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Comparative evaluation of push-out bond strength of light-transmitting and conventional fibre posts cemented with dual-cure resin cement at coronal and middle root levels: An *in vitro* study

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Abstract
Background: The long-term success of post-endodontic restorations depends largely on the retention of fibre posts within the root canal system. Fibre-reinforced composite posts have gained considerable popularity because of their favourable mechanical properties, biocompatibility, and elastic modulus, which is comparable to that of dentine. Light-transmitting fibre posts have been developed to improve resin cement polymerisation by allowing deeper penetration of curing light within the root canal.
Aim: To compare the push-out bond strength of light-transmitting fibre posts and conventional fibre posts cemented with a dual-cure resin cement at the coronal and middle root levels of endodontically treated teeth.
Materials and Methods:
Twenty extracted human single-rooted teeth with mature apices were selected for the study. Following biomechanical preparation, the canals were obturated, and post spaces were prepared using Peeso reamers up to size No. 4. The specimens were randomly allocated into two groups (n = 10): Group I (light-transmitting fibre posts) and Group II (conventional fibre posts). Posts measuring 1.4 mm in diameter were cemented using a dual-cure resin cement. Specimens were sectioned to obtain slices from the coronal and middle root levels. Push-out bond strength was evaluated by measuring the maximum dislodgement force (Fmax) in Newtons (N) using a universal testing machine operating at a crosshead speed of 1 mm/min. Statistical analysis was performed using independent-samples *t*-tests and paired-samples *t*-tests with the level of significance set at $p < 0.05$.
Results: Light-transmitting fibre posts demonstrated significantly greater maximum dislodgement force values at the coronal root level ($p = 0.036$). However, no statistically significant difference was observed between the groups at the middle root level ($p = 0.090$). The coronal root level demonstrated significantly higher values than the middle root level ($p < 0.001$).
Conclusion: Light-transmitting fibre posts provided superior retention at the coronal root level, whereas both fibre post systems demonstrated comparable performance at the middle root level. These findings indicate that the benefits of enhanced light transmission are more pronounced in regions where sufficient light penetration can be achieved.

Keywords: Fibre posts, glass fibre posts, push-out bond strength, resin cement, light-transmitting posts, endodontically treated teeth

Introduction

Endodontically treated teeth frequently require intraradicular posts to provide adequate retention and support for definitive restorations, particularly in cases involving extensive loss of coronal tooth structure. Over the years, fibre-reinforced composite posts have become increasingly popular because of their favourable biomechanical behaviour, superior aesthetics, corrosion resistance, and modulus of elasticity, which is similar to that of dentine. These characteristics contribute to a more homogeneous distribution of functional stresses and reduce the likelihood of catastrophic root fractures [1, 2, 5].

Despite these advantages, failure of fibre post restorations remains a significant clinical concern. Debonding at the post–cement–dentine interface is considered one of the most common causes of failure and may compromise the longevity of post-endodontic restorations. Several factors influence the retention of fibre posts, including the physical properties of the post, adhesive strategy, root canal morphology, polymerisation efficiency of the resin cement, and the region of the root in which the post is bonded [2, 3, 6, 7].

The push-out bond strength test is widely used to evaluate the retention of fibre posts because it effectively reproduces the shear stresses acting along the post–cement–dentine interface. Numerous studies have shown that bond strength varies according to root depth, with the coronal region generally exhibiting higher values than deeper regions. This variation has been attributed to differences in dentinal tubule density, accessibility, moisture control, and the efficiency of light transmission [3, 4].

To improve the polymerisation of resin cements within the root canal system, light-transmitting fibre posts were introduced. These posts possess a translucent structure that facilitates deeper penetration of curing light and may enhance the degree of conversion of dual-cure resin cements [10, 11]. Recent investigations have further demonstrated that increased light transmission through translucent fibre posts contributes to improved polymerisation efficiency, enhanced microhardness of the luting cement, and increased push-out bond strength, particularly in the coronal region of the root canal [13]. In addition, studies evaluating the light transmission profile of glass fibre posts have demonstrated a progressive reduction in light intensity with increasing root depth, indicating that the beneficial effects of light activation diminish beyond the coronal portion of the root canal [14]. Nevertheless, the effectiveness of these posts at different root levels remains controversial, and evidence regarding their influence on post retention is still limited [8, 9].

Therefore, the present *in vitro* study was undertaken to compare the push-out bond strength of light-transmitting fibre posts and conventional fibre posts cemented using a dual-cure resin cement at the coronal and middle root levels.

Aim

To compare the push-out bond strength of light-transmitting fibre posts and conventional fibre posts cemented with a dual-cure resin cement at the coronal and middle root levels of endodontically treated teeth.

Objectives

Primary objective

- To evaluate and compare the push-out bond strength of light-transmitting fibre posts and conventional fibre posts cemented with a dual-cure resin cement.

Secondary objectives

- To assess the push-out bond strength at the coronal root level for both fibre post systems.
- To assess the push-out bond strength at the middle root level for both fibre post systems.
- To compare the variation in push-out bond strength between the coronal and middle root levels within each group.

Hypothesis

Null hypothesis (H0)

There is no statistically significant difference in the push-out bond strength of light-transmitting fibre posts and conventional fibre posts cemented with a dual-cure resin cement at the coronal and middle root levels.

Alternative hypothesis (H1)

There is a statistically significant difference in the push-out bond strength of light-transmitting fibre posts and conventional fibre posts cemented with a dual-cure resin cement at the coronal and middle root levels.

Materials and Methods

Study Design

The present investigation was designed as an *in vitro* comparative study to evaluate the push-out bond strength of light-transmitting fibre posts and conventional fibre posts cemented using a self-adhesive dual-cure resin cement at the coronal and middle root levels of endodontically treated teeth.

Ethical Approval

Ethical approval was obtained from the Institutional Ethics Committee of A. J. Institute of Dental Sciences, Mangalore (IEC Reference Number: IEC/CONSO26/131/V1). The Institutional Ethics Committee is registered under the Department of Health Research (DHR), Government of India (Registration Number: EC/NEW/INST/2023/KA/0238).

Sample Selection

Twenty freshly extracted human single-rooted permanent teeth with mature apices and straight root canals were selected from the Department of Oral and Maxillofacial Surgery, A. J. Institute of Dental Sciences, Mangalore, and from private dental clinics in and around Mangalore.

The teeth were cleaned using an ultrasonic scaler to remove soft-tissue remnants and debris and were subsequently stored in 0.1% thymol solution until further use.

Teeth presenting with caries, restorations, fractures, cracks, root resorption, previous endodontic treatment, or calcified canals were excluded from the study.

Inclusion Criteria

- Extracted human single-rooted permanent teeth.
- Teeth with mature apices.
- Teeth with straight root canals.
- Teeth with intact roots free of cracks and fractures.
- Teeth extracted because of periodontal or orthodontic reasons.
- Teeth standardised to a root length of approximately 15 mm.

Exclusion Criteria

- Teeth with carious lesions.
- Teeth with root fractures or cracks.
- Teeth with internal or external root resorption.
- Teeth with calcified root canals.
- Teeth with previous endodontic treatment.
- Teeth with extensive structural defects.

Sample Size Calculation

The sample size was calculated using G*Power software (version 3.1.9.7). Based on the results of previous investigations, an effect size of 1.7, a significance level of 5%, and a study power of 80% were adopted.

The minimum required sample size was determined to be seven specimens per group. To compensate for possible specimen loss during specimen preparation and testing, ten specimens were included in each group.

Armamentarium

Instruments and materials

- Ultrasonic scaler
- Diamond discs
- Straight handpiece
- Endodontic access burs
- K-files
- Rotary nickel-titanium file system
- Endodontic motor
- Side-vented irrigation needles
- Irrigation syringes
- Paper points
- Gutta-percha cones
- Endodontic spreaders
- Peeso reamers

- Universal testing machine
- Stereomicroscope
- LED curing unit
- Stainless steel plungers

Equipment Used

Equipment	Specification
Fibre post (light transmitting)	AAA fibre post
Conventional fibre post	Waldent radiopaque fibre post
Rotary file system	ProTaper NeoEndo Gold
Instrumentation sequence	SX–S1–S2–F1–F2
Root canal sealer	AH Plus
Resin cement	RelyX™ Unicem
Universal testing machine	ZWICK/ROELL Z020
Load cell	LOADCELL-20KN
Diamond disc	Jinguang C03 (0.2 mm)
LED curing unit	3M Elipar DeepCure

Specimen Preparation
Decoronation
The crowns of all specimens were sectioned at the cementoenamel junction using a diamond disc under continuous water cooling to obtain a standardised root length of approximately 15 mm.

Root Canal Preparation
Working length determination was carried out by introducing a size 10 K-file into the root canal until it became visible at the apical foramen. The working length was established 1 mm short of the apex.
Root canal preparation was performed using the ProTaper NeoEndo Gold rotary file system according to the manufacturer's recommendations using the sequence SX–S1–S2–F1–F2.
Irrigation was performed using 2.5% sodium hypochlorite throughout instrumentation. Following biomechanical preparation, 17% ethylenediaminetetraacetic acid (EDTA) was used for smear layer removal, followed by a final rinse with distilled water.
The canals were dried with paper points and obturated using gutta-percha cones and AH Plus sealer employing the cold lateral compaction technique.
The specimens were then stored at 37°C under 100% humidity for 24 hours.

Post-Space Preparation
Post spaces were prepared by removing gutta-percha while maintaining an apical seal of approximately 4 mm.
Sequential Peeso reamers up to size No. 4 were used to obtain a standardised post-space depth of approximately 10 mm.

Group Allocation
The specimens were randomly divided into two groups (n = 10).
Group I
Light-transmitting fibre posts (AAA fibre posts).
Group II
Conventional fibre posts (Waldent radiopaque fibre posts).

Post Cementation
The prepared post spaces were thoroughly rinsed and dried using paper points.
All fibre posts were cleaned with alcohol and air-dried before cementation.
A self-adhesive dual-cure resin cement (RelyX™ Unicem) was applied according to the manufacturer's instructions. The cement was introduced into the post space, and the post was carefully seated under gentle finger pressure. Excess cement was removed, and polymerisation was initiated by light curing from the coronal aspect for 40 seconds using a 3M Elipar DeepCure LED curing unit.

Sectioning Procedure
Following cementation, all specimens were stored at 37°C for 24 hours.
Each specimen was sectioned perpendicular to its long axis using a Jinguang double-sided diamond disc (C03, thickness 0.2 mm) under continuous water cooling.

Slices measuring approximately 1 mm in thickness were obtained from the following regions
- Coronal root level
- Middle root level

Push-Out Bond Strength Test
Push-out bond strength was evaluated by determining the maximum dislodgement force (Fmax) required to displace the fibre post from the root canal.
Testing was performed using a ZWICK/ROELL Z020 universal testing machine equipped with a LOADCELL-20KN load cell.
Each specimen was positioned on a metallic support jig, and an appropriately sized cylindrical plunger was aligned with the post. A compressive load was applied in an apico-coronal direction at a crosshead speed of 1 mm/minute until complete dislodgement of the post occurred.
The maximum force required to dislodge the post was recorded in Newtons (N).

Statistical Analysis
The collected data were entered into Microsoft Excel and analysed using IBM SPSS Statistics software (Version 26.0; IBM Corp., Armonk, NY, USA).
Descriptive statistics, including mean, standard deviation (SD), minimum values, and maximum values, were calculated for the continuous variables.
The normality of the data distribution was assessed using the Kolmogorov–Smirnov test and the Shapiro–Wilk test. Since the data demonstrated an approximately normal distribution, parametric statistical tests were used for further analysis.
An independent-samples *t*-test was performed to compare the maximum dislodgement force (Fmax) values between the light-transmitting fibre post group and the conventional fibre post group at the coronal and middle root levels.
A paired-samples *t*-test was used to compare the differences in Fmax values between the coronal and middle root levels within the same group.
All statistical analyses were performed using two-tailed tests, and a *p*-value of less than 0.05 was considered statistically significant.

Results
Descriptive Analysis
Push-out bond strength, expressed as the maximum dislodgement force (Fmax), was evaluated in both experimental groups at the coronal and middle root levels.

The light-transmitting fibre post group exhibited a mean Fmax value of 47.29 ± 18.74 N, with values ranging from 24.70 N to 96.10 N.
The conventional fibre post group demonstrated a mean Fmax value of 33.68 ± 18.27 N, with values ranging from 11.80 N to 69.10 N.
Overall, the light-transmitting fibre post group exhibited greater mean Fmax values than the conventional fibre post group.

Table 1: Descriptive Statistics According to Fibre Post Type

Fibre post type	Mean (N)	Standard deviation	Minimum	Maximum
Light-transmitting fibre post	47.29	18.74	24.70	96.10
Conventional fibre post	33.68	18.27	11.80	69.10

The coronal root level demonstrated a mean Fmax value of 51.28 ± 20.05 N, whereas the middle root level demonstrated a mean value of 29.69 ± 11.63 N.
These findings indicated that the coronal root level exhibited greater resistance to post dislodgement than the middle root level.

Table 2: Descriptive Statistics According to Root Level

Root level	Mean (N)	Standard deviation	Minimum	Maximum
Coronal	51.28	20.05	17.20	96.10
Middle	29.69	11.63	11.80	53.10

Normality Analysis
The normality of the data distribution was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests.
The coronal and middle root levels demonstrated normal data distribution patterns (Shapiro–Wilk test, $p = 0.556$ and $p = 0.549$, respectively).
The light-transmitting fibre post group demonstrated a normal distribution ($p = 0.076$), whereas the conventional fibre post group demonstrated a slight deviation from normality ($p = 0.037$). Considering the sample size and the robustness of parametric statistical methods, further analyses were performed using parametric tests.

Comparison Between Fibre Post Types
An independent-samples *t*-test was performed to compare Fmax values between the light-transmitting and conventional fibre post groups.
At the coronal root level, the light-transmitting fibre post group demonstrated significantly greater Fmax values than the conventional fibre post group ($p = 0.036$).
At the middle root level, the difference between the two groups was not statistically significant ($p = 0.090$).

Table 3: Independent-Samples *t*-Test According to Root Level

Root level	Mean difference (N)	t value	p value	95% confidence interval
Coronal	18.41	2.266	0.036	1.34–35.48
Middle	8.81	1.790	0.090	–1.53–19.15

Comparison Between Root Levels
A paired-samples *t*-test demonstrated a statistically significant difference between the coronal and middle root levels ($p < 0.001$).
The coronal root level exhibited significantly higher Fmax values than the middle root level.

Table 4: Comparison Between Coronal and Middle Root Levels

Variable	Mean difference (N)	Standard deviation	Standard error	t value	p value
Coronal–middle	21.59	22.92	5.12	4.213	<0.001

Intragroup Comparison
Light-transmitting fibre posts
The coronal root level demonstrated a mean Fmax value of 60.48 ± 15.72 N, whereas the middle root level demonstrated a mean Fmax value of 34.09 ± 10.35 N.
This difference was statistically significant ($p < 0.001$).

Conventional fibre posts
The coronal root level demonstrated a mean Fmax value of 42.07 ± 20.32 N, whereas the middle root level demonstrated a mean value of 25.28 ± 11.63 N.
This difference was not statistically significant ($p = 0.102$).

Table 5: Intragroup Comparison According to Root Level

Fibre post type	Root level	Mean (N)	Standard deviation
Light-transmitting	Coronal	60.48	15.72
Light-transmitting	Middle	34.09	10.35
Conventional	Coronal	42.07	20.32
Conventional	Middle	25.28	11.63

Table 6: Paired-Samples *t*-Test According to Fibre Post Type

Fibre post type	Mean difference (N)	t value	p value
Light-transmitting	26.39	5.775	<0.001
Conventional	16.79	1.823	0.102

Key Findings
- Light-transmitting fibre posts demonstrated significantly greater push-out bond strength at the coronal root level.
- No statistically significant difference was observed between the two groups at the middle root level.
- The coronal root level demonstrated significantly greater resistance to dislodgement than the middle root level.
- The light-transmitting fibre post group demonstrated a statistically significant reduction in Fmax values from the coronal to the middle root level.
- Conventional fibre posts exhibited lower Fmax values than light-transmitting fibre posts.

Discussion
The present *in vitro* study evaluated the influence of fibre post translucency on push-out bond strength, expressed as the maximum dislodgement force (Fmax), at the coronal and middle root levels following cementation with a self-adhesive dual-cure resin cement. The results demonstrated that light-transmitting fibre posts exhibited significantly greater Fmax values than conventional fibre posts at the coronal root level, whereas no statistically significant difference was observed at the middle root level. Furthermore, irrespective of the fibre post system used, the

coronal root level demonstrated significantly higher values than the middle root level.

The significantly higher Fmax values observed with light-transmitting fibre posts at the coronal root level can be attributed to their superior ability to transmit curing light through the translucent glass fibre matrix. Improved light transmission enhances the polymerisation of the resin cement, thereby increasing the degree of conversion and improving the mechanical properties of the adhesive interface. These findings are consistent with the observations of Vichi *et al*. and Goracci *et al*., who reported improved light transmission and enhanced polymerisation efficiency with translucent fibre posts [10, 11].

The present findings are also in agreement with those of Ferrari *et al*., who demonstrated favourable biomechanical behaviour and clinical performance of fibre-reinforced post systems [1]. In addition, Maiti *et al*. reported significantly greater retention of translucent fibre posts in the cervical region, further supporting the findings of the present investigation [8].

This explanation is further supported by recent evidence demonstrating that fibre posts with greater light transmissibility produce improved polymerisation of resin cements, increased microhardness of the luting material, and greater push-out resistance, particularly at the cervical (coronal) root level where light intensity is highest [13].

At the middle root level, light-transmitting fibre posts exhibited higher mean Fmax values than conventional fibre posts; however, the difference was not statistically significant. This observation may be explained by the progressive attenuation of light as it travels through the post, resin cement, and surrounding dentine. Consequently, the polymerisation of the resin cement becomes increasingly dependent on its chemical curing mechanism rather than on light activation.

A recent investigation evaluating the light transmission profile of glass fibre posts also demonstrated a progressive reduction in transmitted light with increasing root depth, confirming that the benefits of light activation decrease beyond the coronal portion of the canal despite the use of translucent fibre posts [14].

Radovic *et al*. reported that self-adhesive dual-cure resin cements provide reliable polymerisation even in regions where light penetration is limited [6]. This finding may explain the absence of a statistically significant difference between the two groups at the middle root level in the present study.

Irrespective of the type of fibre post used, the coronal root level demonstrated significantly greater resistance to dislodgement than the middle root level. This observation is in accordance with the findings of Bitter *et al*., who reported that the density and diameter of dentinal tubules are greater in the coronal region than in deeper portions of the root canal [4]. The increased density of dentinal tubules may facilitate improved resin infiltration and hybrid layer formation, thereby enhancing retention.

The significantly higher values observed at the coronal root level may also be attributed to improved accessibility during post-space preparation and cementation procedures. Better visibility, easier moisture control, and more uniform cement distribution contribute to improved adhesion in the coronal region. In contrast, the middle root level presents greater anatomical complexity and reduced accessibility, which may adversely influence the adaptation of the resin cement to the dentinal walls.

The findings of the present study are consistent with the systematic review by Skupien *et al*., who emphasised that fibre post retention is influenced by multiple factors, including post design, resin cement properties, dentine characteristics, and clinical technique [7]. Likewise, Goracci and Ferrari concluded that appropriate case selection, proper adhesive protocols, and meticulous clinical procedures play crucial roles in the long-term success of post-endodontic restorations [2].

The present study further demonstrated that the advantages associated with light-transmitting fibre posts are more evident in the coronal region, where adequate light transmission can be achieved. However, these benefits gradually decrease with increasing root depth, thereby emphasising the importance of the chemical curing component of dual-cure resin cements.

From a clinical perspective, the findings suggest that light-transmitting fibre posts may provide improved retention in situations where enhanced polymerisation of resin cement is desirable. Nevertheless, post translucency should not be regarded as the sole determinant of clinical success. Proper case selection, adequate post-space preparation, effective moisture control, and appropriate cementation techniques remain essential for achieving favourable clinical outcomes.

Recent systematic evidence also suggests that although advances in fibre post design may improve retention and reduce catastrophic failures, long-term clinical success remains multifactorial and depends on appropriate case selection, adhesive protocols, and cementation technique rather than post design alone [15].

The present study has certain inherent limitations. As an *in vitro* investigation, it could not completely reproduce the complex biological and functional conditions of the oral environment. In addition, thermocycling, cyclic loading, and long-term ageing procedures were not performed. Future studies involving larger sample sizes and long-term clinical evaluation are therefore recommended.

Overall, the findings of the present investigation indicate that light-transmitting fibre posts provide superior retention at the coronal root level while demonstrating performance comparable to conventional fibre posts at the middle root level.

Conclusion

Within the limitations of the present *in vitro* study, the following conclusions may be drawn:

- Light-transmitting fibre posts demonstrated significantly greater push-out bond strength than conventional fibre posts at the coronal root level.
- No statistically significant difference was observed between the two groups at the middle root level.
- The coronal root level exhibited significantly greater maximum dislodgement force values than the middle root level.
- The influence of post translucency on retention decreased with increasing root depth.
- Appropriate post-space preparation, adhesive procedures, and cementation techniques remain essential for achieving successful clinical outcomes.

Clinical Significance

Light-transmitting fibre posts may provide enhanced retention in the coronal region because of improved light transmission and increased polymerisation of dual-cure resin cement. However, clinicians should recognise that successful fibre post retention depends on multiple factors, including dentine characteristics, adhesive procedures, and meticulous clinical technique.

Limitations

- The study was conducted under *in vitro* conditions.
- The sample size was relatively small.
- Thermocycling and cyclic loading procedures were not performed.
- Only one resin cement system was evaluated.
- Only coronal and middle root levels were assessed.
- Long-term clinical performance was not investigated.

Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethics Committee of A. J. Institute of Dental Sciences, Mangalore (Reference Number: IEC/CONSO26/131/V1).
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Conflict of Interest

The authors declare that no conflict of interest exists.

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