Comparison of the Retentive Strength of 3 Different Posts in Restoring Badly Broken Primary Maxillary Incisors

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ABSTRACT

Purpose: The management of mutilated primary incisors in early childhood caries is a clinical challenge and necessitates the use of intraradicular retention. This study's purpose was to compare the retentive strength of 3 different types of posts in restoring broken primary incisors: (1) composite posts; (2) orthodontic "γ" wire posts; and (3) glass fiber posts.
Methods: This vitro study was performed on 30 extracted human primary maxillary incisors. Samples were randomly divided into 3 groups of 10 each: group 1 (composite posts and composite core); group 2 (orthodontic "γ" wire posts and composite core); and group 3 (glass fiber posts and composite core). Mounted specimens were subjected for tensile strength on an Instron testing machine. The values were statistically analyzed.
Results: Mean tensile strength values for glass fiber posts was 5.89±0.66 kg force, followed by 4.46±0.82 and 3.56±0.53 kg force for orthodontic wire posts and composite posts, respectively, with a statistically significant difference between and within the groups (P<.01). Groups 1 and 2 showed more bulk cohesive failure and less adhesive bond failure. Group 3 showed only adhesive bond failure.
Conclusion: Glass fiber posts showed greater dislodging strength, followed by orthodontic "γ" wire posts and, least of all, composite posts.
(J Dent Child 2010;77:17-24)

Received January 17, 2009; Last Revision June 19, 2009; Revision Accepted June 19, 2009.

KEYWORDS: DENTAL MATERIALS/BIOMATERIALS, INFANT ORAL HEALTH, RESTORATIVE DENTISTRY

Severe early childhood caries is a devastating condition for both the child undergoing dental treatment and the concerned parents. It is also challenging for pediatric dentists to restore badly broken down teeth observed in grossly severely teeth.[1,2] The goal of dental treatment is to restore the lost tooth structure in order to maintain function and prevent changes in mastication, phonetics, development of parafunctional habits and psychological problems that will affect a child's self-esteem.[3]

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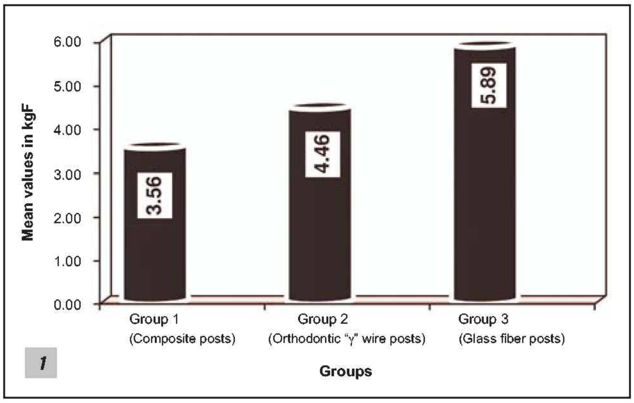
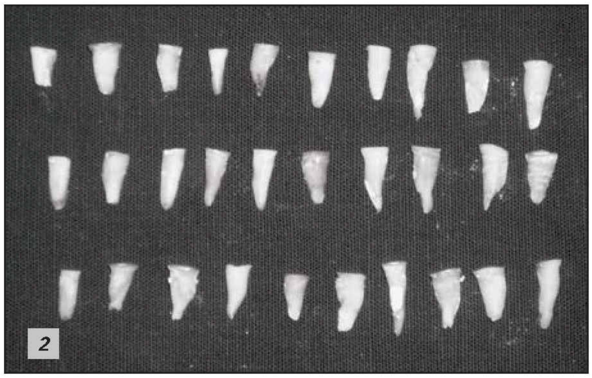
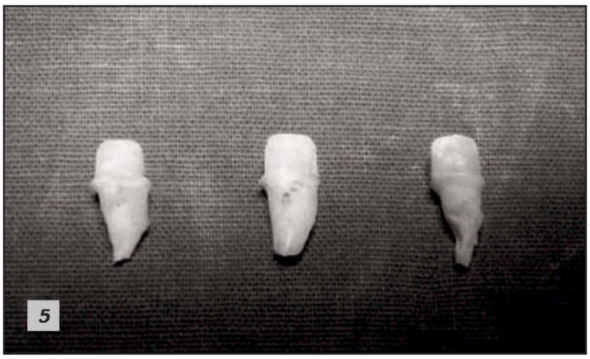
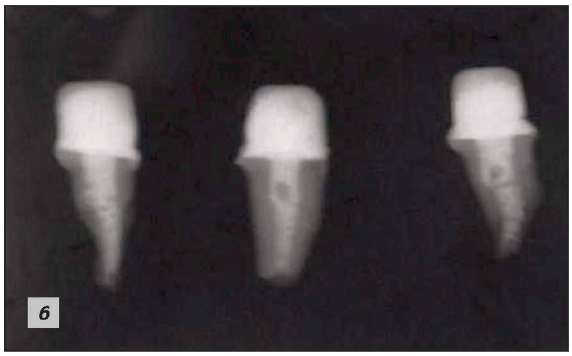
Several attempts have been made by clinicians[2,4-7] to restore grossly decayed anterior primary teeth with innovative root canal retentive post and core systems so that the primary teeth are retained until they are replaced by permanent teeth. There are several types of root canal posts available for use in pediatric restorative dentistry, including premanufactured,[2] orthodontic wire in "α" or "γ" forms,[2] omega forms,[4] metallic posts with macroretention,[5] short posts with composite resin,[6] polyethylene ribbon posts,[2] and biological posts.[7] In addition, newer post systems such as carbon fiber, glass fiber, and zirconium oxide posts, offer excellent features—including biocompatibility, fatigue, and corrosion resistance—and have mechanical properties similar to dentin.[8]

A review of the literature[1,2,4,5,7] shows many clinical reports describing the rehabilitation and follow-up of









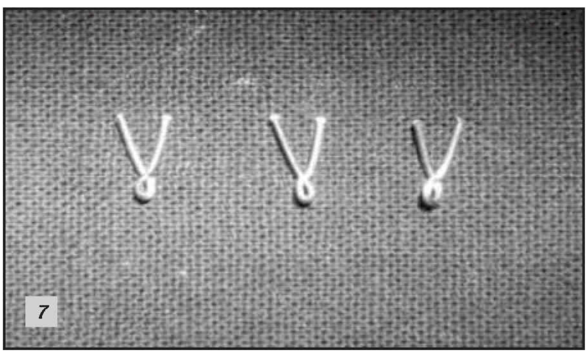


Figure 1. Comparison of mean pull-out strength values of groups (1–3).
Figure 2. Specimens.
Figure 3. Radiograph of 4 mm post-space created.
Figure 4. Radiograph showing 1mm base of GIC placed to isolate the obturated material from the Post-space.
Figure 5. Group-1 (Composite post and core).
Figure 6. Group-1 (Radiograph of composite post and core).
Figure 7. Orthodontic gamma wire posts.
Figure 8. Group-2 (Orthodontic gamma wire posts and core).

Table 1. Distribution of Samples

Group	Number of Samples
1: Composite post and composite core	10
2: Orthodontic "γ" wire posts and composite core	10
3: Glass fiber posts and composite core	10
Total	30

anterior primary teeth restorations, but none of them are related to physical and mechanical properties of post-supported restorations in anterior primary teeth.

Therefore, the purpose of this study was to evaluate and compare the tensile strength of 3 different intracanal posts in restoring mutilated primary maxillary incisors by the in vitro method: composite posts; orthodontic "γ" wire posts; and glass fiber posts.

METHODS

This study was conducted by the Department of Pediatric Dentistry, SDM College of Dental Sciences, Dharwad, India, in association with 3M-ESPE, Bangalore, India. It was approved by the Ethical Committee of the SDM College of Dental Sciences, Dharwad, India.

This in vitro study was conducted on 30 extracted human primary maxillary incisors. Selection criteria included those with: at least a cervical third of a crown; two thirds of the root length intact; and no previous endodontic therapy, as shown in Figure 2. All extracted primary maxillary incisors were cleaned with saline to remove the remaining debris and tissue tags. The coronal portion of specimens were transversely sectioned 1-mm above the cementoenamel junction, retaining 1 mm of coronal tooth structure using a diamond disk, and the separated roots were stored in 250 ml of saline. The radicular portion of the specimens were treated endodontically and obturated with zinc-oxide eugenol cement. The obturated material was allowed to set for 10 minutes.

Preparation of post space and cementation. The post space was created by removing approximately 4-mm of zinc-oxide eugenol obturated material using a thin, straight fissure bur attached with a rubber stopper with a contra angle micromotor handpiece.[2,3,7] The diameter of the straight bur used was less than the root canal's. All visible zinc-oxide eugenol cement on the walls of the post space was removed, as shown in Figure 3. The post space was air-dried, and a 1-mm base of glass ionomer cement (Fuji-II, GC Corp, Tokyo, Japan) was placed to isolate the obturated material from the rest of post space (Figure 4). A post space of 3 mm was standardized for all the specimens.[3] The prepared post space was then cleaned with saline, air-dried, and acid etched with Gluma etch gel (Heraeus Kulzer, South Bend, Ind) and 35% phosphoric acid for 15 seconds.[9] This space was then rinsed and air-dried, and 2 coats of dentin adhesive (Gluma comfort bond, Heraeus Kulzer) were applied followed by light curing for 20 seconds.[3]

All the samples were treated in a similar manner. They were then divided into 3 different groups of 10 each (Table 1 and Figure 2), as follows.

In group 1, the post space was filled by incremental curing of composite resin (Charishma, A2 shade, Heraeus Kulzer) for 40 seconds. Once the post space was filled with composite resin, a core of approximately 4-mm breadth mesiodistally and 6-mm high cervicoincisally was built-up using the same composite resin (Charishma, A2 shade; Figures 5 and 6).

In group 2, a 0.6-mm orthodontic wire (Konark, Everbright Dental stainless steel wire, Comet, Mumbai, India), bent to form the Greek letter "γ," was used (Figure 7). The loop portion was inside the post space, and the 2 free ends were toward the coronal portion. These wire posts were cemented with flowable composite resin (Esthet-X flow, A2 shade, Dentsply Caulk, Woodbridge, Canada) and light cured for 40 seconds. The core was built in same way as in group 1 using Charishma (A2 shade; Figures 8 and 9).

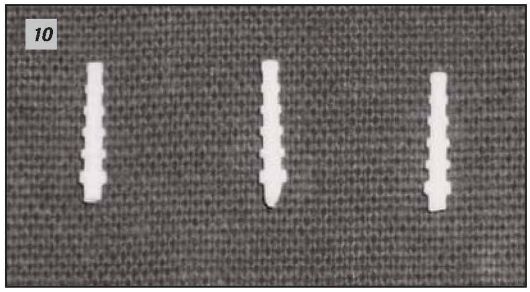
In group 3, standardized 8-mm long and 1.2-mm diameter translucent glass fiber posts (Stabitech, Microtech, Peccioli (Pi), Italy) were used (Figure 10). These posts were cemented into the post space using flowable composite resin (Esthet-X flow, A2 shade) and light cured for 40 seconds. The core was built in same way as in group 1, using Charishma (A2 shade; Figures 11 and 12).

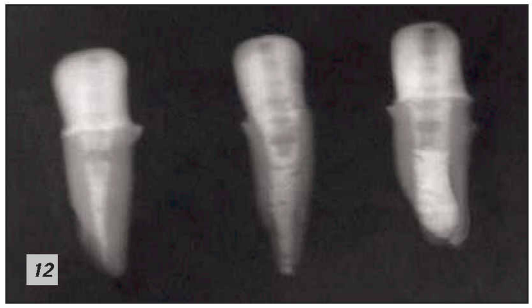
Glass fiber posts (Stabitech) of 21-mm length and 1.2- mm diameter were supplied by the manufacturer. These posts were standardized to 8-mm length by sectioning posts from the head portion; 3-mm and 5-mm of the post was placed into the intracanal post space and the core, respectively.

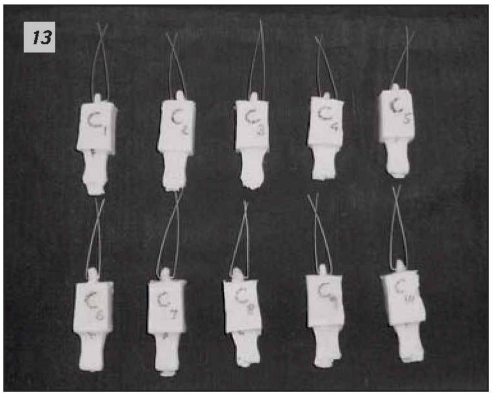
A core of approximately 4-mm breadth mesiodistally and 6-mm high cervicoincisally was standardized for all the specimens.

Mounting of specimens for the tensile test. The radicular portion of all the specimens were embedded in self-cure acrylic resin blocks measuring 2.5 x 1.5 x 1.5 cm each. The acrylic resin blocks extended up to 1-mm below the coronal tooth structure's cementoenamel junction so that the core was clearly exposed (Figure 13). A fine bur hole was made at the center of the core with a small round bur using a high-speed handpiece. A retentive loop of 0.6-mm orthodontic wire was placed into the core, and the 2 free ends of the wire were twisted and cut to a standardized 5" length, as required by the Instron testing machine used (model-4467, Instron, Norwood, Mass). All mounted specimens were stored in normal saline for 24 hours before the tensile test.

Figure 15 shows the Instron testing machine, which is used for conducting tests like removal, tension, and







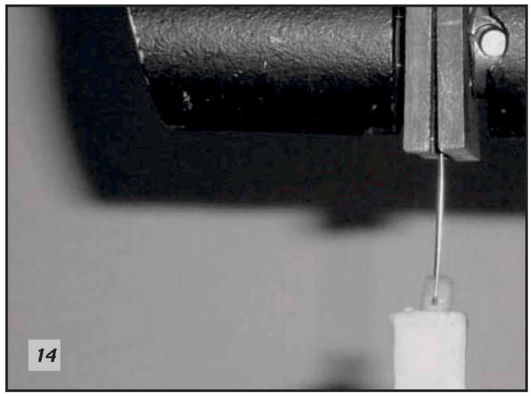


Figure 9. Group–2 (Radiograph of orthodontic gamma wire posts and core).

Figure 10. Sectioned 8 mm length Glass fiber posts.

Figure 11. Group–3 (Glass fiber post and composite core)

Figure 12. Group–3 (Radiograph of Glass fiber post and core).

Figure 13. Specimens mounted on acrylic resin blocks for tensile test.

Figure 14. Specimen mounted on testing machine.

compression. The machine consists of 2 crossheads: upper, which is movable; and lower, which is stationary. The crossheads are mounted on a hydraulic framework connected to a force recording unit or the sensor which measures and indicates the specimen's load.

Each mounted specimen for the dislodging test was positioned in the lower crosshead with the core portion facing upwards. The retentive loop was fixed in the upper cross heads of the Instron testing machine. The mounting was done so that the loading force was parallel to the long axis of the tooth and core (Figure 14).

Dislodging force was applied using a 1,000 N load cell, which applied a load ranging from 0.1 g to 10 kg force at a crosshead speed of 4 mm/minute. Increasingly heavy loads were applied from a minimum of 0.1 g force until the post was dislodged. The load at which post dislodging occurred indicated the tensile strength of that particular specimen, which was displayed on the display monitor in kilogram force (kgF). The same procedure was carried out on all the remaining specimens.

The obtained values were recorded in kgF, and the types of visual bond failure were noted for groups 1 to 3 (Table 2). Cohesive bulk failure was noted when there was bulk fracture of the core (Figures 16 and 17). Adhesive failure was noted when there was total dislodgement of the post core assembly with no visible composite resin inside the post space (Figure 18). The data was tabulated and statistically analyzed using student's *t* test and analysis of variance (ANOVA) statistical tests (Tables 3 and 4). A *P*-value of less than .01 was considered to be statistically significant.

Table 2. In Vitro Tensile Strength Values of the Groups 1 to 3 Expressed in kg Force and Type of Visual Bond Failure Observed

Specimen no.	Group 1: Composite post and composite core		Group 2: Orthodontic "γ" wire posts and composite core		Group 3: Glass fiber posts and composite core	
	kgF	Failure type	kgF	Failure type	kgF	Failure type
1	3.86	Bulk cohesive	4.22	Bulk cohesive	6.14	Adhesive
2	2.84	Bulk cohesive	3.07	Bulk cohesive	5.84	Adhesive
3	3.56	Bulk cohesive	4.75	Adhesive	6.92	Adhesive
4	3.24	Adhesive	5.09	Adhesive	5.64	Adhesive
5	4.27	Bulk cohesive	3.11	Bulk cohesive	6.21	Adhesive
6	4.19	Bulk cohesive	5.42	Bulk cohesive	5.57	Adhesive
7	3.81	Adhesive	4.82	Bulk cohesive	4.36	Adhesive
8	2.64	Bulk cohesive	4.29	Adhesive	6.32	Adhesive
9	3.72	Bulk cohesive	5.32	Bulk cohesive	5.89	Adhesive
10	3.55	Bulk cohesive	4.61	Adhesive	6.01	Adhesive
Mean±(SD)	3.57±0.53		4.47±0.82		5.89±0.66	

RESULTS

Tensile strength values improved from groups 1 to 3 as shown in Figure 1. Mean dislodging strength values of groups 1 to 3 were 3.56±0.53, 4.46±0.82, and 5.89±0.66 kgF, respectively (Table 2, Figure 1). Group 3 showed a higher tensile strength than groups 1 and 2. Pairwise comparison of groups 1 to 3 by student's *t* test (Table 3) showed a statistically significant difference between groups ($P<.01$). The t-value obtained between groups 1 and 2, 1 and 3, and 2 and 3 was 2.89, 8.64, and 4.25, respectively.

A comparison of groups 1 to 3 by ANOVA test (Table 4) revealed a statistically significant difference ($P<.01$) between and within groups. A comparison regarding the type of visual bond failure (Table 2) revealed that 80% of group 1 specimens displayed bulk cohesive failure. Conversely, all group 3 specimens showed adhesive bond failure between cemented flowable composite resin and radicular dentin. In group 2, 60% of specimens showed bulk cohesive failure while 40% showed adhesive bond failure.

DISCUSSION

Esthetic restorations of primary teeth have long been a special challenge to pediatric dentists. Conventional glass ionomer restorations have demonstrated high failure rates in the primary dentition.[7] Not surprisingly, many anterior primary teeth are extracted due to inadequate esthetic treatment options.[1,2-4,7]

The use of intraradicular posts offers an esthetic and functional treatment option in endodontically treated, mutilated primary anterior teeth. This form of reconstruction should provide adequate retention and appreciably withstand masticatory forces in function.[2] The posts primarily provide the necessary retention for the core.[8]

The posts commonly used in pediatric dentistry are: premanufactured[2] orthodontic wire in "α" or "γ" forms[2] or omega forms[4]; metallic posts with macroretention[5]; short posts with composite resin[6]; polyethylene ribbon posts[2]; and biological posts.[7] Irrespective of the type of post employed, the primary tooth should be treated endodontically and the post should extend intraradicularly up to one third of the root's length.[2,5]

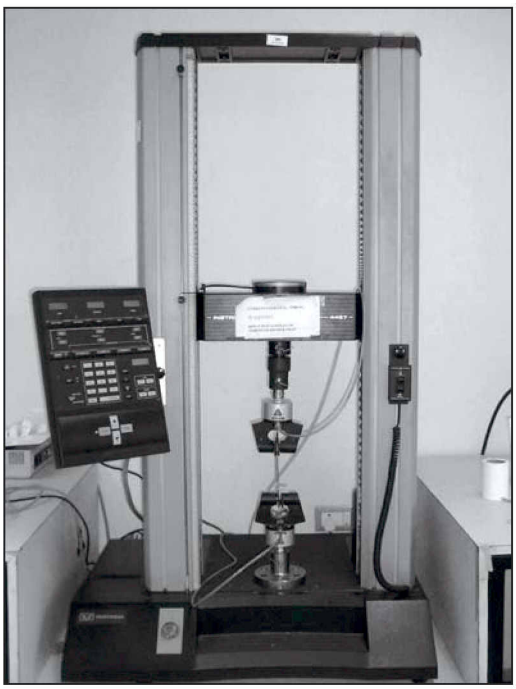


Figure 15. Instron testing machine.

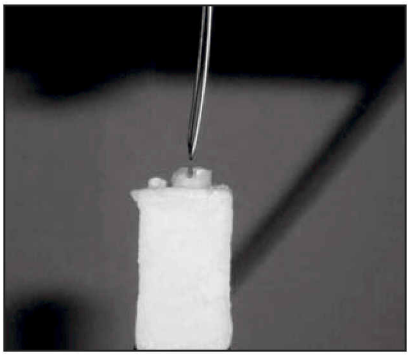


Figure 16. Bulk cohesive failure more common in Group-1.

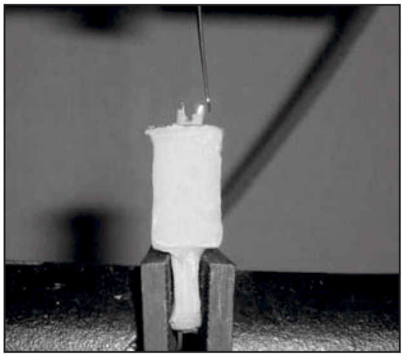


Figure 17. Bulk cohesive failure in Group-2.

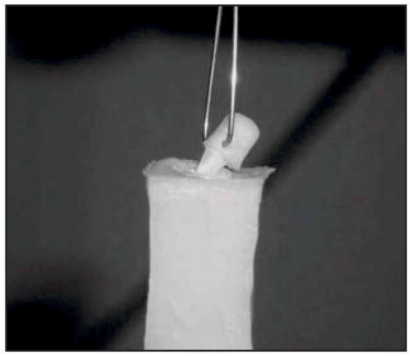


Figure 18. Adhesive failure more common in Group-3.

In this study, composite resin posts and orthodontic "γ" wire posts were chosen, as they are the most commonly used posts in pediatric dentistry. A recent innovation is the glass fiber post system, which has shown excellent results when used in permanent teeth.

A higher retention strength was observed with glass fiber posts, followed by orthodontic "γ" wire posts and composite posts. Glass fiber posts were found to be more retentive when compared to orthodontic "γ" wire posts and composite posts. This may be explained by the fact that these fiber posts are serrated, which helps in mechanical retention.[10] Other factors include better bonding of these posts to cementing media, good adaptability to the root canal, and the fact that these posts offer better light transmission, which enhances the polymerisation of resin cement at the apical region during the cementation procedure.[10]

The properties of fiber-reinforced posts are dependent on the nature of the matrix, fibers, interface strength, and geometry of reinforcement. The addition of fibers to a polymer matrix can result in significant improvement in the mechanical properties of strength, fracture toughness, stiffness, and fatigue resistance.[10]

Orthodontic gamma wire posts showed both cohesive as well as adhesive failure. The reason for bulk cohesive failure, as shown in Figure 17, can be attributed to poor bonding between the smooth surface of wire posts with a composite core. Adhesive bond failure between the cementing media and root canal, however, is due to inadequate adaptation of these posts to the root canal, since they do not copy its form faithfully. In this study, orthodontic gamma wire technique proved to be technical and operator sensitive, and it was more difficult to adapt the bent orthodontic wire into the post space.

Composite posts showed poor retentive strength values when compared to orthodontic gamma wire posts and glass fiber posts. Most of the composite posts showed bulk cohesive failure (Figure 16) and few of them showed adhesive bond failure between the root canal and composite post—suggesting a better bond between the post and root canal wall. The most probable reason for more commonly observed bulk cohesive failure is because these posts act as a single unit. When the load is applied, force is directed toward the core, which is unsupported, resulting in bulk cohesive failure. This finding agrees with Sharaf.[1]

Bulk cohesive failure in composite posts can be prevented by curing the composite resin within the post space incrementally. In this study, although condensing and curing of composite resin was done incrementally, there

Table 3. Pairwise Comparison of Groups 1 to 3 by Student's T Test

Group	Mean±(SD)	t-value	*P*-value	Significance
1: Composite post and composite core	3.57±0.53	2.90	<.01	Statistically significant
2: Orthodontic "γ" wire posts and composite core	4.47±0.82		<.01*	
1: Composite post and composite core	3.57±0.53	8.64	.00	Statistically significant
3: Glass fiber posts and composite core	5.89±0.66		<.01*	
2: Orthodontic "γ" wire posts and composite core	4.47±0.82	4.25	<.01	Statistically significant
3: Glass fiber posts and composite core	5.89±0.66		<.01*	

** Statistically significant.*

was radiographic evidence of voids in the filled space (Figure 6). These voids could be another important factor for causing bulk cohesive failure with composite posts. Therefore, proper care should be taken to avoid voids.

Although related studies[3,12] found no statistically significant difference, an analysis of this study showed a statistical difference. Pinheiro et al. found no statistically significant differences in bond strength between composite posts, 0.7-mm alpha-shaped orthodontic wire, and dentin posts.[12] Silvia et al.[3] used comparable materials in their study between composite posts, orthodontic "γ" wire posts, and glass fiber posts. They reported higher retentive strength with composite posts, followed by orthodontic "γ" wire posts and glass fiber posts, with no statistically significant differences in tensile strength values between the 3 techniques used.[3]

Conversely, in the present study we found that glass fiber posts showed higher retentive strength values, followed by orthodontic "γ" wire posts and composite posts, with a statistically significant difference in retentive strength values among the 3 techniques used. The differences in the results of this study compared to Pithan et al[3]. study may be due to differences in the type of composite resin used for cementing the posts. Pithan et al. used Filtek Z 250 restorative composite resin to cement the post, while we used Esthet-X flow flowable composite resin, which is known to flow well and exhibit better micromechanical retention.

Among its advantages, the fiber post technique described in the present study1:

1. Employs fiber posts that are ready to use;
2. Provides homogeneous mechanical and chemical bonding of all components;
3. Reduces the risk of root fracture, since its modulus of elasticity is similar to that of root dentin and its diametral tensile strength is low; and
4. Presents no potential hazards of corrosion and hypersensitivity.

This study's results suggest that glass fiber posts offer better retention and show adhesive failure between the adhesive system and the canal walls. Interaction between these walls and the adhesive system should be further studied. Additionally, more clinical and laboratory studies should be conducted with different techniques to restore mutilated primary anterior teeth. Also, further studies with stereomicroscope should be done to know the type of bond failure that occured.

Table 4. Comparison of Groups 1 to 3 by ANOVA Test

Source of variation	Sum of squares	Degree of freedom	Mean sum of squares	F-value	*P*-value	Significance
Between groups	27.37	2	13.69	29.33	.00	Statistically significant
Within groups	12.60	27	0.47		<.01*	
Total	39.97	29	14.15			

*** Statistically significant.***

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. Glass fiber posts offered better tensile strength in vitro compared to orthodontic "γ" wire posts and composite posts.
2. The type of bond failure observed with composite posts and orthodontic "γ" wire posts were more of bulk cohesive failure and less of adhesive bond failure, whereas all the glass fiber post specimens showed an adhesive bond failure.
3. There is limited information available on glass fiber post-supported restorations on root resorption and their influence on exfoliation of restored primary incisor teeth. Further long-term clinical studies in this area are needed.

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