

## Original Research

### Comparative evaluation of fracture resistance of three different composite core build-up materialson fiber reinforced composite posts: an in vitro UTM study

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#### ABSTRACT:

This study investigated the fracture resistance of various core buildup materials when used with fiber-reinforced composite (FRC) posts in endodontically treated teeth with significant tooth loss. The objective was to determine how different core materials contribute to regaining the tooth's proper crown-to-root ratio. Thirty specimens were prepared and allocated into three equal groups (n=10 each) based on the core buildup material used: Group A utilized Para Core, Group B used Multicore, and Group C employed Te-Econom plus. To create the core buildup specimens, a plexiglass mold was positioned on an acrylic base, ensuring the post was centrally located. The fracture resistance of these specimens was subsequently evaluated using a universal testing machine. The study's findings indicated that Para Core demonstrated the highest mean fracture resistance, followed by Te-Econom plus, with Multicore flow exhibiting the lowest resistance (Para Core > Te-Econom plus > Multicore flow). In conclusion, the study determined that Para Core provided superior fracture resistance when compared to both Te-Econom plus and Multicore Flow materials.

**Keywords:** Fracture resistance, Paracore, Multicore Flow, Te-Econom Plus, Universal Testing Machine

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#### INTRODUCTION

Modern restorative dental therapy has revolutionized dentistry, offering solutions for retaining fractured teeth that would have been extracted few decades ago. Advancements in dental procedure, particularly in endodontics and restorative techniques, have significantly enhanced the longevity and function of compromised tooth. It is well established that with appropriate endodontic treatment and a well-executed post endodontic restoration, teeth that have lost their pulp can continue to serve efficiently. This is especially true only if the supporting structures are intact and healthy<sup>1</sup>.

A core build up is a restorative procedure used to reconstruct the severely damaged coronal portion of tooth, creating a stable foundation for the placement of an extra coronal restoration, such as crown. The main objectives of a core buildup are to establish a visible

and accessible platform for the final restoration, enhance its retention and ensure efficient distribution of occlusal forces from the restoration to the underlying tooth structure<sup>2,3</sup>.

Core build ups are contraindicated in certain clinical situations where long term success is unlikely. This includes the presence of persistent periapical lesions, compromised periodontal health, and unfavourable crown-to-root ratio, teeth subjected to heavy occlusal forces, financial limitations, and cases where the clinician lacks the necessary skills or experience to perform the procedure effectively<sup>4,5</sup>.

The properties of core build up materials not only restore the tooth effectively but also contribute to the long-term success and function of tooth following restorations. Ideal properties for core build up materials include<sup>6</sup>.

1. Ease of Manipulation

2. Tooth- Coloured Appearance
3. High compressive and flexure strength
4. Dimensional stability
5. Insolubility in oral fluids
6. Ability to resist dental caries.

The restoration of endodontically treated teeth has seen a notable rise in the use of fiber-reinforced composite (FRC) posts. This increased adoption is largely attributed to their advantageous physical characteristics, including high tensile strength and excellent resistance to fatigue. A significant benefit of FRC posts is their modulus of elasticity, which closely mirrors that of natural dentin. This similarity facilitates more effective stress distribution within the tooth structure, thereby diminishing the likelihood of root fracture. When used in combination with FRC posts, composite core buildup materials are commonly employed to reconstruct the coronal portion of the tooth. This approach helps establish proper retention and resistance form, essential for the long-term success for the final crown restoration.<sup>7</sup>

Para Core is a composite core buildup material that's reinforced with glass fibers, dual-cured (meaning it sets with both light and chemical reactions), and radiopaque, allowing it to be visible on X-rays. Para Core incorporates glass particles that impart high strength<sup>8</sup>. MultiCore Flow (Ivoclar) is a selfcured core buildup composite with light- cured options.it incorporates.The inorganic fillers used include barium glass, ytterbium trifluoride, barium-aluminum-fluorosilicate glass, and highly dispersed silicon dioxide.<sup>9</sup>Te-Econom plus is a composite material composed of dimethacrylate resin and 22wt% TGEDMA. Its filler content includes barium glass, ytterbium trifluoride, silicon dioxide, and mixed oxides, providing both strength and radioopacity.<sup>10</sup>.

To understand how different restorative options perform, this study will examine the fracture resistance of three diverse core buildup materials paired with fiber-reinforced composite (FRC) posts.

## MATERIAL AND METHODOLOGY

**Study Design:** This study was reviewed and approved by the Institutional Ethical Committee of Meghna Institute of Dental Sciences, Nizamabad, India in 2023,(approval number: 2023/MIDS/MDS/ENDO/IEC/06). Power analysis was performed using G\*Power software [ $\alpha$  ( $\alpha$ ) = 0.05; power ( $1-\beta$ ) = 0.80]. It indicated a requirement of 30 samples.

**Procedure:** In this study, a total of 30 specimens were prepared. These specimens were subsequently categorized into three groups according to the specific material employed.

**GROUP A:** samples of Para Core(n=10)

**GROUP B:** samples of MultiCore (n=10)

**GROUB C:** samples of Te-Econom plus (n=10)

This study involved careful standardization of all experimental variables, including the specimen's size and shape, testing configuration, fabrication

procedure, temperature, humidity, storage conditions, strain rate, and setting time. Uniform treatment was applied to all specimens to maintain consistency throughout the experiment. Additionally, all materials were handled and used strictly according to the manufacture's instructions.

## SPECIMEN PREPARATION

The specimen dimensions for each sample were determined based on the INTERNATIONAL STANDARDS ORGANIZATION (ISO) 4049 (ISO, 1992). Compressive strength was assessed using tubular samples measuring 4 X 6 mm, which were mounted on FRC posts embedded in an acrylic base at an angle of approximately 45°. This setup ensured that 5mm of the post was surrounded by the core buildup material. The acrylic base was tilted at a 45° angle to position the specimen optimally during mechanical testing that is shown in Figure 1. The oblique loading was intentionally chosen to replicate a critical stress distribution during testing<sup>1</sup>.

To prepare the core buildup specimens, a plexiglass mold was placed on the acrylic base with the post positioned in the centre. For Para Core (ColteneWhaledent) Non -Rinse Conditioner(NRC) was applied for 30 sec and allowed to dry 2 sec. One drop of adhesive A was mixed with one drop of adhesive in to the mixing well and applied for 30sec and allowed to dry for 2sec. Para Core was applied using automix tip and cured for 30 sec.For Multicore Flow (Ivoclar), etching was done with an application of 37% phosphoric acid, subsequently applying a universal bonding agent, and then curing was done. Multicore Flow was applied using automix tip and cured for 10 sec and left for selfcure.ForTe-Econom plus (Ivoclar), etching was done with 37% phosphoric acid, Te- Econom bond was applied and curing was done.

Following the removal of molds, the specimens were kept stored in distilled water at  $37\pm 1^{\circ}\text{C}$  until the testing began. The crosshead speed was set at 1mm/min. Throughout the test, the control system, along with its software, tracked the load and extension of the samples, documenting any sudden decrease in load.



**FIGURE 1: SHOWING 45° ANGULATION OF SPECIMEN FOR TESTING.**

**STATISTICAL ANALYSIS**

To statistically analyze the collected data, it was organized into tables and processed using SPSS version 22.0 software. The mean fracture resistance and standard deviation were determined for each core material. Subsequently, a one-way ANOVA with a post hoc test was performed to identify any statistically significant variations among the core buildup materials.

**RESULTS**

The observed fracture resistance (N) of three groups summarized in table 1. Table findings indicate that the mean fracture resistance of Para Core was superior, with Te-Econom plus ranking second, and Multicore flow exhibiting the least resistance (**Para Core >Te-Econom plus > Multicore flow**). Table 2 showing the ANOVA test results. Table 3 illustrates the outcomes of the Post Hoc test conducted across all three experimental groups. Figure 2 showing the graphical representation of the result.

**TABLE 1: SHOWING THE DESCRIPTIVE STATISTICS OF COMPRESSIVE STRENGTH OF ALL GROUPS**

	N	Mean	Standard Deviation	Standard Error	95% of confidence interval for mean		Minimum	Maximum	F value	P value
					Lower bond	Upper bond				
<b>PARACORE</b>	10	452.20	26.33038	8.32640	433.3644	471.0356	409.00	482.00	78.526	<b>0.000*</b>
<b>MULTICORE FLOW</b>	10	299.60	37.90690	11.98722	272.4830	326.7170	245.00	360.00		
<b>TE-ECONOM PLUS</b>	10	420.80	18.72491	5.92134	407.4050	434.1950	392.00	445.00		
<b>Total</b>	30	390.87	72.44533	13.22665	363.8151	417.9182	245.00	482.00		

\*Significant difference

**TABLE 2: ANOVA TEST**

	Sum of squares	Df	Mean square	F	Sig.
<b>Between groups</b>	129873.867	2	64936.933	78.526	<b>0.000*</b>
<b>Within Groups</b>	22327.600	27	826.948		
<b>Total</b>	152201.467	29			

\*Significant difference

**Interpretation:** Statistically significant difference exists in the mean fracture resistance of the three experimental groups (p<0.05).

**TABLE 3: POST HOC TEST**

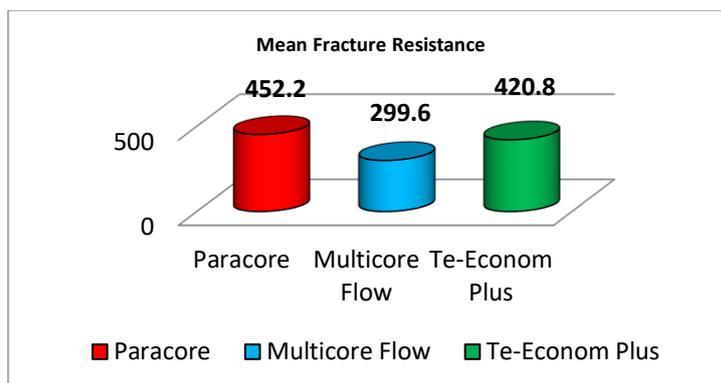
(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
PARACORE	MULTICORE FLOW	152.60000*	12.86039	<b>0.000*</b>	120.7137	184.4863
	TE-ECONOM PLUS	31.40000	12.86039	0.054	-.4863	63.2863
MULTICORE FLOW	PARACORE	-152.60000*	12.86039	<b>0.000*</b>	-184.4863	-120.7137
	TE-ECONOM PLUS	-121.20000*	12.86039	<b>0.000*</b>	-153.0863	-89.3137
TE-ECONOM PLUS	PARACORE	-31.40000	12.86039	0.054	-63.2863	.4863
	MULTICORE FLOW	121.20000*	12.86039	<b>0.000*</b>	89.3137	153.0863

\*Significant difference

**Interpretation:**

- The mean fracture resistance of the Para Core and Multicore Flow groups differed significantly (p<0.05)

- The Multicore Flow and Te-Econom Plus groups showed a statistically significant difference in their mean fracture resistance ( $p < 0.05$ ).



**FIGURE 2: MEAN FRACTURE RESISTANCE OF 3 EXPERIMENTAL GROUPS**

## DISCUSSION

The longevity and success of restorations in fiber-reinforced composite (FRC) posts and cores, along with their application techniques and material choices, play a crucial role in the outcome of endodontically treated teeth restored with them. Specifically, these include the FRC post's type and geometry, surface treatment methods, cementation approach, and the core material<sup>11</sup>. This research aimed to determine how core materials affect fracture resistance. To ensure that only the core material's impact was measured, all other experimental conditions were kept uniform. The study's goal was to evaluate the effectiveness of various core buildup materials, taking into account their unique curing mechanisms. The application of the three selected materials followed their manufacturers' prescribed instructions.

Within a universal testing machine (UTM), specimens were set vertically. A 1.5 mm diameter steel rod applied a load at a 45-degree angle to induce fracture. A steady compressive force was applied at a crosshead speed of 1 mm/min until specimen failure. The moment of fracture was detected by a sudden drop in load, and the peak load at that point was recorded in Newtons. Compressive strength, expressed in megapascals (MPa), was subsequently calculated from the maximum load applied.<sup>1</sup>

The widespread preference for composite resin cores in core build-up procedures stems from their impressive compressive strength, powerful adhesive capabilities, reduced modulus of elasticity, and their overall economic benefit. Their tooth-colored appearance also helps maintain dental aesthetics by preventing discoloration. Furthermore, their fast setting time allows for efficient tooth and core preparations, enabling clinicians to procedure promptly with rotary instrumentation without unnecessary delay<sup>12</sup>.

The core build-up materials were used precisely according to the manufacturers' guidelines. When testing for fracture resistance, failure was identified by an abrupt reduction in load, and this peak load at

failure was recorded in Newtons as the definitive measure of the material's fracture resistance.

In the present study, a statistical difference was seen in the fracture resistance among the Para Core and Multicore Flow and between Multicore Flow and Teeconom plus.

Para Core's impressive strength comes from its large, unidirectional fiber bundles. These fibers strengthen the resin, improving its mechanical properties and hindering crack growth during fracture, improving the material's fracture toughness. Para Core as a dual-cure material, ensures complete curing, further boosting its strength<sup>4</sup>. Additionally, the Including Trimethylolpropane Trimethacrylate (TMPTMA) as a crosslinking agent boosts the strength of the polymeric matrices, leading to improved physical properties. Moreover, Para Core offers excellent bond strength to dentin and enamel, which helps establish a durable foundation for restorations.<sup>14</sup>

Teeconom manufacturer claims for enhanced physical properties due to their patented technology, which optimizes filler particle size and increases inorganic filler content<sup>15</sup>.

Multicore flow is a dual cure, resin-based composite recognized for its strong robust compressive strength and effective bonding characteristics. Several studies have shown that multicore exhibits notable fracture resistance, which can be attributed to its commendable flexural strength and elastic modulus<sup>16</sup>. It has been observed that fracture resistance tends to correlate with the filler content of the core material. In the multicore flow, the filler content – 71.3 wt% in the base and 70.6 wt% in the catalyst—plays a significant role in influencing its mechanical properties. The relatively lower strength may be attributed to this specific filler composition<sup>17</sup>.

## LIMITATIONS

Sample size of the study is relatively small. It was not possible to accurately replicate the oral state because this study was conducted in vitro. To make a firm conclusion about the long-term effects on different

composites and post systems , more research is needed.

### CONCLUSION

Given the limitations of this research, it's evident that Para Core offered the highest fracture resistance in comparison to Te-Econom Plus and Multicore Flow. Paracore achieves its superior strength through the incorporation of glass particles and high filler content. In contrast, the fracture resistance of Multicore Flow was lower than both Para Core and Te- econom plus materials.

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