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Role of reinforcement methods in retention of composite restorations of primary anterior teeth

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Objectives This study aimed to evaluate the retention of composite restorations of primary anterior teeth reinforced with composite posts, glass fiber posts, para-pulpal pins with composite posts, and para-pulpal pins alone.
Methods Forty freshly extracted sound primary canine teeth with at least two-third of the root length remaining were selected. After disinfection, the tooth crown was cut perpendicular to the longitudinal axis. Root canals were prepared and filled using zinc oxide eugenol paste. The teeth were randomly allocated into four groups and restored using one of the following: Composite posts, glass fiber posts, para-pulpal pins with composite posts, and para-pulpal pins alone. Composite cores were constructed while a preformed U-shaped orthodontic wire was placed in the composite tip, samples were then placed in a universal testing machine for measurement of retention. The minimum force required to dislodge the restoration or cause fracture was considered as the retentive strength. The collected data were analyzed using one-way ANOVA and Tukey's test ($P < 0.05$).
Results There were statistically significant differences between groups ($P = 0.011$). The mean retention in the para-pulpal pins with composite post group (131.72 ± 32.35N) was greater than that in composite posts (93.65 ± 24.45N), glass fiber post (95.92 ± 25.35N), and the para-pulpal pin group (95.34 ± 29.56N) ($P < 0.05$). Other differences were not significant ($P > 0.05$).
Conclusion para-Pulpal pin alone may not help in improving the retention of full crown restoration of primary anterior teeth. However, when used along with a composite post, it appears to improve the retention of restoration.
Keywords deciduous, dental pins, dental restoration, permanent, retention, tooth

Introduction

Although early childhood caries, if timely referred, can be restored with conservative methods, basically, restoration of severely decayed teeth is a challenge for pediatric dentists. This is due to the technique sensitivity of restorative materials as well as poor compliance of young children.[1] In addition, based on the small size of the remaining tooth structure in primary teeth, the bonding potential is limited causing frequent failure of such restorations.[1,2] In many instances, such severely decayed primary teeth may no longer be preserved and need to be extracted.[1] Appropriate treatment planning for such destructed teeth has therefore shifted from extraction to restoration by saving them. Parents are more likely to request restoring child's anterior teeth. Clinicians, should consider parents' attitudes, beliefs, and expectations besides routine aesthetic and functional aspects in such cases.[3] Currently, the most common methods for restoration of primary anterior teeth include stainless steel crowns, pre-veneered crowns, zirconia crowns, polycarbonate crowns, and direct and indirect composite resin restorations.[4] Composite resins are considered as an acceptable choice for restoration of severely decayed primary teeth, due to their bonding ability and esthetic properties. A major advantage of composite resins is preservation of tooth structure while restoring the normal shape and dimensions of the tooth.[5] As caries development and pulpal involvement occur faster in primary teeth than permanent teeth, primary teeth with complete crown destruction requiring total reconstruction are more frequently encountered. Insufficient tooth structure at the cervical area indicates the need for reinforcement of the restoration by use of root canal walls to improve the retention of restoration.[6] In recent years, several intra-canal reinforcement methods have been introduced to restore the primary teeth including short composite posts, glass fiber posts, polyethylene fiber posts, alpha or omega-shaped orthodontic wires and biologic posts.[2] Self-threading para-pulpal pins have been used as an effective tool to help reconstruction of severely decayed permanent teeth for many years due to their excellent retention.[7] But the use of these pins in primary teeth has not been much considered. The risk of damage to the tooth structure and formation of dentinal cracks by para-pulpal pins has been the subject of extensive research. However, if some conditions are met, it seems that using these pins in primary canine teeth does not increase the possibility of crack formation. These conditions include using the smallest pin that provides adequately high retention, creating the pin hole with the appropriate angle of drill, and at least 1 mm distance from dentinoenamel junction.[8] The aim of this *in vitro* study was to evaluate and compare the retention of composite restorations in endodontically treated primary teeth using composite posts, glass fiber posts, para-pulpal pins with composite posts, and para-pulpal pins alone.

Materials and Methods

After approval of the research protocol by the ethics committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.RIDS.REC.1394.125), 40 freshly extracted primary canine teeth with at least two-third of the root length remaining were selected. Samples were stored in 0.1% chloramine T solution (Shahr Teb, Tehran, Iran) prior to the experiment. All teeth were subjected to total coronal amputation from 1 mm above the cementoenamel junction using high-speed hand-piece (NSK, Tochigi, Japan) under steady flow of water with a long cylindrical diamond bur (Jota AG, Rüthi, Switzerland). Pulpectomy was performed for all samples up to #45 using K-files and canals were then filled with zinc oxide eugenol paste (Kemdent, Wiltshire, UK). One millimeter of the coronal part of the canal was evacuated subsequently followed by temporary restoration (Zonalin, Kemdent, Wiltshire, UK). Samples were then mounted from their cervical area 1 mm below the cementoenamel junction in self-cure acrylic blocks (Pyrax, Roorke, India) measuring 1 × 1 × 1.5 cm. Samples were then stored in saline for 48 hours and randomly assigned into four study groups.Post space was prepared in teeth in groups 1–3 using a round carbide bur (Jota AG, Rüthi, Switzerland) on a low-speed hand-piece (NSK, Tochigi, Japan). This was done to create a 4 mm deep space at the canal orifice. After ensuring that no ZOE residues remained on the root canal walls, the canal was rinsed with water and dried with gentle air stream. A 1 mm thick layer of resin-modified glass ionomer (Fuji II LC; GC Corp., Kyoto, Japan) was placed at the bottom of the post space and cured with halogen light curing unit (Kerr, Orange, CA, USA) for 20 s. A 1.2 mm in diameter fissure diamond bur which was judged larger than the canal diameter was used to prepare a standardized post space in all samples.

Post and core fabrication

Group 1 (composite post)

The tooth surface and root canal walls were etched with 37% phosphoric acid gel (N-Etch; Ivoclar Vivadent, Schaan, Liechtenstein) for 15 s followed by rinsing for 10 s and gentle drying with air stream. Two layers of Single Bond II adhesive (3M ESPE, ST. Paul, MN, USA) were applied on the tooth and light cured for 10 s. Composite resin restorative material (Z250; 3M/ESPE, St. Paul, MN, USA) was placed in the coronal space prepared in the canal incrementally, and each composite layer was light cured separately for 20 s. A stainless steel split mold with an internal diameter of 4 mm and height of 6 mm was placed on top of the tooth surface. Increments of Z250 composite resin were then applied in this mold with 2 mm thickness and light cured each for 20 s. Before placing the final layer, a U-shaped orthodontic wire (0.5 mm in diameter) was embedded in the composite resin to enable the pulling process for the retention test.

Group 2 (glass fiber post)

The apical 6 mm of #1 parallel glass fiber post (Reforpost; Angelus, Londrina, Brazil) was cut with a cylindrical diamond bur mounted on a high-speed hand-piece. The cavity was etched with 37% phosphoric acid gel (N-Etch; Ivoclar Vivadent, Schaan, Liechtenstein) for 15 s, rinsed for 10 s, two layers of adhesive (Excite; Ivoclar Vivadent, Schaan, Liechtenstein) were applied on the tooth and light cured for 10 s. A dual-cure resin cement (Variolink II; Ivoclar Vivadent, Schaan, Liechtenstein) was used to cement the fiber post. It was coated with the mixture and inserted into the canal space. We made sure that 3 mm of the post remained outside the canal for core reinforcement. The excess bulk of cement was removed after short light curing for 3 s and then the light curing was continued for 60 s. Composite cores were then constructed similar to the first group.

Group 3 (para-pulpal pins with composite post)

One pin hole was prepared in the palatal part of the remaining tooth structure using the factory-provided twist drill on a low-speed hand-piece. A 0.53 mm para-pulpal pin (TRI-JET; NTI, Kahla, Germany) was inserted into the pin hole and manually rotated in a clockwise direction until its handle was separated. The post and composite core were then prepared as in the first group.

Group 4 (para-pulpal pin alone)

As this method did not require a post space, to make sure the root surface is bonded to the composite core similar to other groups, A fissure diamond bur (diameter: 1.2 mm) was used to widen the canal orifice to the same size as in other teeth. The ZOE was also covered with resin-modified glass ionomer cement. Pin placement and core construction were performed similar to group 3.

The teeth were stored in normal saline at 37°C for 1 week. To measure the restoration's retention, samples were placed in the lower head grip of Zwick-Roell Z020 universal testing machine (Zwick-Roell, Ulm, Germany) from the acrylic block end. The wire end was attached to the upper head of the universal testing machine. The upper head was then started to move at a crosshead speed of 1 mm/min until the restoration was detached from the tooth bulk or broke. The load at the breaking point as recorded. Statistical analyses were done with one-way ANOVA and the Tukey's test for paired comparisons. P value <0.05 was considered significant.

Mode of failure

Assessment of the mode of failure was done by a stereomicroscope (SZX9; Olympus, Tokyo, Japan). The teeth were evaluated under 12× magnification. Categorization was performed based on the area of fracture and divided into three groups: (A) Adhesive failure: complete dislodgement of posts and restoration from the teeth, (B) cohesive failure inside the canal, and (C) cohesive failure in composite core. Obtained data were statistically analyzed using one-way ANOVA, Tukey's test, and Fisher's exact test.

Table 1. **Mean retention and the frequency of the modes of failure in different groups (*n* = 10)**

Group	Mean ± SD (*N*)	Mode of failure		
		Adhesive	Cohesive in core	Cohesive (intra-canal)
Composite post	93.65 ± 24.45	0	1	9
Glass fiber post	95.92 ± 25.35	2	1	7
Para-pulpal pin + composite post	131.72 ± 32.35	1	9	0
Para-pulpal pin alone	95.34 ± 29.56	8	2	_

SD: Standard deviation.

Results

The highest mean (±standard deviation) retention (131.72 ± 32.35N) was seen in group 3 (Table 1). Statistical analysis using one-way ANOVA showed a significant difference in this regard among the groups ($P = 0.011$). Based on a *post-hoc* analysis with Tukey's HSD test, the mean retention in group 3 (para-pulpal pin + composite post) was significantly higher than that in group 1 (composite post, $P = 0.022$), group 2 (glass fiber post, $P = 0.035$), and group 4 (para-pulpal pins, $P = 0.031$). However, the differences between groups 1 and 2 ($P = 0.998$), groups 1 and 4 ($P = 0.999$) and groups 2 and 4 ($P = 1.000$) were not significant. Table 1 also shows the frequency of different failure modes in all groups. The *Fisher's exact test* showed significant differences in the mode of failure as the adhesive type mainly occurred in group 4, while other groups showed mostly cohesive type of failure.

Discussion

It has been reported that the use of self-threading pins is efficient to increase the long-term durability of resin-based restorations.[9] This method, in addition to increasing the retention of adhesive restorative materials and preserving the tooth structure, decreases the risk of restoration failure.[9,10] Andrade et al.,[11] in a case report with a 1.5-year follow-up assessed the use of direct composite restorations with self-threading pins in severely decayed permanent teeth and reported the use of pins to be comfortable, esthetic and affordable.

In the present study, para-pulpal pin with composite post group had significantly greater mean retention than the composite post, fiber post, and para-pulpal pin groups. But the difference among other groups was not statistically significant. The insignificant difference between the composite post and fiber post groups is consistent with the results of the study by Memarpour et al.[12] and Pithan et al.[13] Thus, it seems that inappropriate fit of the fiber post in the root canal of primary teeth explains this result. Nevertheless, Gujjar and Indushekar[14] reported greater retention mean in fiber post group cemented with flowable composite than composite post group, which is probably because of difference in the type of luting cement used.The current study showed no significant difference in retention between para-pulpal pins alone and fiber posts and composite posts. Moreover, post space preparation did not weaken the tooth structure. Thus, this method can be suggested as an alternative to intra-canal reinforcement methods. Although based on the significant difference between para-pulpal pin + composite post group and para-pulpal pin group, if more retention is required (severe destruction of tooth structure), it can be provided by using para-pulpal pins plus composite posts. Obviously, the advantages of this method can be achieved only when the operator has appropriate skills for the use of para-pulpal pins since inadequate knowledge about tooth morphology and inadequate angle of drilling may lead to perforation.[9] The most common mode of failure in fiber post group was cohesive failure inside the canal, while cohesive failure in the core had the highest frequency in composite post and para-pulpal pin plus composite post groups. Adhesive failure had the highest frequency in para-pulpal pin group. Higher frequency of cohesive failure in core in composite post group (90% of total cases), compared to fiber posts (10% of all cases), was also reported in the studies by Gujjar and Indushekar[14] and Memarpour et al.[12] The most likely reason for the abovementioned distribution of restoration failure modes can be insufficient support of composite core by composite post in groups 1 and 3, while fiber post strongly reinforces the core structure.[12] In the case of para-pulpal pin group, it can be said that lack of intra-canal retention and also insufficient core structure reinforcement by pins caused mostly adhesive mode of failure, which is easier to repair than the cohesive failure.

Conclusion

Considering the limitations of this study, it can be concluded that using para-pulpal pins with composite posts significantly increased the retention. There was no significant difference in retention between para-pulpal pin and intra-canal retention methods, i.e. composite posts and fiber posts. The bond failure in para-pulpal pin group was mainly adhesive while it was cohesive in other groups.

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Conflict of Interest

"None Declared." ■

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