Original Article

Comparative evaluation of the compressive strength of two different post systems in primary anterior teeth restored with pediatric zirconia crowns

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ABSTRACT

Background: In cases where there is an extensive loss of crown structure, these treatments require intracanal posts placement for retention as occlusal forces make the tooth structure weak and prone to fracture. Thus, restoration of primary anterior teeth, followed by post placement and cementation with pediatric zirconia crowns helps withstand masticatory forces to a greater extent. **Aim:** This *in vitro* study evaluates the compressive strength of two different post systems in the primary anterior teeth, restored with pediatric zirconia crowns. **Materials and Methods:** The present study was an *in vitro*, experimental, comparative study, with a study sample selected using a convenience sampling method. Forty-five primary anterior teeth were obturated and restored with enhanced omega-shaped loop and reinforced glass-fiber posts were cemented with pediatric zirconia crowns. The compressive strength and the type of fracture were evaluated for each group. **Results:** This study demonstrated that the glass-fiber posts had a higher compressive strength, although omega-shaped posts showed a higher presence of favorable fracture. **Conclusion:** Retentive omega-shaped loops and reinforced glass-fiber posts were both capable of withstanding high fracture loads. The addition of cemented pediatric zirconia crown on decayed primary anterior teeth restored with post systems helped withstand the load to a greater extent.

KEYWORDS: Compressive strength, omega-shaped posts, pediatric zirconia crowns, reinforced glass-fiber posts, retentive post

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Access this article online

Quick response code

Website: www.jisppd.com

DOI: 10.4103/JISPPD.JISPPD_138_20

Introduction

Early childhood caries (ECC) is a predominant cause of tooth as well as tooth structure loss at a very early age. It is a serious public health issue in both the developing and industrialized countries, especially where malnutrition is common in the communities. In extreme cases, ECC can result into a complete loss of the crown/tooth structure. It affects the dentition immediately after the eruption of teeth within the oral cavity. It causes early tooth loss, loss of vertical dimension, tongue thrusting, reduced masticatory efficiency, malocclusion, space loss, speech problems, and psychological problems in a child.[1] According to the American Academy of Pediatric Dentistry, ECC is defined as the presence of one or more decayed teeth, missing (due to caries) or filled tooth surfaces

How to cite this article: Gab G, Rao BD, Panwar S, Narula H. Comparative evaluation of the compressive strength of two different post systems in primary anterior teeth restored with pediatric zirconia crowns. J Indian Soc Pedod Prev Dent 2020;38:253-8.

Submitted: 24-Mar-2020 **Revised:** 02-Sep-2020
Accepted: 09-Sep-2020 **Published:** 29-Sep-2020

in any primary tooth in a child aged 71 months or younger.[2]

Esthetics is perhaps a result of today's societal expectations. However, the demand for esthetic restorations is quite evident. A study by Peretz and Ram[3] described the increasing desire by both parents and children for tooth-colored restorations. The esthetic restoration of severely mutilated anterior primary teeth has long been a standing challenge for the pediatric dentists all over the world. Although the esthetic restorations of primary anterior teeth involved placement of stainless steel crowns and ceremo-based metal crowns initially, they have been replaced with the composite strip crowns, despite their limitations, as they are preferred esthetically.

In recent years, parents prefer full-coverage restorations for the primary dentition of their child despite the cost, as esthetics has become the main concern. Cost-effective prefabricated zirconia crowns have become available for restoring not only function but also form[4,5] for all primary teeth, molars, cuspids, and incisors. 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 ones.[6] The use of zirconia crowns in pediatric clinical practice since 2010 has revolutionized pediatric dentistry. The most obvious advantage of zirconia crowns is their excellent esthetics and durability which is far superior to other pediatric crowns. Many clinical reports have been quoted in the literature describing rehabilitation of severely damaged primary anterior teeth, but none relate to the physical and mechanical properties of these restorations.[6] Zirconia offers many benefits, including far greater flexural strength than that of a natural tooth.[7] It wears at a similar rate to a natural tooth, excellent fracture resistance,[8] full coverage, autoclavability, and a superior esthetics. *In vitro* fracture load studies by Townsend *et al*.[8] showed variances in crown thickness and fracturability between crowns from different manufacturers.

The development of novel materials such as strip crowns, art glass crowns, and zirconia crowns has effectively been used to restore carious teeth with sufficient tooth structure. However, in cases where there is a loss of crown structure, these treatment modalities fail to withstand the occlusal forces. Hence, the use of an intracanal post in endodontically treated teeth improves the retention for a longer duration.[9] A variety of materials can be used for this purpose, such as prefabricated metal posts, resin composite, orthodontic wire posts, omega-shaped stainless steel wire posts, and recently, fiber core posts.[6]

The use of omega loops provides a quick, inexpensive, and efficient option. The technique of placing omega loops is quite simple; it involves the placement of an omega-shaped stainless steel wire extension into the entrance of the root canal before restoring the crown with a compomer material. In recent years, various types of fiber reinforcements have also come into widespread use as an alternative to cast or prefabricated metal posts in the restoration of endodontically treated teeth.[10] The advantages of reinforced fiber to construct an intracanal post over other posts are due to resin composite crown reinforcement, translucency, and relative ease of manipulation.[10,11]

Although over the course of time, various studies have been conducted to evaluate and compare different types of intracanal posts, no such study has been conducted that compares the fracture resistance of different intracanal posts in the anterior teeth, esthetically restored with pediatric zirconia crowns. Therefore, the purpose of this *in vitro* study is to evaluate the compressive strength of two different post systems, placed in the primary anterior teeth restored with pediatric zirconia crowns.

Materials and Methods

After obtaining ethical clearance from the institutional authority, the sample size was calculated through "EJ" Power Software with effect size "f": 1.39, α: 0.05, and the power of the study "β": 95%. Although the minimum sample size was calculated and found to be 36, the number was eventually increased to 45.

Freshly extracted primary anterior teeth were collected, cleaned, and stored in 0.5% chloramine-T solution (Neelkanth Healthcare Private Limited, Boranada, Jodhpur, Rajasthan, India) for 72 h.[12] Selection criteria included primary anterior teeth with at least 1 mm of the crown portion above the cemento-enamel junction (CEJ) and at least 2/3rd of the remaining root length, without any kind of enamel defects, cracks or dental caries, periapical cyst, previously restored teeth, internal or external resorption, or fractured roots.

The collected samples were all sectioned 1 mm coronal to the CEJ with a disc bur. The working length was determined and all the samples were obturated with the zinc oxide eugenol paste (Prevest Eugenol, Deepak Enterprises, Mumbai, Maharashtra, India) after the biomechanical preparation. Glass ionomer cement (GC Fuji) base was applied on the zinc oxide eugenol paste and a 3 mm space was left below the CEJ within the canal for post placement. The samples were randomly divided into three groups of 15 each.

- Group 1: A 1.25 cm, 0.6 mm orthodontic stainless steel wire (KC Smith and Co., Redbrook Road, UK) was bent into a mushroom-shaped preparation and was incorporated into the root canal as omega-shaped post [Figure 1]
- Group 2: A 6 mm reinforced glass fiber post (CBD®, USA) was cemented into the root canal with 3 mm extending beyond the CEJ [Figure 2]

Figure 1: Enhanced omega-shaped post placement in the specimen

Figure 2: Reinforced glass-fiber post placement in the specimen

- Group 3: Flowable composite resin cement (Tetric N-Ceram, Ivoclar Vivadent) was used to fill the post space.

All the posts were cemented using flowable composite resin and the specimens were then restored with pediatric zirconia crowns (Kids-e-dental, Mumbai, India) cemented using luting GIC (GC Fuji) [Figure 3]. The specimens were then mounted on acrylic blocks (DPI-RR Cold Cure, Bombay Burmah Trading Corporation Limited, Mumbai, Maharashtra, India) and were subjected to a load at an angle of 0° at a speed of 0.5 mm/min using Instron Universal Testing Machine (Llyod instruments, LR50K). The compressive strength, in Newton, was calculated as the maximum load at which the tooth fractured.

The fracture mode was assessed using the criteria stated by Seraj *et al*.[12]

- Favorable: Fractures above CEJ which are restorable.
- Unfavorable: Fractures below CEJ which are nonrepairable.

The fracture analysis was done using a stereomicroscope (Lawrence and Mayo).

Data collected were analyzed using the Statistical Package for the Social Science software version 22 for Windows (SPSS Inc., Chicago, IL, USA). Results were expressed as mean with a standard deviation. One-way analysis of variance and Tukey–Kramer multiple comparisons test were used to compare the compressive strength between the groups. For all the tests, *P* value of 0.05 or less was considered to be statistically significant.

Results

In this study, the mean values with standard deviations of compressive strength of enhanced retentive omega-shaped post (Group 1), reinforced glass-fiber post (Group 2), and core buildup (Group 3) restored with pediatric zirconia crowns were calculated and compared.

The mean compressive strength of Group 1, Group 2, and Group 3 was found to be 828.35 N, 846.62 N, and 778.25 N, respectively [Table 1]. Group 2 showed a higher compressive strength in comparison to the other groups, although Group 1 had a higher percentage of favorable fractures amounting to 73%, followed by Group 2, 67%, and Group 3, 53% [Figure 4].

Discussion

In the present study, to obtain clinical conditions of the damaged tooth structure, the tooth was decoronated 1 mm above the CEJ. Thus, the compressive load was borne by the post and core. This similar concept was utilized by many authors.[13-15] According to Pithan *et al*.,[6] the minimum post length should be 2–3 mm to provide more support and retention to the crown. In primary teeth, it should not interfere with root resorption and the physiological eruption of the permanent teeth.[16]

The *in vitro* study of Pithan *et al*.[6] yielded the fracture resistance values between 28 N and 275 N. On a parallel note, permanent tooth studies showed higher compressive strength ranging from 400 N to 935 N. This high value was due to the larger diameter of the permanent teeth.[17]

The crown was prepared for all the samples. This was performed considering that most of the post and core restorations are clinically followed by full-crown restorations. Owing to the benefits of zirconia crowns, in the current study, pediatric zirconia crowns were used as full-coverage restorations as it has proved to be a promising alternative to metals in dentistry along with its greater esthetic properties.

Figure 3: Obturated tooth cemented with a pediatric zirconia crown

Table 1: Mean compressive strength of all groups in Newton (N)

Compressive strength	Mean	SD	*P*
Group 1	828.35	12.09	<0.0001
Group 2	846.62	11.60	
Group 3	778.25	12.47	

The mean compressive strength of the three groups was calculated using the Instron universal testing machine. SD=Standard deviation

In an *in vitro* study by Vorse *et al*.,[13] endodontically treated carious deciduous incisors, restored with a short post of composite resin (flowable) in which an omega-shaped wire was embedded and crown buildup using strip crowns was done, sustained 124.64 N as the load at maximum and stress at the maximum was found to be 4.4598 N/mm^2. Furthermore, dislodgement was incomplete in 60% of the samples. In another *in vitro* study by Nilavarasan *et al*.,[18] primary anterior teeth, where omega loops were used as intracanal post, followed by crown buildup showed compressive strength values ranging between 28 N and 144 N.

In the current study, primary anterior teeth restored with reinforced glass-fiber post, followed by pediatric zirconia crowns showed maximum compressive strength, whereas the control group with core buildup using composite resin showed the lowest compressive strength. This difference may be due to high tensile strength and similar modulus of elasticity to dentin, in reinforced glass-fiber posts. The mean compressive strengths of the current study were higher than the study conducted by Sharaf,[19] where the glass-fiber post showed a significant difference in compressive strength compared to the composite post. This difference may be due to the difference in the type of posts, cement used, and the type of composite resin. Similarly, the present study showed better compressive strengths, as all the specimens were finally restored with pediatric zirconia crowns.

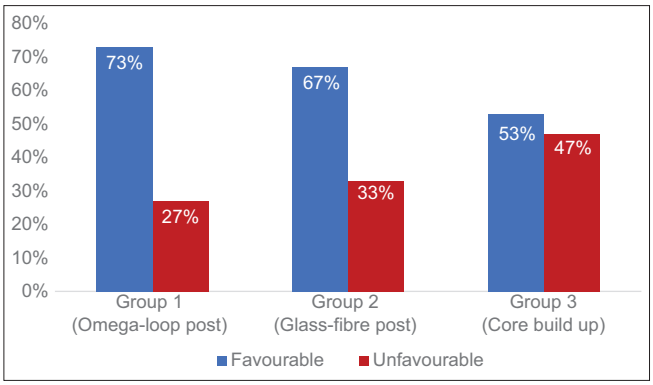

Figure 4: Graphical representation of the type of fracture

In this current study, the frequencies of nonrestorable fracture modes were 27% in the omega-shaped post group, 33% in reinforced glass-fiber post group, and 47% in the control group. It indicated that the use of posts in primary dentition reduced catastrophic fractures, which is consistent with the results of the study carried out by Sherfudhin *et al*.[20] and Pithan *et al*.[6] that showed that the fracture was 80% for glass fiber posts and 47% for composite posts, whereas these values in the study of Gujjar and Indushekar[21] were 100% and 20%, respectively. They attributed that the bond failure between the cement and root canal resulted in tooth fracture. It should be kept in mind that the mentioned studies used resin composite cement for post placement, but in this study, flowable composite resin cement was used to cement posts. The benefits of this cement are its high bond strength, reduced chairside time, increased working time, high degree of conversion, and good mechanical properties.[22-25]

There exists a connection between the fracture of a root and the inserted post material. The post material should possess a similar modulus of elasticity as the root dentin. This aids in distributing the applied forces evenly along the length of the post as well as the root. Studies have shown that when a system with components of different rigidity is loaded, the more rigid component is capable of resisting forces without distortion, whereas the less rigid component fails and relieves stresses.[26] Post with the modulus of elasticity significantly greater than that of dentin might create stresses at the tooth/cement/post interface, with the possibility of post separation and failure. The modulus of elasticity of dentin of the primary anterior tooth is approximately 19–25 GPa.[27] The reinforced glass-fiber posts have a modulus similar to that of primary dentin. The post flexion may mimic the tooth flexion because of this similarity in elasticity. The glass-fiber post absorbs and distributes the stresses and thus, shows reduced stress transmission to the root.[28] The longitudinal arrangement of fibers in the glass-fiber post and the modulus of elasticity of the post, that is less than or equal to that of dentin, can redistribute the stress into the tooth and also away

from the chamfered shoulder, so as to increase the likelihood of failure of the post core/root interface instead of root fractures.[29]

The modulus of elasticity of zirconia is 205 GPa, which is approximately 10 times that of dentin. Pediatric zirconia crowns are more rigid and withstand more stress which provides more strength to the primary teeth.

The other factors that affect the fracture resistance of endodontically treated teeth are post diameter, length, design, and adaptability; amount of remaining dentin, cement, and method of cementation; core material and design; crown design; and biocompatibility of post material.[30]

The results from this study should be interpreted with caution, as teeth were mounted for load testing in materials showing limited resiliency. This takes the viable periodontal ligament and resilient alveolar bone out of the equation, which are crucial parameters in load bearing.[30] Compressive strength was studied on a universal testing machine, which does not take into account the torsional, oblique, and lateral shearing forces produced during mastication. Another factor is the multidirectional characteristics of the masticatory forces, which cannot be duplicated where a single unidirectional load is applied in such machines.[30] It is clear that this type of *in vitro* loading does not represent the complete situation *in vivo*. However, it was focused on the basis of tests previously reported in the literature involving different post and core systems.

Conclusion

From the observation of the present study, the following conclusions can be made:

1. Retentive omega-shaped loops and reinforced glass-fiber posts were both capable of withstanding high fracture loads
2. The addition of cemented pediatric zirconia crown on decayed primary anterior teeth restored with post systems helped withstand the load to a greater extent
3. Reinforced glass-fiber posts withstood a higher compressive strength in comparison to the retentive omega-shaped loop posts
4. Reinforced glass-fiber posts and enhanced omega-shaped posts both showed a greater degree of favorable fracture at the bond failure site
5. Considering the results of the study, it can be concluded that glass-fiber posts were better in performance and also withstood a greater fracture load when restored with pediatric zirconia crowns in comparison to omega-shaped loops. However, further studies are required to evaluate other physical properties of the two post systems restored with pediatric zirconia crowns.

Acknowledgments

The authors wish to express their appreciation to the management of Pacific Dental College and Hospital, Udaipur, Rajasthan, India, for providing the infrastructure to conduct the study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Why this paper is important to pediatric dentists?

- It compares the compressive strength of two posts frequently used in the primary anterior teeth restored with pediatric zirconia crowns
- It compares their strength with the presence of zirconia crowns
- No such study has been conducted to evaluate the post systems with pediatric zirconia crowns.

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