which was the glass fiber post combined with conventional composites (Filek Z350) endocrown showed the fracture resistance of (1131.32 ± 55) as the fracture resistance of glass fiber post cannot withstand the stresses and load and it leads to the fracture of the whole endocrown fragment.[10-12] Group IV which was polyethylene fiber reinforced composites with alternate layers of conventional composites endocrown showed the lowest fracture resistance (591.60 ± 38). Finally, it is

**Table 2: *Post hoc* analysis for inter group analysis of fracture resistance among different groups**

| Group | Comparison group | Mean difference | 95% confidence interval | | *P*-value |
|---|---|---|---|---|---|
| | | | Lower bound | Upper bound | |
| Control | Bulk-fill | 210.765 | −485.1570 | 906.6870 | 1.000 (NS) |
| | Conventional Filtek Z350 | 1115.077 | 419.1550 | 1810.9990 | 0.000* |
| | Polyethylene fiber reinforced composite | 1654.798 | 958.8760 | 2350.7200 | 0.000* |
| Bulk-fill | Control | −210.765 | −906.6870 | 485.1570 | 1.000 (NS) |
| | Conventional Filtek Z350 | 904.312 | 208.3900 | 1600.2340 | 0.005* |
| | Polyethylene fiber reinforced composite | 1444.033 | 748.1110 | 2139.9550 | 0.000* |
| Conventional Filtek Z350 | Control | −1115.077 | −1810.9990 | −419.1550 | 0.000* |
| | Bulk-fill | −904.312 | −1600.2340 | −208.3900 | 0.005* |
| | Polyethylene fiber reinforced composite | 539.72 | −156.2010 | 1235.6430 | 0.222 (NS) |
| Polyethylene fiber reinforced composite | Control | −1654.798 | −2350.7200 | −958.8760 | 0.000* |
| | Bulk-fill | −1444.033 | −2139.9550 | −748.1110 | 0.000* |
| | Conventional Filtek Z350 | −539.72 | −1235.6430 | 156.2010 | 0.222 (NS) |

NS: Not significant, *: Significant




**Graph 1:** Typical compressive stress -strain curve

worth mentioning that the present findings may not be directly translated to the clinic, since the experimental conditions were composed of static axial loading. According to Gresnigt *et al*., axial loading produces greater forces than lateral loading, generally above the mean masticatory forces in humans (e.g., approximately 600–900 N for females and males, respectively). In the present study, we tested the endocrowns using only static axial loading, overestimating the load-to-fracture performance of the restoration. However, we must emphasize that the purpose of our study was to investigate the mechanical performance and the fracture behavior of endocrowns prepared using distinct restorative materials; hence, axial loading would be more advisable. Gresnigt *et al*. also demonstrated that axial loading may evaluate more directly the effect of inherent characteristics (e.g., elasticity modulus) of materials on their mechanical behavior rather than lateral loading, which would be more associated with the adhesion effect of the restoration on high load-to-fracture values obtained in the present study, which are important for understating the mechanics of structurally distinct endocrowns, as demonstrated by our load-to-fracture and work-of-fracture results.[13-15]

## Conclusion

Considering the above study findings, the endocrowns prepared using bulk-fill composite resin demonstrated better performance compared with endocrowns fabricated using glass fiber post with conventional composite or polyethylene fiber reinforced composites.

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