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Comparative Evaluation Of Fracture Resistance Of Bulk-Fill and Conventional Resin Composites Used For The Restoration Of Endodontically Treated Teeth: An In-Vitro Study

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ABSTRACT

Aim: To compare the fracture resistance of bulk-fill resin composites and conventional resin composites used to restore endodontically treated maxillary premolars.

Settings and Design: Academic, invitro study

Materials and Methods: After seeking approval from the institutional ethical committee following extracted premolars were selected, disinfected and , divided into six groups (n=15 each). Group 1 was left intact (control); Group 2 received endodontic treatment without restoration (positive control). Groups 3–6 received endodontic treatment and were restored with either bulk-fill (Beautifil Bulk, Prime Restorite) or conventional composites (Beautifil II, Dentsply Spectrum). Standard MOD cavity preparations and root canal procedures were performed. The restorations were done as per the respective manufacturer's instructions. All specimens were mounted in acrylic and subjected to vertical compressive force using a Universal Testing Machine. Fracture loads were recorded in Newtons (N).

Statistical Analysis: Data were analysed using Shapiro-Wilk, ANOVA and Tukey's post hoc test ($p < 0.05$).

Results: The intact group had the highest fracture resistance (1691.06 N), followed by Beautifil Bulk (1546 N), Dentsply Spectrum (1478.93 N), and Prime Restorite (1226.33 N). Beautifil II (755.27 N) and the positive control group (704 N) showed the lowest values. Statistical analysis revealed significant differences among most groups, except between Beautifil II and the positive control, suggesting limited reinforcement from Beautifil II.

Conclusion: Bulk-fill composites, especially Beautifil Bulk, significantly enhance the fracture resistance of ETTs and offer clinical advantages over conventional composites in terms of ease of application and reduced treatment time. These materials represent a promising solution for posterior restorations where high load resistance is required.

1. INTRODUCTION

Because of their decreased structural integrity from trauma, caries, and loss of internal anatomy, endodontically treated teeth pose a substantial clinical issue when it comes to restoration. These teeth become more prone to fracture after treatment because of things like endodontic instrumentation, occlusal access preparation, and large cavities.[1–2] Despite the favourable long-term survival rates (97.1% after eight years), the last restoration phase is crucial to success [3].

Resin-based composites (RBCs) are preferred for post-endodontic restorations because of their aesthetic appeal, strong adhesion to tooth surfaces, and minimal need for structural removal.[4] RBCs reinforce weakened structures and help preserve residual tooth tissue. Traditional RBC placement involves 2 mm incremental layers to ensure proper curing and reduce shrinkage stress.[5] However, this technique is time-intensive and increases the risks of voids and sensitivity due to incomplete polymerization.[6]

To address these limitations, manufacturers developed bulk-fill resin composites that allow placement in 4 mm or deeper increments while maintaining similar physical properties.[7] These materials include innovations such as stronger photo-initiators, higher translucency, and optimized filler content to enhance light transmission and depth of cure.[8-9]

Studies emphasize that RBCs must exhibit adequate fracture resistance and crack inhibition to withstand occlusal stresses, especially in posterior restorations.[10-11] Some bulk-fill materials have slightly lower hardness than conventional composites, but newer formulations using pre-polymerized fillers and enhanced matrix chemistry show comparable or improved performance.[12-13] A study by **BroshT et al.** demonstrated that placement location significantly affects fracture resistance, with bulk-fill layers showing higher resilience than traditional techniques.[14] Research also suggests that combining bulk-fill and conventional composites or using fibre reinforcement may further enhance durability in severely compromised teeth.[15-16]

In summary, bulk-fill RBCs offer promising alternatives to conventional methods in the restoration of ETTs. Their improved efficiency, ease of use, and mechanical performance align with the evolving demands of modern adhesive dentistry. However, clinical success ultimately depends on material selection following proper bonding protocols, and placement technique to achieve optimal fracture resistance and long-term functionality.

2. MATERIALS AND METHODOLOGY

This in-vitro study titled "Comparative Evaluation of Fracture Resistance of Bulk-Fill and Conventional Resin Composites Used for the Restoration of Endodontically Treated Teeth" was conducted at the Department of Conservative Dentistry and Endodontics, Himachal Dental College and Hospital, Sundernagar, Himachal Pradesh. Mechanical testing was performed using a Universal Testing Machine (UTM) at the Indian Institute of Technology (IIT) Mandi.

One hundred sound human maxillary premolars were used for this study. Out of (n=100) specimens, (n=10) of teeth were excluded as they failed to meet the inclusion criteria.

Sample preparation

Teeth were extracted for periodontal problems and orthodontic reasons. The calculus and soft tissues were removed using a scaler (Woodpecker UDS-P Piezo Ultrasonic Scaler). The mesiodistal and buccopalatal dimensions of the teeth were evaluated using a digital caliper (Vernier Caliper Gauge Micrometer) to ensure that the teeth were of similar size. The teeth were stored in distilled water until use. Teeth were embedded in self-curing acrylic resin (Dental Product of India (DPI), The Bombay Burmah Trading Corporation Ltd) using a Teflon cylinder mold (3cm in diameter and 3 cm in height) up to 1mm below the cemento-enamel junction (CEJ). The teeth were randomly divided into six groups of 15 teeth (n=15). The teeth in the first group were left intact and tested as a negative control (group 1). Cavity preparations, endodontic treatments, and restorations were done by an operator. The mesio-occluso distal (MOD) cavities and endodontic access cavities of the 5 groups were prepared using a high-speed round bur #2 and inverted cone diamond burs size #35 (Mani Medical India Pvt, Ltd) under cooling air and water. The MOD cavities were prepared to a width of one-third of the intercuspal distance (mean 2.2mm) on occlusal, and one-third of the buccopalatal distance (mean 3mm) on gingival. The cavity depth of the preparations was set to 4mm. The canal length was measured with a 10 K file (Mani, Inc.). The canals were prepared with ProTaper gold rotary files (Dentsply Maillefer, Switzerland) according to the manufacturer's guidelines. 5.25% 5ml NaoCl was used for irrigation for each tooth. Smear layer was removed with 17% EDTA. Finally, the canals were rinsed with distilled water and dried with paper points. AH plus canal sealer (Dentsply De-Trey, Konstanz, Germany) and single cone (ProTaper Next-X2) technique were used for filling the canals. The endodontic access cavities were restored up to the MOD cavity floor with temporary restorative material (Smart Temp, Safe endo)

• **Bulk-Fill Composites**:	• **Conventional Composites**:
1. Prime Dental Restorite Bulk-Fill (Prime Dental Products Pvt. Ltd.) 2. Shofu Beautifil Bulk (SHOFU INC, Japan)	1. Shofu Beautifil II (SHOFU INC, Japan) 2. Dentsply Spectrum (Dentsply Sirona Inc.)

Table 1- Restorative materials that are used in the study.

Group Distribution

- **Group 1 (Control)**: Intact teeth without any cavity preparation
- **Group 2 (Positive Control)**: Teeth with MOD cavity preparation and endodontic treatment, but no restoration

For groups 3 to 6, MOD cavity preparation and endodontic treatment were done. Etchant gel (Dentsply Sirona DeTray conditioner 36 etching gel) was applied on the prepared cavity surfaces, after 15 seconds the etched cavity was thoroughly rinsed with an air-water syringe for 30 seconds. A thin layer of bonding agent (Dentsply Sirona Spectrum Bond nanotechnology dental adhesive bonding system) was applied to the enamel and dentin surfaces. It was gently blown for 5 seconds with an air syringe. A second layer of bonding agent was applied and light cured (Waldent Smart-LED Curing Light). A 6mm metal band with a Tofflemire retainer was used for cavity restorations. The thickness of the composite was recorded using a Williams periodontal probe Restorations were finished using polishing discs, rubber cups, and fine burs.

- **Group 3**: Endodontically treated teeth restored with Shofu Beautifil Bulk (SHOFU INC, Japan). The cavity was filled with a 4 mm-thick Shofu Beautifil Bulk Fill resin composite and light-cured for 10 seconds.
- **Group 4**: Endodontically treated teeth restored with Dentsply Spectrum (Dentsply Sirona Inc.). Each layer was 2mm thick and light-cured for 20 seconds,
- **Group 5**: Endodontically treated teeth restored with Prime Dental Restorite Bulk-Fill (Prime Dental Products Pvt. Ltd.). The cavity was filled with a 4 mm-thick Prime Dental Restorite Bulk Fill resin composite and was light-cured for 10 seconds.
- **Group 6**: Endodontically treated teeth restored with Shofu Beautifil II (SHOFU INC, Japan). The cavity was filled incrementally with 2mm thickness using Shofu Beautifil II resin composite and light-cured for 20 seconds.

Each restored tooth was embedded in a self-cure acrylic resin block, with 2 mm of the root exposed to simulate natural periodontal conditions.

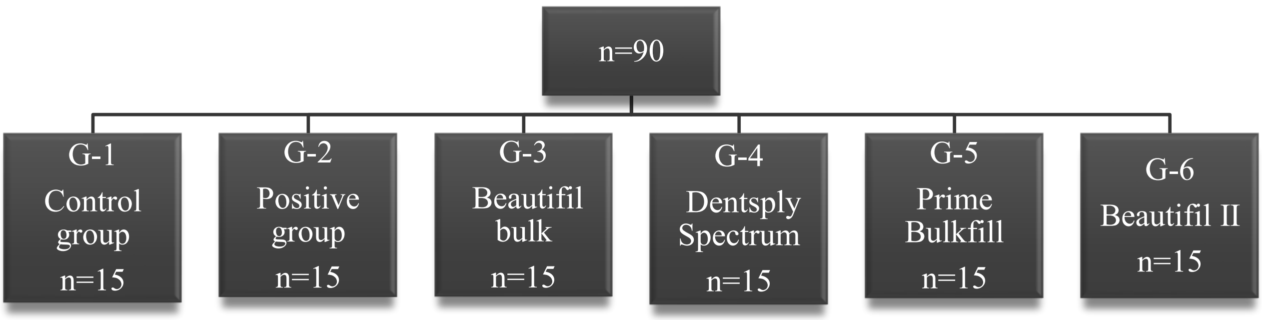

Figure:1 Specimen Groups distribution

Mode of Fracture strength test

The mounted specimens were tested for fracture resistance using a Universal Testing Machine (Tinius Olsen, Noida) (Figure 1). A 5 mm-diameter steel indenter applied a compressive load vertically to the occlusal surface at a crosshead speed of 1 mm/min until fracture occurred (Figure 2). The testing machine stopped automatically when a fracture occurred in the restoration or the teeth. The maximum force at which each specimen fractured was recorded in Newtons (N).

Figure 2: cavity design

Figure 3: specimen mounted on acrylic cylinder

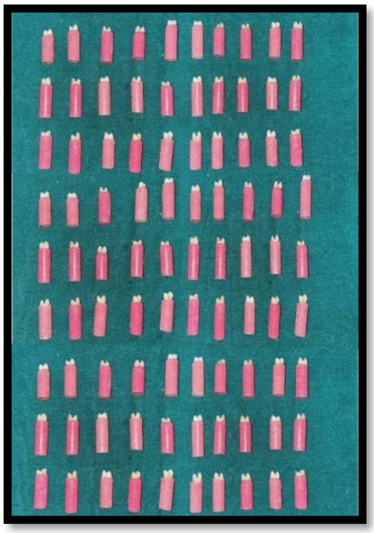

Figure 4: A 5 mm-diameter round tip applied a compressive load vertically to the occlusal surface

Statistical evaluation

SHAPIRO–WILK TEST, The Shapiro–Wilk test is a test of normality in frequentist statistics. The Shapiro-Wilk test is a way to tell if a random sample comes from a normal distribution.

ANOVA, is a statistical method that stands for analysis of variance. This test is also called as Fisher analysis of variance, which is used to do the analysis of variance between and within the groups whenever the groups are more than two.

TUKEY'S TEST, A popular method of post-hoc analysis is named Tukey's Test after John Tukey. Tukey's test compares the means of all treatments to the mean of every other treatment and is considered the best available method in cases when confidence intervals are desired or if sample sizes are unequal.

3. RESULT

The study assessed the fracture resistance of six groups, each consisting of 15 specimens. The Control group (intact teeth) exhibited the highest mean fracture resistance (Table 2) at 1691.06 N, followed by Beautifil Bulk (Shofu) with 1546 N, and Dentsply Spectrum with 1478.93 N. Prime Dental Restorite Bulk-Fill showed a moderate mean of 1226.33 N, while Beautifil II recorded a lower value of 755.27 N. The Positive control group (endodontically treated, unrestored) had the lowest resistance at 704 N.

Statistical analysis using one-way ANOVA revealed a significant difference in fracture resistance among the groups ($p < 0.001$). Tukey's post hoc test confirmed that most intergroup differences were statistically significant, especially between the Control group and all others, as well as between Beautifil Bulk and other restorative groups. Interestingly, Beautifil II and the Positive control group did not differ significantly ($p > 0.05$), indicating limited restorative reinforcement by Beautifil II.

In conclusion, bulk-fill composites, particularly Beautifil Bulk, demonstrated superior reinforcement of endodontically treated teeth compared to conventional composites, validating their clinical utility in high-stress restorations.

Table 2: Mean, Standard deviations (sd), Standard error of fracture resistance of different groups:

Group	Mean	Standard deviation	Standard error	95% ci Lower bound	95% ci Upper bound
CONTROL	1691.06	± 13.94	3.72	1682.31	1698.41
POSITIVE GROUP	704.00	±81.52	21.04	659.39	749.68

BF SHOFU	1546.00	± 49.77	12.85	1518.43	1573.57
DENTSPLY	1478.93	±46.38	11.97	1453.25	1504.62
PRIME BF	1226.33	±19.18	4.95	1215.71	1236.96
SHOFU II	755.27	±65.15	16.82	1147.03	1309.84

4. DISCUSSION

Endodontically treated teeth (ETTs) often suffer from structural weakening due to the removal of pulp tissue and surrounding dentin during root canal therapy.[17] While root canal treatment (RCT) is effective in eliminating infection, it reduces the tooth's ability to withstand masticatory forces, especially in posterior regions, thereby increasing the risk of fracture.[18] To counteract this, restorative materials must not only seal but also reinforce the compromised tooth structure.

Bulk-fill resin-based composites (RBCs) have emerged as a favourable option for restoring ETTs. These materials allow placement in 4 mm increments, reducing chairside time and minimizing polymerization shrinkage stress—a key factor in restorative failure.[19] Unlike conventional RBCs that require incremental layering, bulk-fills improve efficiency and reduce voids or uncured layers.[20]

In the current study, Beautifil Bulk demonstrated the highest fracture resistance among the tested materials. This performance can be attributed to its high filler content (87% by weight), presence of S-PRG fillers, and giomer-based formulation. These features combine the benefits of composite and glass ionomer materials, such as better stress distribution and fluoride release. Prime Restorite Bulk-Fill also performed well but slightly below Beautifil Bulk, likely due to its lower filler content and different resin chemistry.

On the other hand, conventional RBCs like Beautifil II and Dentsply Spectrum showed lower fracture resistance. Despite their long-standing clinical use and strong mechanical properties, these composites require a time-intensive placement process, with 2 mm incremental layers and individual curing steps.[21] This increases the risk of incomplete polymerization and interlayer stress, negatively impacting restoration durability.[22]

Several studies support the superiority of bulk-fill composites in restoring ETTs. Sufi et al.[23] and Strini et al.[24] reported improved fracture resistance with bulk-fills in large cavities, highlighting their advantage in deeper restorations. Their reduced shrinkage stress and improved depth of cure contribute significantly to the mechanical reinforcement of weakened teeth.

Nonetheless, findings from Atalay et al.[25] and Toz et al.[26] found no statistically significant difference between bulk-fill and conventional composites. Such discrepancies may be attributed to differences in filler systems, material viscosity (flowable vs. packable), or the use of nano-hybrid vs. micro-hybrid formulations.

Beautifil Bulk's higher fracture resistance is supported by its specific monomer composition—Bis-GMA, UDMA, and TEGDMA—paired with S-PRG fillers that improve bonding and reduce polymerization stress.[27] These components increase the modulus of elasticity and stiffness, thus enhancing overall resistance to fracture.

However, as an in-vitro study, limitations exist. The experimental setup did not fully simulate oral conditions such as cyclic loading, multidirectional forces, and temperature changes. Real teeth experience dynamic forces including tensile and shear stresses, not just compressive loading. Additionally, the limited sample size restricts the ability to generalize findings across broader populations.

Despite these limitations, the study affirms the clinical potential of bulk-fill composites, particularly Beautifil Bulk, in restoring structurally compromised ETTs. The simplified placement, improved curing, and superior mechanical properties make bulk-fills an efficient and effective alternative to conventional composites.[28] Yet, further in-vivo studies and long-term clinical trials are essential to validate these advantages under real-world conditions.

5. CONCLUSION

Within the limits of this study, our findings demonstrate that the bulk-fill composite increases the fracture resistance of endodontically treated teeth, provide ease of use and decreases the time of application.

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Conflict of interest

The authors report no conflicts of interest

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