Original Article

Comparative Evaluation of Fracture Load Resistance and Retention of Polyethylene Fiber Post with Enhanced Retentive Omega-shaped Short Post in Primary Anterior Teeth: An *In vitro* Study

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Abstract

Aims: This study aims to evaluate the effective method for restoring badly mutilated primary anterior teeth, by comparing the fracture load resistance of polyethylene fiber post with composite resin short post containing omega-shaped stainless steel wire. **Subjects and Methods:** Sixty carious deciduous incisors, with 2/3 root length remaining, were endodontically treated and divided into two groups. Group I consisted of thirty samples of Ribbond fiber post and Group II consisted of thirty samples of resin short post with omega-shaped stainless steel wire. They were tested under the universal testing machine for fracture resistance, and the fracture site was noted under the stereomicroscope. **Statistical Analysis Used:** Data were statistically analyzed using Windows IBM SPSS 8.0 and Student's *t*-test. **Results:** Resin short post with omega-shaped stainless steel wire showed a statistically significant high fracture resistance and retention when compared with Ribbond fiber post. **Conclusions:** Insufficient fiber length and shape of the fiber post had reduced its resistance to fracture, whereas resin short post and omega-shaped wire have got synergistic action when they are used together resulting in increased resistance and retention to fracture.

Key words: Omega post, polyethylene fiber post, primary teeth, Ribbond post

Introduction

Restoration of mutilated teeth has always been a challenge. Early childhood caries (ECC) is a very common disease in children, which causes massive destruction of primary teeth.[1] However, premature loss of these teeth can cause mastication and phonetic alterations, lack of development of premaxilla leading to malocclusions, establishment of parafunctional habits, and psychological problems affecting the self-esteem of the child.[1-3] Thus, even though challenging, the restoration and maintenance of these teeth should be performed. In larger lesions of ECC where little supporting structure is left, it is necessary to have intracanal retention which allows for building a post and core and cementation of an artificial crown.[1,2]

Different intracanal posts: Which can be used are:

1. Omega-shaped wire[3]
2. Ribbond fibers[2]
3. Intracanal reinforcement fiber[2]
4. Resin short posts[1,4,5]
5. Alpha-shaped orthodontic wire (0.5 or 0.7 mm)[2]
6. Metal tube[6,7]
7. Prefabricated posts[6]
8. Stress relieving posts such as flexi posts[6]
9. Natural teeth (biological post)[6,8]
10. Nickel-chromium (Ni-Cr) cast posts.[1,6,9]

The need for restoring the esthetic and function of these teeth for a longer period in the oral cavity has made newer materials and techniques replace the conventional and traditional

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ones. Many clinical reports have been quoted in literature describing rehabilitation of severely damaged anterior teeth, but none related to physical and mechanical properties of these restorations.[1]

Aim and objectives

1. To evaluate the retention and stability of the polyethylene fiber post in comparison with composite short post containing omega-shaped wire by comparing five variables using universal testing machine:
    a. Load at maximum
    b. Displacement at maximum
    c. Stress at maximum
    d. Percentage of strain
    e. Load at yield.
2. To assess the type of fracture at the bond failure site using stereo microscope.

Subjects and Methods

Source of data

Sixty carious primary anterior teeth indicated for extraction with at least 2/3 of root remaining were selected. These teeth were then divided into two groups based on the type of post used for restoration.

- Group I: Thirty teeth for the polyethylene fiber post sample
- Group II: Thirty teeth for resin short post containing omega-shaped stainless steel wire.

Criteria for collection of data:

1. Extracted carious teeth were collected from healthy children
2. Extracted teeth should have at least 1 mm of crown portion above the cementoenamel junction
3. Presence of at least 2/3 of root length
4. There should be no evidence of internal root resorption.

Method of collection of data

Sixty carious and nonrestorable primary anterior teeth with at least 2/3 root length were selected. They were divided into two groups: Group I and II. These teeth were stored in physiological saline until pulpectomy was performed. The coronal portion of the tooth was cut up to 1 mm above the cementoenamel junction with the help of a wheel-shaped diamond bur. Access to pulp chamber was gained with the help of round bur. Working length was determined with the help of K-file number 10 and 15. Biomechanical preparation was done up to 35 number Hedstrom endodontic file. Subsequently, canal was obturated with zinc oxide eugenol (unfilled) and was sealed with a layer of polycarboxylate cement leaving 3 mm space below the cementoenamel junction for post placement. Polycarboxylate cement was used as a barrier between zinc oxide eugenol and composite because eugenol interferes with the polymerization of composite resin.

Each tooth was embedded in a plaster of Paris square block so that on completion of each step, X-rays can be taken more comfortably. In the 3 mm created post space, self-etching priming adhesive (CLEARFIL) was applied for 20 s then dried with high pressure syringe for 5 s followed by light curing for 10 s.

Group I: Thirty teeth were restored using a 12 mm length of polyethylene fiber (non-preimpregnated) Ribbond (Bondable Reinforcement Ribbon), Ribbond. Inc., Seattle, Washington, USA, as a post and core material. Twelve millimeters length of polyethylene fiber was folded at the center to make it 6 mm. Flowable composite was used to place the fiber post into the post space. Three millimeters fiber post was inside the canal and 3 mm above the cement-enamel junction. Followed by light polymerization for 30 s, same flowable composite was used for the core buildup. Crown reconstruction was done using nanocomposite material with the help of strip crown [Figure 1].

Group II: Thirty teeth were restored using a short post of composite resin (flowable) in which an omega-shaped wire was embedded. This omega-shaped wire was constructed using 25-gauge (0.6 mm) stainless steel wire. A total of 1.5 cm length wire was taken, and it was bent into omega shape with the help of universal plier. Before placing omega-shaped wire and composite in the canal, an inverted "mushroom-shaped preparation" (3600) was made in root canal using number 1

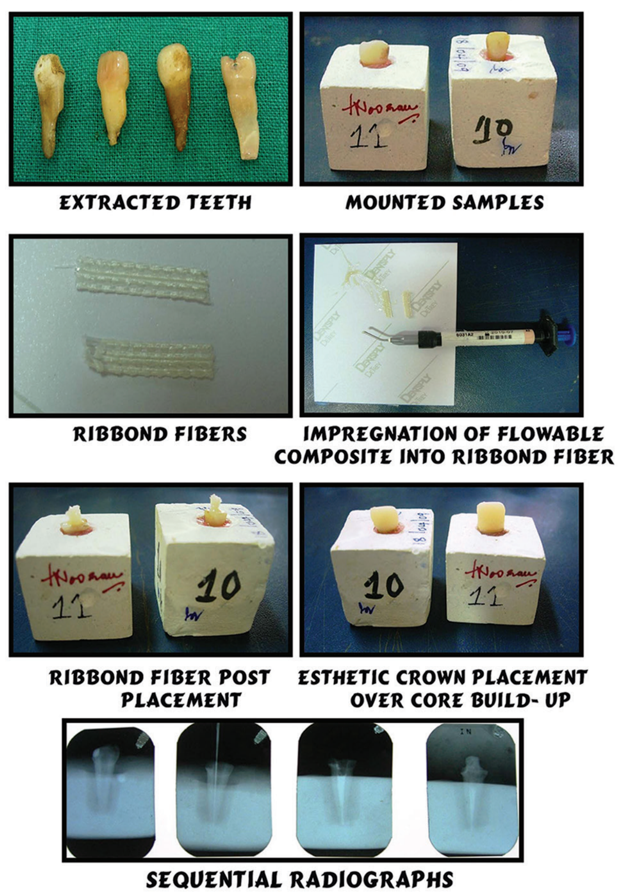

Figure 1: Procedure for Ribbond fiber post placement (Group I).

round bur. Omega-shaped wire was placed 3 mm inside the canal and 2 mm above the cement-enamel junction. Composite was placed in the canal and cured in two steps: first resin in the post space was light cured using multi-layered technique with flowable composite resin, and same was used to build core. Crown buildup was done with nanocomposite using strip crowns [Figure 2].

All teeth were mounted onto the metal cylinder with the help of cold cure resin and stored in physiological saline at room temperature for 72 h. The teeth were then ready for testing under Instron Universal Testing Machine (Lloyd instruments, LR50K). Samples in both groups were tested for fracture load resistance [Figure 3]. Type of fracture and bond failure site were then recorded by stereomicroscope (Lawrence and Mayo), and the results obtained in Group I and II were statistically compared.

Results

The samples in both the groups were tested for fracture load resistance using universal testing machine in which five variables with respect to fracture load resistance were compared [Table 1].

Comparison of omega and Ribbond post with respect to load at maximum

Omega post demonstrated a mean of 124.6 N as load at maximum, whereas Ribbond post demonstrated maximum load of 75.3 N only. This difference between Group I and Group II is statistically significant [Table 1].

Comparison of omega and Ribbond post with respect to stress at maximum

The difference in omega wire post and Ribbond post with respect to stress at maximum was statistically significant; omega wire group mean was at 4.4 N/mm^2, and Ribbond fiber group has mean of 2.7 N/mm^2 [Table 1].

Comparison of omega and Ribbond post with respect to displacement at maximum

The results of the two groups were compared, and the difference in values was not statistically significant. In this variable, the mean values of the omega wire group were 1.3 mm and that of Ribbond fiber post group was 1.56 mm [Table 1].

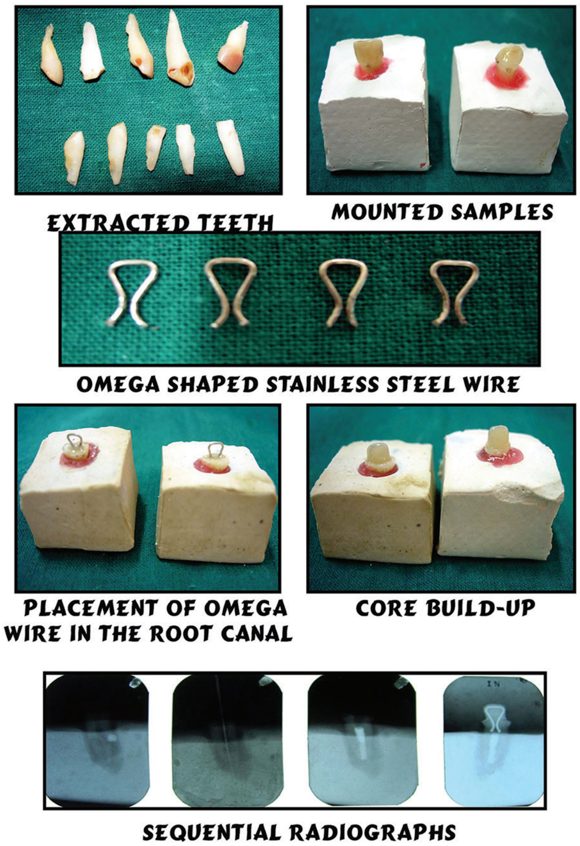

Figure 2: Procedure for Resin short post with omega-shaped wire (Group II).

Table 1: Comparison of Omega post and Ribbond post using Student unpaired *t*-test

Group	*n*	Mean	SD	SE	*t*	*P*
With respect to load at maximum						
Omega post	30	124.6433	40.6977	7.4304	5.1181	0.0001*
Ribbond post	30	75.2940	33.6566	6.1448		
With respect to stress at maximum (mm)						
Omega post	30	4.4598	1.4648	0.2674	4.9386	0.0001*
Ribbond post	30	2.7386	1.2240	0.2235		
With respect to displacement at maximum						
Omega post	30	1.3097	0.4074	0.0744	−0.9870	0.3278
Ribbond post	30	1.5680	1.3742	0.2509		
With respect to percentage of strain						
Omega post	30	8.2527	2.4613	0.4494	−0.9485	0.3468
Ribbond post	30	9.8000	8.5894	1.5682		
With respect to load at yield scores						
Omega post	30	17.2914	11.3860	2.0788	1.8963	0.0629
Ribbond post	30	12.6713	6.9587			

*Significant at 5% level of significance ($P<0.05$). SD: Standard deviation, SE: Standard error

Figure 3: Fracture resistance test using the Instron machine.

Comparison of omega and Ribbond post with respect to percentage of strain

The difference between the results of both the group was not statistically significant in this variable. The mean value of omega wire group was 8.3% and that of the Ribbond fiber post group was 9.8% [Table 1].

Comparison of omega and Ribbond post with respect to load at yield

The results obtained in this variable were slightly higher for the omega wire group at 17.29 N as compared to the Ribbond fiber group at 12.67 N, but the difference in variables was not statistically significant [Table 1].

Stereomicroscopic analysis

Each sample was examined by an investigator using stereomicroscope to determine where the bond failure occurred:

- Type I: Complete fracture and fiber post dislodgment with the composite unit (post along with the core) (Group I)
- Type II: Complete fracture and the post dislodgement with the omega wire embedded in the core part. With the omega wire, retentive ends were straitened (Group II)
- Type III: Cracks and fracture but the fractured segment is intact with the tooth without dislodgment (Group II) [Figure 4].

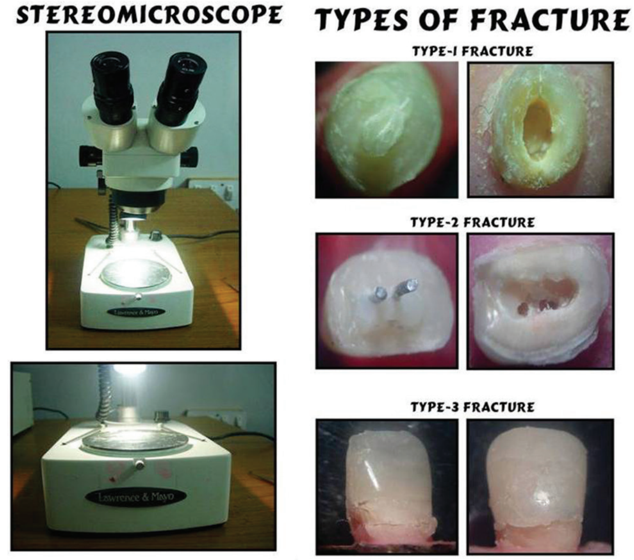

Figure 4: Various types of fractures as seen under the stereomicroscope.

On stereomicroscope observation, there was Type I fracture with 26 samples of Ribbond fiber group. Type II fracture was seen with 4 samples of Ribbond fiber group and 12 samples of omega post group. Type III fracture was seen with 18 samples of omega post group.

While observing these samples under stereomicroscope, we noticed the fracture of tooth with seven samples, in which four were of Ribbond post group and three were of omega post group with the fracture being in an oblique direction. Out of three omega post, Group 1 sample had multiple fractures of the tooth.

Discussion

The goal of available restorative techniques in pediatric dentistry is to restore the masticatory function, phonetics, and esthetics of the patient when destruction of the upper and lower primary anterior teeth has occurred.

When there is severe loss of the coronal tooth structure, the use of post and core placed inside the canal after endodontic treatment will provide retention and stability to the reconstructed crown. Cohen *et al*. stated that post retention was an important factor for a successful restoration where little or no coronal dentin is present.

Sidolic *et al*. stated that:

1. Post material should have the homogenous mechanical and chemical bonding of all components which serve to reinforce the tooth
2. The fiber core content should have a Young's modules of elasticity approximating that of the tooth, hence decreasing stress concentration and therefore increasing longevity of the restoration.[5,9]

Various posts have been proposed for restoration in primary teeth; however, they all come with the set of advantages and disadvantages.

Although resin short post is easy to apply and exhibit an excellent esthetics, there is always an inherent risk of loss of retention owing to polymerization shrinkage.[10,11]

The use of conventional prefabricated metal posts is a fast, low cost, and simple technique but is not accepted in pediatric dentistry because of potential interference with physiological root resorption. The Ni-Cr cast posts are not only expensive and require an additional laboratory stage but also could pose problems during natural tooth exfoliation.[12]

In the year 1970, Wanderley *et al.* used a 0.5–0.7 mm alpha-shaped orthodontic wire, pressed and bonded inside the root canal, and cemented with zinc phosphate which was used to provide reinforcement and retention for the coronal restoration.[6]

In 1995, Wanderley *et al.* described the use of Ni-Cr cast posts with macro-retentive elements of 1.5–3.0 mm post diameter. The round macro-retentive elements in Ni-Cr cast posts offer a better distribution of masticatory loading forces.[6]

Resin short post: The composite resin short post and crown was developed for restoration of severely decayed primary anterior teeth. An inverted mushroom-shaped preparation technique was developed and reported first in the year 1986. Mushroom shape with a full undercut of 3600 around the canal chamber ensures retention of the post and crown.[4,13]

Biological crown and post restoration for primary teeth affected by ECC has shown promising results. The cost of these restorations when compared with conventional methods of using intracanal reinforced composite resin restorations was 6–7 times lesser. Hence, it proved to be a cost-effective alternative making it possible to recycle precious biological tissue which has been discarded as biowaste. However, patient acceptance of a biological restoration is an important issue, and donor selection from siblings could be a more acceptable alternative.[14]

The placement of simple wire posts in primary teeth was described by Refkin. It is a simple yet effective technique to overcome the failures associated with primary anterior teeth restoration.

This study was conducted to test two intracanal posts, i.e., fracture resistance and retention, which was used for restoring badly mutilated primary anterior teeth.

Group I used Ribbond fiber post which is a nonimpregnated polyethylene fiber, and this material had sustained maximum load of 75.29 N and maximum stress of 2.7 N/mm^2. Adhesive failure was seen between the tooth and the post and core which acted as one unit. The dislodgement was complete. In previous studies, the non-preimpregnated fiber post had shown results of maximum load resistance of 71.3 N. Its low resistance to bear load and complete dislodgement of fiber post was because of its reduced extension into the canal (2–3 mm), which was not sufficient to withstand the forces. These results were obtained probably because the material did not stretch with the tooth owing to its high elasticity modulus. This assumption was related to the mechanical properties of the restorative material, and from a mechanical viewpoint, the Young's moduli of the restorative materials played a very important role. This reason has made its use limited in pediatric endodontics.

Group II used omega-shaped orthodontic wire embedded in root canal. In which inverted mushroom shape preparation was done in canal (3600) to engage the omega wire and cured with flowable composite resin. The core too was prepared using the same flowable composite resin while the crown buildup was done with nanocomposite using strip crowns. This group sustained 124.64 N as load at maximum and stress at maximum was 4.4598 N/mm^2, and dislodgement was incomplete in 60% of the samples.

On comparing both the groups, Group II (omega wire) showed high load and stress resistance and even after fracture, fractured segment was intact or remained in contact with the tooth. This was because of the shape of the wire, i.e., omega and inverted mushroom preparation (3600) within the canal which provided improved retention and resistance of the post and core system.

The distribution of the dentinal stress depends on the design of the post and the nature of the material from which the post and core are made. A mushroom-shaped short-post technique gives better results than simple short-post cores. Indeed, a short-post core in conjunction with a mushroom-shaped, full undercut that reaches 360° around the canal chamber helps ensure crown retention. Absence of such undercut risks the restoration for dislodgement.[15,16]

Conclusions

Upon comparing the two materials, the following conclusions were drawn from the study:

- Resin short post with an omega-shaped stainless steel wire (Group II) showed a statistically significant higher resistance and retention than the Ribbond fiber post in Group I
- Stereomicroscopic evaluation revealed that Type I fracture was seen with Ribbond fiber post samples, whereas the omega post and core samples showed Type II and Type III fractures.

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Conflicts of interest

There are no conflicts of interest.

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