COMPARITIVE EVALUATION OF BOND STRENGTH OF INDIVIDUALLY FORMED FIBER REINFORCED COMPOSITE POST AND PREFABRICATED FIBER POST CEMENTED BY TWO DIFFERENT RESIN CEMENTS -AN IN-VITRO STUDY

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Article History: Received: 10.05.2023 **Revised:** 24.06.2023 **Accepted:** 04.08.2023

Abstract

Context: Conservative dentistry emphasizes the importance of avoiding tooth extraction and preserving the functionality of decayed teeth through endodontic treatment whenever possible. However, this treatment can weaken the tooth structure, making it prone to fracture during chewing. Thus, it is essential to provide proper restoration to endodontically treated teeth to ensure their longevity and optimal function in the oral cavity, which can be provided by post and core restoration.

Aim: The aim of this study is to compare the bond strength of individually formed fibre reinforced post and prefabricated fibre post using Variolink II and ParaCore adhesive cement.

Materials and methods: 40 mandibular first premolars were decoronated and divided into two groups. Each group was further divided into two subgroups as follows:

Group A(a) : Individually Formed Fiber Reinforced Post with Variolink II cement

Group A(b): Individually Formed Fiber Reinforced Post ParaCore Resin

Group B(a): Prefabricated Fiber Reinforced Post with Variolink II cement

Group B(b): Prefabricated Fiber Reinforced Post with ParaCore Resin

Statistical analysis: Data was analysed using ANOVA and repeated measures ANOVA. $P<0.05$

Results: The result showed that the bond strength was higher for both everStick posts and 3M posts when cemented with ParaCore, compared to Variolink cement, in the coronal third

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DOI: 10.31838/ecb/2023.12.s2.524

1. Introduction

In contemporary conservative dentistry, extraction should only be considered as a final resort in the treatment plan. Whenever feasible, a decayed tooth should undergo endodontic treatment to retain its functionality in the oral cavity. However, such treatment involves removing the vital contents of the root canal, which can result in a weakened tooth structure vulnerable to fracture under chewing forces. Therefore, any endodontically treated tooth must receive adequate restoration for optimal clinical outcomes. One of the major challenges faced during prosthodontic rehabilitation is the lack of sufficient crown structure in such teeth, which cannot retain the fixed restoration. If the coronal tooth structure is over 50% intact on a pulpless tooth, a post-and-core procedure is usually unnecessary, except in cases of heavy occlusion, planned prosthesis abutment, or visible cracks. On the other hand, if less than 50% of the coronal tooth structure remains on a pulpless tooth, placing a post-and-core is advisable to ensure proper connection between the root and coronal core.

There are two types of posts for dental restorations: custom-fabricated and prefabricated. Custom made cast metal posts have a successful clinical history but require more time and laboratory procedures. Prefabricated metal posts are easy to place but may not be as ideal as fibre posts, which have a tooth-coloured appearance and similar modulus of elasticity to dentin. However, post space preparation for prefabricated fibre posts involves removing root dentin, which can weaken the tooth. Individually formed fibre posts can be used to address this issue, resulting in better bond strength, reduced risk of leakage, and less removal of root dentin.

For many years, glass ionomer cement has been the conventional choice for post cementation. However, it is a brittle cement with low fracture toughness that can cause it to fail quickly. This disadvantage has made resin-based cements more popular, as they are highly valued for their strength and low solubility. They come in two paste systems with dual cure mechanisms, allowing them to cure even in areas where light cannot reach. Resin-based core build up material has a triple advantage, as it can be used for post cementation, core build-ups, and bridge cementation. Its composition involves dual-polymerization and a glass-reinforced structure, making it a reliable and effective solution for simultaneous post placement and core build-ups.

There are very few studies that compare effectiveness of conventional resin cements (e.g.: -Variolink) & the resin based core materials (e.g:-Paracore) used for luting on bond strength of prefabricated posts and individually formed posts. In view of above study was planned to evaluate and compare these two different resin cements (Variolink and Paracore) on bond strength of prefabricated fibre posts (3M RelyX) and individually formed FRC post (everStick post). In the current study, the null hypothesis proposed is that the type of posts, adhesive cements used, and the level of the root (coronal or apical portion) does not affect the bond strength of the prefabricated and individually formed post.

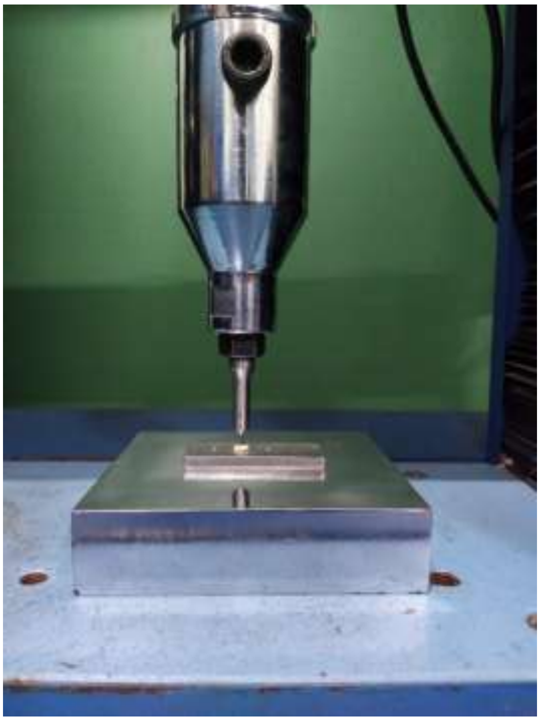
2. Materials And Methods

In this study, 40 mandibular first premolars were used and divided into two groups for comparison. One group was treated with individually formed fibre reinforced composite posts, while the other group received prefabricated fibre posts. These groups were then further subdivided into two subgroups each, with one subgroup receiving ParaCore dual cure resin and the other receiving Variolink II adhesive cement. After the groups were established, the crowns of the teeth were sectioned below the CEJ using a water-cooled diamond bur. The root canals were then instrumented using number 40 files, irrigated with 2.5% NaOCl using a 27-gauge needle, and dried before being obturated with gutta percha of the corresponding size. Any excess gutta percha was removed to ensure proper sealing of the canal.

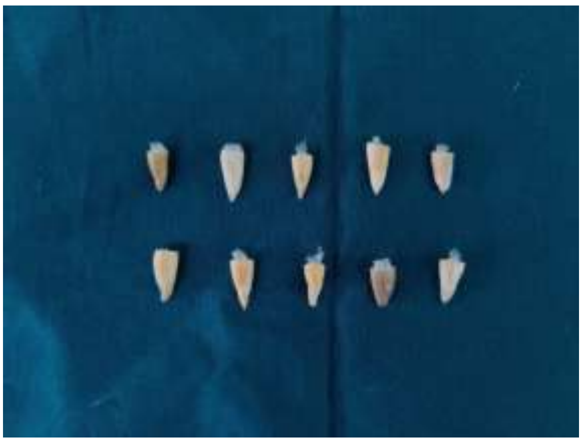
Group A(a): Individually Formed Fiber Reinforced Post with Variolink II
Group A(b): Individually Formed Fiber Reinforced Post ParaCore Resin
Group B(a): Prefabricated Fiber Reinforced Post with Variolink II
Group B(b): Prefabricated Fiber Reinforced Post with ParaCore Resin

For post space preparation, gates glidden burs, peeso reamer burs, and fibre post drills were used to prepare the root canals to receive a post length of 9 mm. All the roots were separated into two groups of 20, depending on the type of post used for each group. After preparation of the post spaces, all of the root canals were rinsed with 10 ml of saline and dried using paper points to ensure that they were clean and dry before the post was placed. This process of post space preparation is essential to ensure that the post is securely placed within the canal, allowing for proper support of the final restoration.

For post preparation and cementation, the everStick post group (n=20) had the post pre-cut to the desired length and checked for suitability before cementation. On the other hand, the prefabricated fibre post group (n=20) had the post inserted to check the fit, and then cut to the desired length using a diamond bur. Before cementation, the specimens from each group were subdivided into two subgroups (n=10) based on the type of cement to be used: Variolink II and ParaCore. This subdivision into subgroups allowed for comparison of the effectiveness of the different types of cement used for post cementation, helping to determine which cement was more suitable for each post type. Proper post preparation and cementation are crucial for successful restoration of the tooth, as they provide the necessary support and stability for the final restoration to function properly. With the use of universal testing machine, micro push out test was done after specimens were divided into thin sections of 2 mm and classifying into apical and coronal portions. The values obtained were then subjected to statistical analysis.



The sample size was calculated using GPower software. The effect size was determined using the data obtained from a previous study conducted by Kadam A et al. (J Conserv Dent 2013;16(5):444-8). Considering the mean score of impact strength from previous study, effect size calculated was 1.17. Keeping the level of significance at 5%, the power of the study was kept at 80% and effect size of 1.17, the sample size estimated was 10 per group. Data obtained were analyzed using SPSS v23 software, keeping the level of significance at 5%.



Group A(a)

Group A(b)

3. RESULTS

Group A(a) : Individually Formed Fiber Reinforced Post Variolink Adhesive Cement					
Sr. No.	Sample ID	Coronal		Apical	
		Load (N)	Pushout Bond Strength (MPa)	Load (N)	Pushout Bond Strength (MPa)
1	No.1	130.35	15.76	70.15	12.17
2	No.2	123.45	14.92	69.15	12.00
3	No.3	124.85	15.09	76.95	13.35
4	No.4	128.90	15.58	72.55	12.59
5	No.5	126.80	15.33	61.05	10.59
6	No.6	129.10	15.61	70.60	12.25
7	No.7	120.40	14.55	75.95	13.18
8	No.8	127.65	15.43	73.65	12.78
9	No.9	119.50	14.44	77.70	13.48
10	No.10	124.80	15.09	69.60	12.08
Average			**15.18**	**Average**	**12.45**

Table 1 represents Group A(a), everStick post cemented with Variolink cement. The average push out bond strength observed in coronal third of the root was 15.18MPa and in apical third of the root was 12.45 MPa.

Table 2 represents Group A(b), everStick psot cemented with Paracore resin cement. The average push out bond strength observed for coronal third was 17.57 MPa and 16.24 MPa for apical third of the root.

Group B(a) : Prefabricated Fiber Reinforced Post_Variolink II Adhesive Cement					
Sr. No.	Sample ID	Coronal		Apical	
		Load (N)	Pushout Bond Strength (MPa)	Load (N)	Pushout Bond Strength (MPa)
1	No.1	95.15	11.50	60.25	10.46
2	No.2	100.75	12.18	61.55	10.68
3	No.3	102.25	12.36	56.35	9.78
4	No.4	109.25	13.21	52.45	9.10
5	No.5	104.85	12.67	58.65	10.18
6	No.6	94.15	11.38	50.40	8.75
7	No.7	108.30	13.09	55.85	9.69
8	No.8	98.85	11.95	63.15	10.96
9	No.9	93.55	11.31	67.30	11.68
10	No.10	101.85	12.31	59.70	10.36
Average			**12.20**	**Average**	**10.17**

Table 3 represents Group B(a), 3M RelyX fibre post cemented by Variolink cement. The average push out bond strength observed for the coronal third was 12.2 MPa and 10.17 MPa for apical third.

Group B(b) : Prefabricated Fiber Reinforced Post_ ParaCore Composite Resin					
Sr. No.	Sample ID	**Coronal**		**Apical**	
		Load (N)	Pushout Bond Strength (MPa)	Load (N)	Pushout Bond Strength (MPa)
1	No.1	117.50	14.20	71.85	12.47
2	No.2	115.45	13.96	65.75	11.41
3	No.3	116.50	14.08	70.35	12.21
4	No.4	113.15	13.68	72.45	12.57
5	No.5	116.80	14.12	68.65	11.91
6	No.6	115.15	13.92	57.20	9.93
7	No.7	120.30	14.54	65.45	11.36
8	No.8	117.90	14.25	63.35	10.99
9	No.9	111.10	13.43	57.80	10.03
10	No.10	114.45	13.83	59.90	10.39
Average			**14.00**	**Average**	**11.33**

Table 4 represents Group B(b), 3M RelyX fibre post cemented by Paracore cement. The average push out bond strength observed for coronal third was 14.00 MPa and 11.33 MPa for apical third

4. Discussion

The success of endodontic treatment depends on various factors, including the skill of the endodontist, quality of the root canal filling, and the coronal restoration used to seal the tooth. A proper coronal restoration is important to prevent leakage of oral fluids and bacteria that can lead to reinfection or failure. Selection of materials and techniques for restoring endodontically treated teeth is influenced by factors such as remaining tooth structure, physical changes, anatomic position, occlusal forces, restorative and aesthetic requirements. These factors help determine the most appropriate material and technique for each case to ensure the best possible outcome for the patient.

Metal posts used to reinforce endodontically treated teeth can cause aesthetic issues and have risks such as root fractures, corrosion, and allergic reactions. Non-metallic posts such as bondable, fibre-reinforced, and ceramic posts have been developed as a more aesthetic option with better retention, resistance to fractures, and lower risk of corrosion or allergic reactions. Fibre-reinforced composite (FRC) has gained attention as an alternative to metal posts due to its improved retention, aesthetics, and lower risk of complications. Fibre posts are made of unidirectional fibres and a resin matrix, usually composed of quartz or glass fibres. Some FRC posts have prestressed fibres and resin injected under pressure to provide solid cohesion. These materials have a comparable modulus of elasticity with composite resins and fibre posts, providing high impact resistance, attenuation, vibration softening, shock absorption, and increased fatigue resistance properties. Finite element analyses have shown that these materials generate stresses in the dentin around the central third of the canal, reducing the risk of root fracture, unlike rigid posts that generate stresses in the interface area.

Fibre-reinforced composite (FRC) posts have diverse mechanical properties that are influenced by various factors such as the type of fibre, matrix material, fibre concentration, and fibre orientation. Quartz fibres are frequently used as reinforcing fibres, while epoxy resins and BisGMA are typical matrix materials. Glass fibres are also utilized, with E-glass being less costly but having inferior fatigue resistance compared to S-glass, which is more expensive but has higher tensile strength. The fibres in FRC posts are designed to offer high tensile strength, while the resin matrix is created to withstand compressive forces and distribute stress evenly. Consistent distribution of fibres within the resin matrix, high-quality fibre and resin combinations, and a homogeneous post structure without blisters or inclusions can boost overall performance. Nevertheless, stress buildup may occur at the interface between the fibres and resin matrix, leading to cracks, voids, or microbubbles that can decrease the overall strength of the post. Individually formed glass fibre reinforced composite (FRC) posts are manufactured from silanated E-glass fibres infused with a combination of non-polymerized PMMA and poly Bis-GMA, forming a semi-interpenetrating polymer network. They allow for easy shaping to fit the root canal, decreasing the chance of post decementation and preserving dentin. The coronal part of the IPN-post can be bent to fulfill crown restoration requirements. These posts possess superior flexural strength, higher fracture resistance, and a stronger bond without adhesive failure compared to prefabricated glass fibre posts. Nonetheless, they may be challenging for inexperienced clinicians due to the adhesive nature of the non-polymerized matrix and the tendency of fibres to separate.

To prevent failure of post-retained crowns, dental luting cements are crucial for maintaining post retention and preventing coronal microleakage. Failures can occur due to mechanical or oral diseases such as caries or periodontal disease. Composite resin-luting cements require etchants, primers, and/or adhesives for a strong adhesive bond formed through micromechanical retention. Some resin cements contain 4-META, which creates a chemical bond with metallic oxide layers. However, applying these agents to the narrow confines of a post channel can be challenging and may cause premature setting of the cement. This group of cements usually has a higher film thickness and viscosity compared to other types of cements, making it more difficult to achieve an even application.

This study involved 40 mandibular first premolars divided into two groups, with one group receiving individually formed fiber reinforced composite posts and the other receiving prefabricated fiber posts. Each group was further subdivided into two subgroups based on the type of cement used. Root canals were obturated and post spaces were prepared before cementation. Micro push-out tests were conducted using a universal testing machine.

In Group A(a), everStick post cemented with Variolink cement. The average push out bond strength observed in coronal third of the root was 15.18MPa and in apical third of the root was 12.45 MPa. Group A(b), everStick post cemented with Paracore system, the average push out bond strength observed for coronal third was 17.57 MPa and 16.24 MPa for apical third of the root. Group B(a), 3M RelyX fibre post cemented by Variolink cement, the average push out bond strength observed for the coronal third was 12.2 MPa and 10.17 MPa for apical third. Group B(b), 3M RelyX fibre post cemented by Paracore cement. The average push out bond strength observed for coronal third was 14.00 MPa and 11.33 MPa for apical third.

Formula for Pushout bond strength :

$$\text{Pushout bond strength (MPa)} = \frac{\text{Force to dislodgement / Push load (N)}}{\text{Surface area (mm}^2\text{)}}$$

Where, Area of bonded interface (sq/mm) = $2\pi rh$

$\pi = 3.1416$, r = Radius of perforated cross section, h = Height of perforation

Significantly higher bond strength was observed in coronal third when compared to apical third in all the groups. Also, bond strength was found be higher for both everStick posts and 3M post when cemented with paracore, compared to Variolink cement. Similarly, bond strength was found to be higher for everStick post compared to 3M post when they were cemented with either Paracore or Variolink cement. These observations are supported with another study[36], in which they had compared Everstick fibre post with a prefabricated fibre post, GC fibre post, where they observed higher bond strength with the Everstick fibre post in the coronal third of the root. Also, in another study by Zaitter et al, similar observation was made when comparison was done between the bond strength of prefabricated fibre post and individually formed fibre post, it was observed that Everstick post resulted in highest values[38.] Least bond strength was observed when 3M fibre post was cemented with Variolink cement at the apical third. This observation is supported by another study, where they compared bond strength of prefabricated fibre post cemented with three different adhesive cements which included ParaCore, Variolink and 3M RelyX Unicem cements, least bond strength was observed with posts cemented with Variolink cement.[37] In another study by Zaitter et al, similar observation was made when comparison was done between the bond strength of prefabricated fibre post and individually formed fibre post, it was observed that Everstick post resulted in highest values[38].

The increased bond strength in Everstick post compared to prefabricated glass fibre post can be attributed to the presence of both linear and cross-linked phases. The bonding strength of Everstick posts can also be improved by using dual-cure resin cements, as concluded by Khan et al. in their study. This can be attributed to the fact that the monomers of dual-cure cement can penetrate the linear phase of the IPN polymer structure of the Everstick posts[39]. In another study, Makarewicz et al. noted that prefabricated glass fibre posts, due to their highly cross-linked polymer matrix, have difficulty bonding with resin luting cements and core materials. This can be attributed to lower bond strength compared to other posts[30].

Limitations

The present in vitro study has some limitations in respect to its clinical relevance and cannot indicate precise results. So, further evaluations, in vivo studies are required to support our results. A study by Aleisa et al reported significantly higher bond strength with Variolink after two weeks40. This can be added as another limitation as time factor affecting the bond strength was not considered in this study stressing the need to perform time dependant studies over period. Cementing individually formed FRC post is also a technique sensitive procedure which can affect the accuracy of the study.

Scope of the Study

1. Comparison can be done with CAD CAM designed zirconia post
2. Studies can be done with self-adhesive cements which do not require separate etching and bonding steps.
3. Certain cements can improve their mechanical properties over the time. Time dependent studies can be done.
4. Future studies can be done in relation to the fracture strength of the crown placed over the post and core fabricated with individually formed posts.

5. Conclusion

1. Higher bond strength was observed at the coronal third compared to apical third of the root, when 3M relyX post was cemented with Variolink cement
2. Higher bond strength was observed at the coronal third compared to apical third of the root, when 3M relyX post was cemented with Paracore system
3. Higher bond strength was observed at the coronal third compared to apical third of the root, when everStick post was cemented with Variolink cement
4. Higher bond strength was observed at the coronal third compared to apical third of the root, when everStick post was cemented with Paracore system
5. Higher bond strength was observed with everStick post compared to 3M RelyX post when cemented with Variolink cement
6. Higher bond strength was observed with everStick post compared to 3M RelyX post when cemented with Paracore system

6. Referance

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