A Comparative Study to Evaluate the Shear Bond Strength of Different Surface Treated Fiber Posts Luted with Different Luting Agents: An In – Vitro Study

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Abstract

Background and Objectives: To evaluate the shear bond strength of different surface treated fiber posts luted with different luting agents.

Methods: Post space was prepared in sixty endodontically treated single-rooted teeth and distributed into 3 groups (n=20). Group-A received no surface treatment. Group-B and Group-C were treated with 10%Hydrofluoric Acid and 24%Hydrogen Peroxide. Each group subdivided into 2 subgroups (n=10) i.e. Total etch resin cement and self adhesive cement. Pull-out evaluation test was performed to measure bond strength.

Results: Statistical analysis performed using post-hoc Tukey HSD and Bonferroni test. Specimens treated with 24%Hydrogen Peroxide, luted with Total Etch resin cement showed the maximum bond strength (17.317 Mpa). No significant difference in bond strength values were observed between the luting agents, however significant difference ($p < 0.05$) was observed in relation to the surface treated specimens.

Conclusion: Surface treatment is a necessary protocol in enhancing the bond strength of the fiber posts irrespective of the luting cement used in the post and core system.

Keywords: Fiber posts, Shear bond strength, Total Etch Resin Cement, Self Adhesive cement

INRODUCTION

Endodontically treated teeth are affected by a higher risk of biomechanical failure than vital teeth. Posts have been used for restoration of these teeth since many years ; but post retained crowns may present both biologic and mechanical failures commonly due to loss of retention. [1] Long-term studies on post and core technique reveal variable survival rates, indicating the possibility of root fractures. Weaknesses in stress distribution at material interfaces highlight the importance of posts with biomechanical properties similar to dentin to prevent such fractures. [2]

Advances in adhesive techniques have revolutionized restorative dentistry, allowing for the preservation of more tooth structure. This includes bonding fiber posts to root canal dentin, which offers flexibility and a modulus of elasticity akin to dentin, thus enhancing the overall strength of the restoration. Furthermore, fiber-reinforced materials eliminate risks associated with metal posts and provide aesthetic benefits, especially crucial for anterior teeth. Additionally, their retrievability makes them advantageous for potential future retreatment needs. However, despite these benefits, further clinical evaluation is necessary to fully understand their long-term performance. [3]

Proper post space preparation and effective bonding with resin cement are critical for retention and resistance to fracture. Glass-fiber posts, known for their aesthetic appeal and ability to bond well to root dentin, distribute stress more evenly, reducing the risk of root fractures. Retention largely depends on the type of luting cement used, with resin cements offering properties closer to dentin and thus providing better performance.[4]

The unique adhesive procedure for fiber posts involves considering the histological characteristics of dentin and understanding the properties of different bonding materials. The even distribution of forces through effective bonding reduces the occurrence of root fractures, although "deboning" remains a common failure mode. Several factors influence the bonding capacity of fiber post systems, and controlling these factors is crucial for achieving a strong bond between the post, cement, and dentin interface. Techniques such as silane or sandblasting surface treatment have been found to enhance bond strength, leading to more reliable restorations. [5,6]

Surface treatment of fiber posts significantly affects retention. Studies have shown that treatments like silane coupling agents or hydrofluoric acid etching can improve adhesion by enhancing the bond strength between the post and composite materials. [7] Silane coupling agents, in particular, alter the physical and mechanical properties, thereby improving the overall performance of the restoration. [8,9]

Thus restoration of endodontically treated teeth requires careful consideration of various factors, including material selection, post design, adhesive techniques, and surface treatments. Fiber-reinforced posts offer several advantages over traditional metal posts, including flexibility, aesthetic appeal, and retrievability. Effective bonding with resin cement is crucial for long-term success, and surface treatments can significantly enhance the bond strength between the post and composite materials.[3,10]

The objective of many studies in this field is to compare the shear bond strength between differently surface-treated fiber posts using various luting cements. Pull-out tests and other methods are utilized to assess the bond strengths, with the goal of understanding how different surface treatments and cement types affect the overall performance of the restoration.

MATERIAL AND METHODOLOGY

a) Study Design

An in-vitro observational descriptive study which included sixty extracted single rooted human teeth with well-preserved coronal and radicular structures without endodontic treatment were selected from the Department of Oral and Maxillofacial Surgery, Pacific Dental College and Hospital, Udaipur. The method for sample collection was non probability sampling technique. In the present study, 60 samples were tested.

b) Eligibility criteria

Inclusion criteria

1. Teeth that were extracted due to any dental problem
2. Approximately Straight roots

3. Root length of at least 13-18 mm

Exclusion criteria

1. Root with vertical fracture
2. Grossly decayed teeth
3. Teeth with failed endodontic treatment

c) Sample Preparation :

The teeth were collected, stored in distilled water at room temperature after extraction and cleaned with hydrogen peroxide solution to get rid of the debris attached with the teeth. Specimens were sectioned with diamond rotary instrument at coronal level under water spray to standardize size of specimens at 16 mm from root apices. They were then embedded into chemically cured acrylic resin block of 4cm x 4cm in size till cemento enamel junction. Each group comprising of 20 samples and each subgroup containing 10 samples. (Flowchart)

d) Procedure

1. Root canal preparation

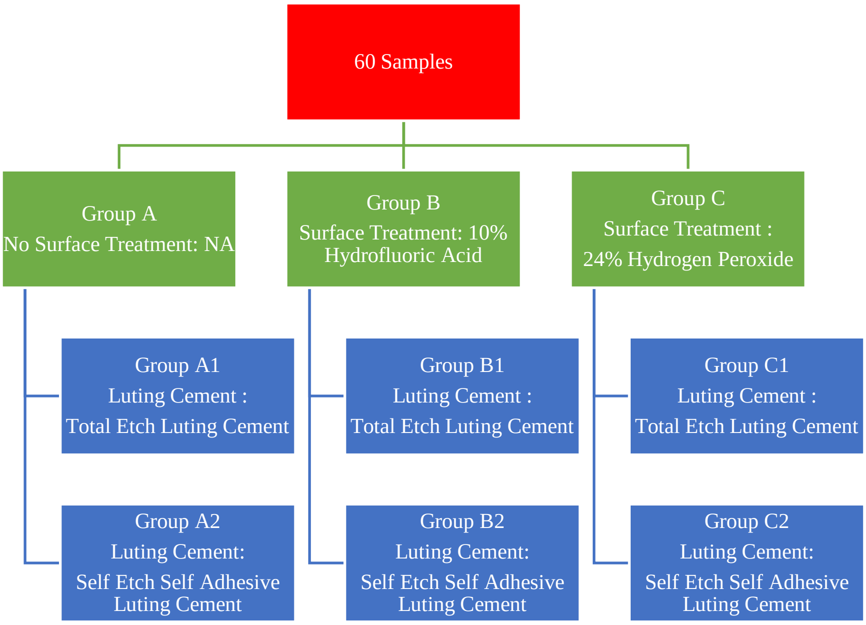
Access opening was done using a round diamond bur (MANI India pvt ltd) Followed by determination of working length using #15 K file (Dentsply USA). The teeth were treated endodontically according to a Step back technique. All procedures were followed by irrigation with 1% sodium hypochlorite and copious irrigation with normal saline. The prepared canals were dried with paper points followed by obturation with gutta percha cones (Dentsply, USA) using cold lateral condensation technique using canal sealer (Sealapex, Sybron-Endo, USA).The same was evaluated using intraoral periapical radiograph.

2. Preparation of the coronal tooth structure

The access cavities and apexes were sealed. Teeth were horizontally de-coronized 3 mm above the CEJ. The remaining tooth structure coronal to CEJ helped to simulate the ferrule effect, which was instrumental in protecting the tooth from fracture.

3. Dowel/Post space preparation & Post insertion

The dowel space was first prepared incrementally using Gates Glidden drills of size 1, 2 and 3 having diameter 0.6, 0.7 and 0.9 respectively, followed by use of Peeso reamers respectively to remove 10 mm of gutta-percha from the canal and was verified by taking intra oral periapical radiographs. 4-5 mm gutta percha were left inside apically. Previously decided surface treatments were done and respective luting agents were applied for each group.**(Flowchart 1)**



Flowchart 1 : Grouping of Samples

4. Surface treatment protocol

1) Hydrofluoric acid (10%)

The post surface was etched with 10% hydrofluoric acid gel applied over the post surface for 1 minute. It was rinsed and dried. The silane agent was then applied on the post surface for 1 min. **(Figure:1)**

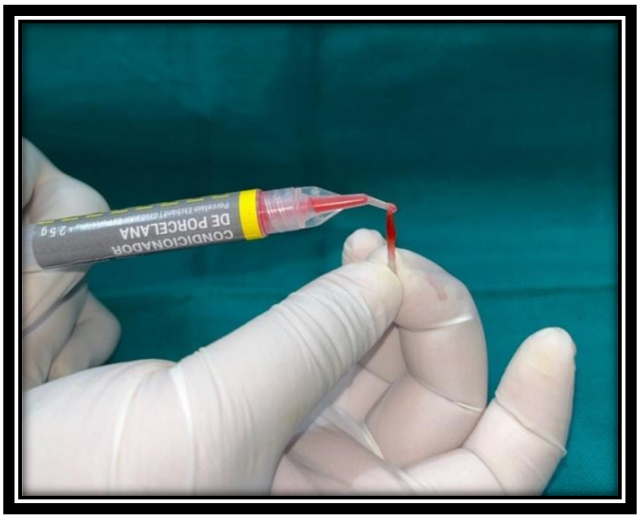


Figure: 1 :Application of 10% Hydrofluoric Acid Gel on Fiber Post

2) Hydrogen peroxide (24%)

The fiber post was immersed in 24% hydrogen peroxide solution in measuring cylinder for 1 minute.It was rinsed and dried. The silane coupling agent was applied for 1 minute allowing solvent evaporation. **(Figure:2)**

Figure 2: Immersion of post in 100ml of 24% Hydrogen Peroxide

5. Luting protocol

1) Total Etch Resin Cement

Root canal was etched by 37% phosphoric acid for 15 seconds and were rinsed with water.The canal will be dried with paper points. Adhesive agent was applied all over etched surface and light cured.A small amount of cement was flowed into canal using syringe tip. Some quantity of cement was dispensed and applied all over the post. The post will be placed into root canal under gentle finger pressure and light cured with the UV light. **(Figure:3)**

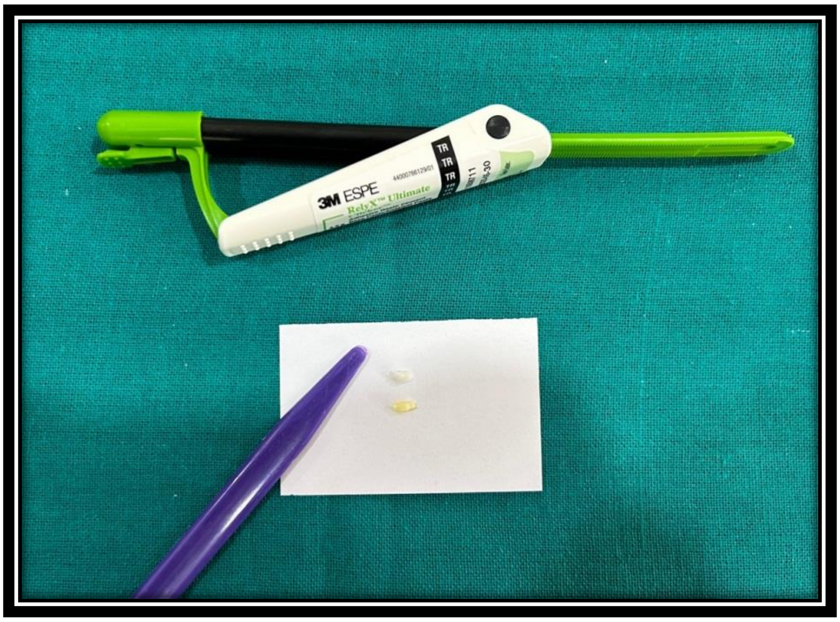


Figure 3 : Fiber post luted with Total Etch Resin Cement

2) Self adhesive resin luting agent

The post was cleaned with isopropyl alcohol and dried with air. A small amount of cement was flowed into canal using syringe tip. Some small quantity of cement was dispensed and applied all over the post. The post was placed into root canal under gentle finger pressure ad light cured with UV light. **(Figure:4)**

Figure 4 : Self Adhesive Resin Cement pushed in post space preparation before inserting fiber post

6. Laboratory Testing

All the prepared specimens were kept under universal testing machine(Instron) and shear bond strength (SBS) was measured . Each specimen was fixed on inferior part of universal testing machine. **(Figure:5)** The force required to dislodge each post were recorded in Mpa.

Figure 5: Instron Universal Testing Machine. Specimen fixation on the inferior part of mandril – Pull out test is performed.

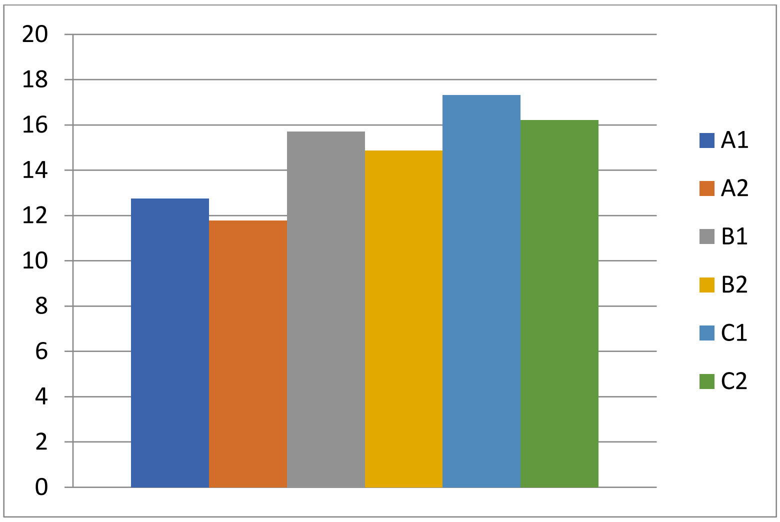
RESULTS

60 Samples were tested for shear bond strength in Universal Testing machine. We can find the subgroup C1 with highest mean shear bond value followed by Group C2, B1, B2, A1 and A2. (Table 1 & Graph 1).

Table 1 : Results for Shear Bond Strength of various group in Mpa

Sub Group	Group A Surface Treatment = NA		Group B Surface Treatment = 10%Hydofluoric Acid		Group C Surface Treatment = 24% Hydrogen Peroxide	
	A1	**A2**	**B1**	**B2**	**C1**	**C2**
Luting Cement	**Total Etch Resin Cement**	**Self Etch Self Adhesive Resin Cement**	**Total Etch Resin Cement**	**Self Etch Self Adhesive Resin Cement**	**Total Etch Resin Cement**	**Self Etch Self Adhesive Resin Cement**
1	12.87	11.86	15.98	14.76	17.3	16.26
2	12.54	12.5	13.84	13.57	17.58	15.76
3	13.6	10.4	17.65	15.75	17.11	16.95
4	11.76	13.63	14.26	14.56	16.96	15.25
5	14.24	9.87	16.85	14.22	17.56	17.05
6	10.76	10.45	15.46	15.27	16.28	16.5
7	11.84	12.94	15.74	13.98	18.28	15.98
8	13.04	9.84	16.23	15.56	16.65	15.65
9	13.25	13.56	14.28	15.7	17.95	16.45
10	13.77	12.87	16.84	15.34	17.5	16.26
Mean	12.767	11.792	15.713	14.871	17.317	16.211

Graph 1 : Mean Shear Bond Strength in Mpa



After obtaining these values statistical analysis was performed with post-hoc Tukey HSD method. P values were obtained for each comparisons. (Table 2). These values were verified with Scheffé, Bonferroni and Holm methods. (Table 3)

Table 2 : post-hoc Tukey HSD Test results

Control	Test	Tukey HSD Q statastic	Tukey HSD p-value	Tukey HSD Inference
A1	A2	3.0097	0.288793	INSIGNIFICANT
	B1	9.094	0.0010053	** P<0.01
	B2	6.4949	0.0010053	** P<0.01
	C1	14.0454	0.0010053	** P<0.01
	C2	10.6313	0.0010053	** P<0.01
A2	B1	12.1038	0.0010053	** P<0.01
	B2	9.5046	0.0010053	** P<0.01
	C1	17.0552	0.0010053	** P<0.01
	C2	13.641	0.0010053	** P<0.01
B1	B2	2.5992	0.4526225	INSIGNIFICANT
	C1	4.9514	0.011467	*P<0.05
	C2	1.5373	0.8778374	INSIGNIFICANT
	C1	7.5506	0.0010053	** P<0.01
	C1	4.1365	0.0538326	INSIGNIFICANT
C1	C2	3.4141	0.1698156	INSIGNIFICANT

Table 3 : Tukey HSD, Scheffé, Bonferroni and Holm methods

Control	Test	Bonferroni and Holm T-statastics	Bonferroni p-value	Bonferroni inferfence	Holm p-value	Holm Inference
A1	A2	2.1282	0.5685065	insignificant	0.1137013	insignificant
	B1	6.4304	5.18E-07	**p<0.01	3.11E-07	**p<0.01
	B2	4.5926	0.0003992	**p<0.01	0.0001863	**p<0.01
	C1	9.9316	1.31E-12	**p<0.01	1.22E-12	**p<0.01
	C2	7.5175	8.93E-10	**p<0.01	6.55E-09	**p<0.01
A2	B1	8.5587	1.88E-10	**p<0.01	1.50E-10	**p<0.01
	B2	6.7208	1.76E-07	**p<0.01	1.17E-07	**p<0.01
	C1	12.0598	0.00E+00	**p<0.01	0.00E+00	**p<0.01
	C2	9.6457	3.62E-12	**p<0.01	3.14E-12	**p<0.01
B1	B2	1.8379	1.073724	insignificant	0.1431632	insignificant
	C1	3.5012	0.0140635	*p<0.05	0.0056254	**p<0.01
	C2	1.087	4.2278405	insignificant	0.281856	insignificant
	C1	5.3391	2.86E-05	**p<0.01	1.53E-05	**p<0.01
	C1	2.9249	0.0754268	insignificant	0.0251423	*p<0.05
C1	C2	2.4141	0.2878745	insignificant	0.0767665	insignificant

It was analyzed when no surface treatment was employed i.e. Subgroup A1 and A2 the difference for shear bond strength is statistically insignificant, whereas these both have significant statistical difference when compared with all other groups. These analysis suggest surface treatment to fiber post increases shear bond strength.

For subgroup B1 and B2, hydrofluoric acid was used as a surface treatment agent. Comparison is statistically insignificant irrespective of cement used. Hence, cement doesn't play role when Hydrofluoric acid gel is used.

For Subgroup C1 and C2, same scenario is seen, inter comparisons of these groups are statistically insignificant. Showing role of Surface treatment more significant in this study.

Among all Group C2 which has surface treated fiber post with 24% Hydrogen Peroxide and etched with total etch resin cement shows highest mean shear bond strength.

With all the analysis performed we can observe that

- When same surface treatment was used, difference between cement did not affect shear bond strength significantly.
- When different surface treatments were employed statistically significant differences were noted, despite use of same or different cement.

Results indicates significance of surface treatments in post and core system. In which 24% Hydrogen Peroxide has highest effect on shear bond strength followed by 10% Hydrofluoric Acid.

DISCUSSION

Endodontic treatments have revolutionized dentistry, allowing damaged teeth to be salvaged and restored to functionality. However, the success of such treatments hinges not only on the procedures within the root canal but also on the subsequent restoration of the tooth. One crucial aspect of this restoration process is the use of posts to support and retain coronal restorations. Traditionally, metal posts have been favored for their strength, but they pose challenges in terms of aesthetics, especially with translucent ceramic crowns. Here, the narrative shifts towards exploring the advantages of fiber posts in endodontic restorations.[11]

Fiber posts have emerged as a promising alternative to metal posts due to their biomechanical properties that closely mimic natural dentin. Studies have shown that fiber posts possess excellent transverse strength and act as shock absorbers, reducing stress on the restored tooth. Additionally, the light-transmitting nature of fiber posts facilitates improved polymerization of composite resins within the root canal, enhancing mechanical properties such as elasticity and hardness.[12]

In the realm of adhesive cements, which are crucial for bonding fiber posts to radicular dentin, challenges arise due to the high configuration factor within the root canal system. This factor leads to gaps at the cement-dentin interface, compromising bond strength. Moreover, the choice of resin cement can influence the luting ability of fiber posts, with mismatches between adhesive systems and resin cements potentially leading to compromised bonding.[13]

To address these challenges, researchers have investigated various surface treatments for fiber posts. Hydrofluoric acid and hydrogen peroxide have emerged as potential candidates. [14,15,16] Hydrofluoric acid, despite its effectiveness in creating surface roughness for micromechanical interlocking, has been associated with damage to glass fibers, affecting post integrity.[17] On the other hand, hydrogen peroxide has shown promise in enhancing surface morphology and promoting micromechanical retention without causing substantial damage to fiber posts.[15,16]

Studies comparing different adhesive systems have demonstrated varying results, with three-step etch & rinse adhesive systems exhibiting higher bond strengths compared to single-bottle etch & rinse or self-etch primer systems. This difference in performance underscores the importance of selecting the appropriate adhesive system for optimal bonding efficacy.[18]

The presented study delves into the shear bond strength of fiber posts treated with different surface treatments and luted with different resin cements. Results indicate a significant increase in bond strength with surface treatments, particularly with hydrogen peroxide compared to hydrofluoric acid. Additionally, the use of total etch resin cement consistently yielded higher bond strengths than self-etch adhesive cement, regardless of the surface treatment employed.

These findings challenge the traditional approaches to endodontic post and core systems, highlighting the importance of surface treatments and adhesive selection in achieving optimal bond strength and restoration longevity. While fiber posts offer advantages in terms of biomechanical properties and aesthetics, their successful integration into endodontic treatments relies heavily on meticulous surface preparation and compatible adhesive systems.

CONCLUSION

The recent study was carried out with the purpose to compare and evaluate the shear bond strength of different surface treated fiber posts luted with different luting agents. This invitro study could help predict the shear bond strength of the fiber posts treated with Hydrogen Peroxide (24%) and Hydrofluoric Acid gel (10%) ; luted with Self etch adhesive cement and Total etch resin cement and facilitate determination of which combination offered a higher value of the bond strength.

Within the limitations of this study following conclusions can be drawn:

- 24% Hydrogen Peroxide has highest effect on shear bond strength compared to 10% Hydrofluoric Acid.
- For luting cements, application of the total etch resin cement shows consistent higher values than the self etch adhesive cement irrespective of employed surface treatment, but the difference was statistically insignificant ; concluding surface treatment as a necessary protocol in the post and core system.
- 24% Hydrogen Peroxide and Total Etch Resin cement (3M ESPE) showed the maximum value for shear bond strength with the mean value of 17.317 Mpa.

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