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Comparative evaluation of bonding between composite relined fibre post and Conventional fibre post: an *in-vitro* study

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Abstract

Background: Fiber posts are widely used aesthetic material in restorative dentistry. These materials were introduced to overcome the inherent shortcomings of cast posts.

Aim: This study aimed to evaluate and compare the pull-out bond strength of fibre posts with relining and without relining.

Materials and methods: Twenty maxillary canines were extracted and underwent endodontic treatment, involving the removal of their crown portion. Post-space preparation was performed, and the appropriate post size was selected. In Group 1, ten samples were coated with a layer of composite, reinserted into the post space of the canal, and then light cured outside the canal. The other ten samples (Group 2) were without relining. The fibre posts from both groups were cemented with RMGIC. The samples were mounted in tensile fixtures of the universal testing machine and subjected to a tensile load until the posts were debonded. The debonded samples were analysed using a stereo microscope for bond failure analysis. The obtained results were subjected to statistical analysis.

Results: The mean pull-out force in group 1 and group 2 was 72.2100±8.56420 and 61.3700±11.00611, respectively. One way ANOVA analysis showed a significant difference in the pull-out force among the groups (P=0.043). In Group 1, 30% of the samples reported adhesive-2 failures and 70% adhesive-1&2 failures. But in Group 2, all samples were reported with adhesive-3 failures. Fisher's Exact test displayed a significant difference in the type of bond failure between the groups (P=0.003).

Conclusions: This study concluded that the coating of the fibre posts improves their tensile strength.

Keywords: Relined fiber post, Bond failures, Tensile bond strength.

1. Introduction

For decades, endodontically treated teeth have been restored using cast metal posts, owing to the presence of high elastic modulus (220-230MPa). Stresses in the metal posts are concentrated at the apical third of the root resulting in a wedging effect, which can lead to root fracture. Glass fiber posts were introduced in restorative dentistry as an alternative to cast metal posts, as they have good aesthetic results and better stress distribution around the dentin /resin and cement /post interface due to the similar elastic modulus of glass fiber post and dentin [1].

Cast metal posts have a high success rate as reported by several in vitro and clinical investigations. Another option to restore endodontically treated teeth is fiber posts. Glass fibre posts have a similar elastic modulus to that of dentin (MOE of dentin: 18Gpa, MOE of resin cement: 16GPa, MOE of fiber post: 25GPa), Similar elastic modulus is considered as an advantage for improving the performance of restorations. The post presents an elastic modulus of about 25GPa, flexure strength of 920 MPa, resistance to compression of 340 MPa, better distribution of external forces along the teeth, and better aesthetics than another fiber post [2].

The prognosis of endodontically treated teeth depends on many factors, including teeth position in the arch, presence of adjacent teeth, occlusal contacts and thickness of the remaining coronal dentin. In some cases, when significant loss of coronal tooth structure is observed, the restoration of endodontically treated teeth often requires intracanal retainers, which require an intracanal impression for fabricating the cast metal posts.

Recently, prefabricated posts have been widely used, as they are simple and less time-consuming procedures and also require fewer visits to the dentist. In addition, these posts render appropriate aesthetics and uniform stress

distribution along the root that decreases the risk of fracture [3].

The concept of Monoblock aims to make homogeneous units between the posts, cements and radicular dentin, to function as a single unit in the root. To aid in achieving the monoblock effect, adhesive cements are recommended for use in the cementation of fibre posts. Mostly, in the case of elliptical-shaped canals, coronal 1/3rd has space between the post and dentin interface that leads to a thick cement layer. Achieving the Monoblock effect is recommended to avoid voids at the interface and reduce the thickness of the cement layer. If the thickness of the cement layer increases sliding friction will be reduced. Furthermore, owing to a large portion of the stress, which is reabsorbed by the adhesive cement, root fracture and stress transfer to the dentin are prevented [5,6].

Occasionally, Post-retained crowns may present mechanical or biological failures, commonly due to loss of retention. The tensile bond strength of root canal posts should be adequate to prevent displacements of crowns during function. The chief function of posts is to aid in crown retention, especially when 50% or more of the remaining coronal structure has been lost [7]. A simple solution for this issue is post relining with composite and converting the conventional fiber post to an anatomical or chair-side custom post, which enhances the adaptation of relined posts to the root canal walls and reduces the thickness of resin cement [8]. So, this study aimed to investigate the tensile strength of fiber posts with relining and without relining and also to determine the types of bond failures.

2. Materials and methods

The current in vitro study was carried out in the Department of Prosthodontics Crown and Bridge, Navodaya Dental College, Raichur, Karnataka. The study evaluated and compared the tensile strength between relined and conventional fibre posts and mode of failures.

2.1. Preparation of the teeth

A total of twenty teeth were subjected to decoronation and subsequent endodontic treatment. The crowns were removed, and the root length was standardized to 15 mm, with a working length of 14 mm. The chemo-mechanical root canal preparation followed a crown-down manual technique. An apical stop was created using a flexofile instrument up to size 40. The middle and cervical thirds were prepared using Gates Glidden drills #2 and #3. Throughout the biomechanical preparation, irrigation was performed using 1% sodium hypochlorite (NaOCl). For final irrigation, 10 mL of 17% ethylenediaminetetraacetic acid (EDTA) was employed. The canals were then irrigated with 10 mL of distilled water, followed by aspiration and drying using absorbent paper points. After applying glycerine in the prepared post space, a total of 10 samples (n=10) were coated with a layer of Fusion Universal composite (UK). This composite was applied to the fiber post (Endoking, Delhi), and it was left uncured. The post was then placed into the prepared post space in the tooth's canal and light cured externally. Prior to cementing the fiber posts, radiographic confirmation was obtained (Figure 1). The remaining ten specimens (n=10) did not receive a composite lining. Subsequently, each layer was applied, and the post was reinserted into the post space, removed, and light cured externally. This process was repeated until a snug fit of the post was achieved. Once the tug fit was ensured, both groups were cemented using RMGIC (Fuji Plus, Japan).

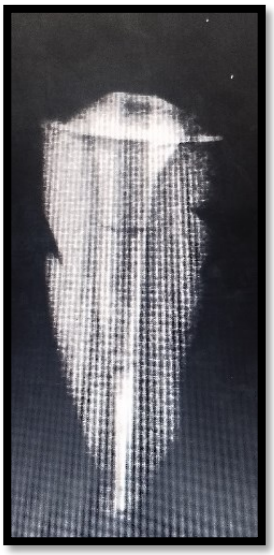

Fig 1: post cementation radiograph

2.2 Preparation of acrylic mould

A cubical elastomeric mould was prepared with a dimension of 4x4 cm. The prepared tooth samples were held firmly in an acrylic resin (Dental Products of India, India) using elastomeric moulds in a vertical position with the help of a surveyor in order to minimize the incidence of non-axial forces. The teeth were stored in a 0.1% thymol solution at 9^0C and were washed with tap water after 24 hours for neutralization.

2.3 Evaluation of pull-out bonding

The coronal portion of the fiber posts was prepared with composite resin to create an area for securing the post firmly with a 3/8 shaft connected to the universal testing machine (UTM) (Instron, UK). The samples were stored in distilled water at 37˚C for 72 hrs and were fixed in the tensile grips of the UTM. The tensile load is applied at a crosshead speed of 1.0 mm/min until the dislodgement of the post. The debonded load was recorded in newtons (N).

2.4 Bond failure analysis

The debonded samples were observed under a stereomicroscope (CARL ZEISS 1000-stemi 508) for bond failure analysis, and the various types of bond failures were observed at a 30X magnification and classified as follows (Figure 2) cohesive and adhesive failures. If the bond failure occurs in between, unlike molecules it is known as an adhesive bond failure. The bond failure within the like substances was considered a cohesive bond failure, and the bond failure in a combination of adhesive and cohesive was considered a combination bond failure. Adhesive failures were subdivided as type - 1 bond failure between post and composite interface; type - 2 bond failure between composite and cement; type - 3 bond failure between post-cement interface; type - 4 bond failure between dentin-cement interface [7].

2.5 Statistical analysis

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 21.0 from the United States. One-way analysis of variance (ANOVA) was performed to assess the significance of tensile bond among the groups. Additionally, Fisher's Exact tests were utilized to analyze the significance of bond failure.

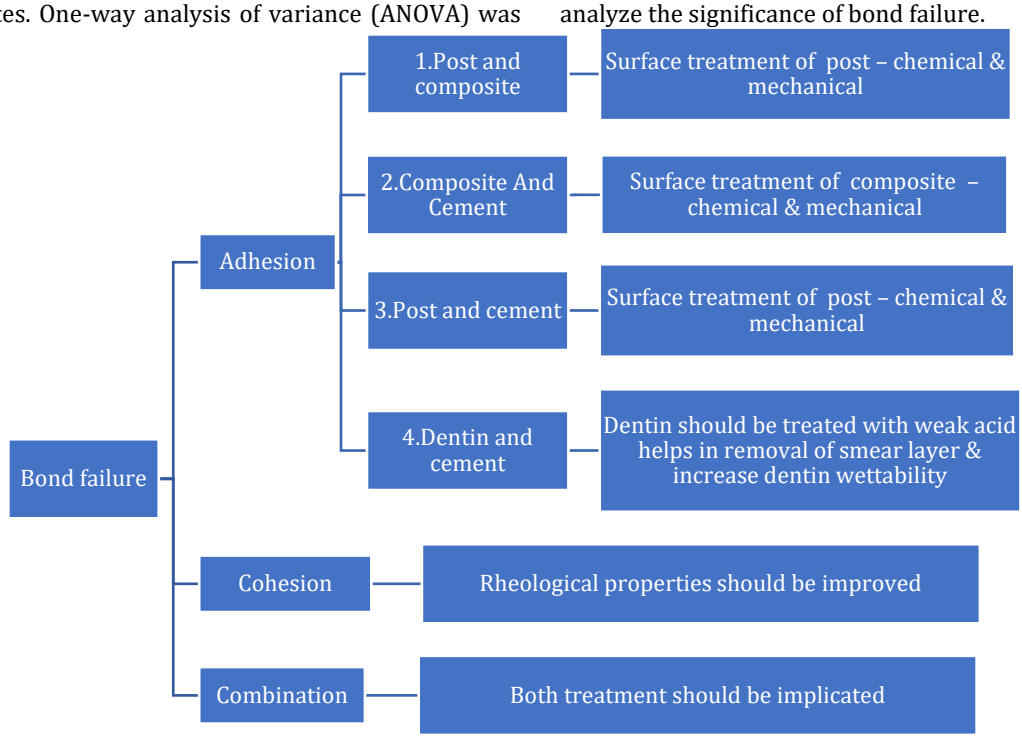

Figure 2. Bond failures and management

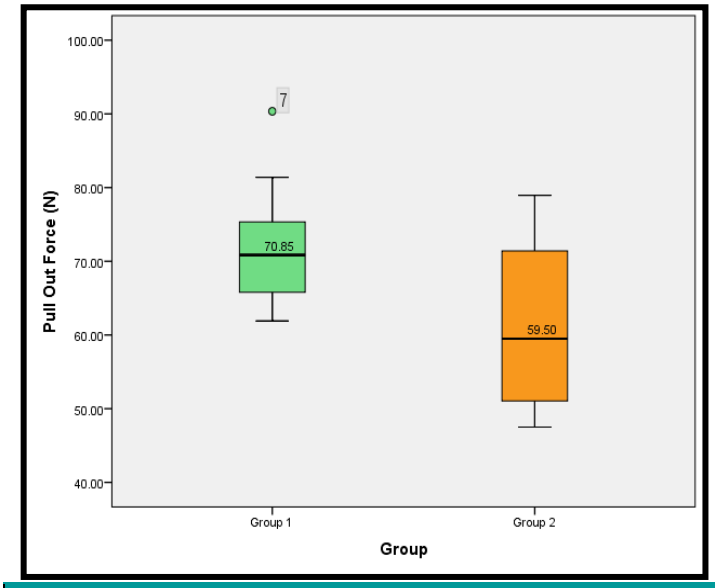

Figure 3. Pull-out forces between the groups

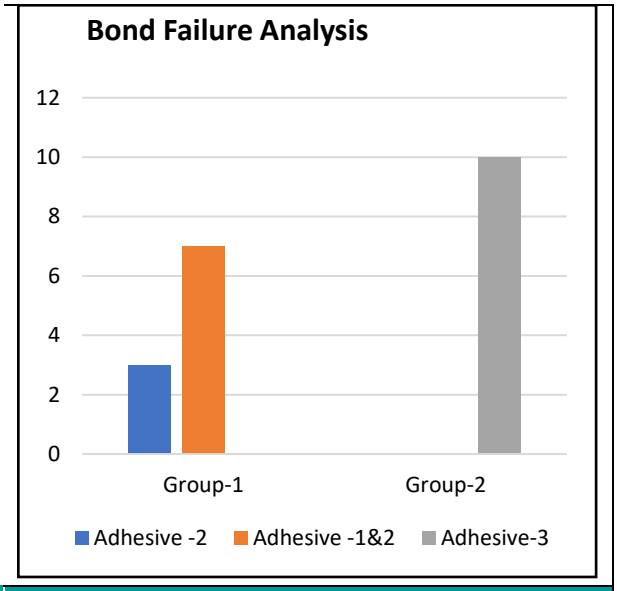

Figure 4. Microscopic evaluation of bond failure in between the groups

3. Results

Table 1 and Figure 3 show the comparison of pull-out force (N) between the groups. The mean pull-out force in group 1 and group 2 was 72.2100±8.56420 and 61.3700±11.00611, respectively. One-way analysis showed a significant difference in the pull-out force among the groups (P=0.043).

Table 2 and Figure 4 show the microscopic evaluation of bond failure in both groups. In Group 1, 30% of the samples reported adhesive-2 failures. and 70% adhesive-1 & 2 failures. But in Group 2, all samples were reported with adhesive-3 failures. Fisher's Exact test exhibited a significant difference in the type of bond failure between the groups (P=0.003).

4. Discussion

In the present study, relining improved fiber post retention and bond failures are different between relined and without relined fiber posts. Thus, the null hypothesis is rejected. Reducing the thickness of the resin cement layer is the primary objective of fibre post-relining. The probability of

cohesive failures may be decreased by relining. Sliding friction appears to be the primary cause of the retention of the fibre posts [1]. The presence of blisters could potentially reduce the contact between resin cements and the walls of the root canal. Considering that sliding friction occurs through contact, it is reasonable to assume that improving fiber post-retention involves eliminating the blisters formed between the resin cement and root dentin, thus facilitating sliding friction.

The mismatch between fiber post and post space diameter post remains a clinical challenge. Although the use of size-matched drills supplied by post manufacturers permits satisfactory fit between post and canal walls, certain canals have an elliptical shape in cross-section while posts have a circular shape. Flared canals caused by various forms of extension, trauma, pulpal pathosis, and iatrogenic error also make it difficult for fibre posts to adapt to canal walls. The resin cement layer would be extremely thick, if the post does not fit well, especially at the coronal level, and air bubbles are likely to form in it, which predisposes to de-bonding [9-12].

According to a recent study, friction rather than actual attachment to the root canal appears to be the primary cause of the resistance to displacement of fibre posts. Therefore, RMGIC may be used for fiber post-luting since their hygroscopic expansion increases the frictional resistance to post-displacement [13].

By increasing the pressure during cementation, fibre post-relining can reduce blister formation. The relined fibre posts made closer contact with the root canal walls compared to non-relined ones. A well-fitted post exerts more pressure on the resin cement and propagated to the cement-post-dentin interface. Pressure application reduces water sorption and blister development, which improves the bond between the dentin and cement/post set. In comparison, when the fibre post is not relined, this results in stronger sliding frictional retention and, as a result, higher bond strength. Based on these findings, it appears that relining improves cement-adhesive contact to maximise fibre post-retention rather than by lowering the flaws shown in the thin resin cement layers [14].

Compared to other prefabricated intracanal posts, fibre posts have several advantages, including an elastic modulus similar to dentin, lower stress, better aesthetics, lower cost, no corrosion effects, preservation of tooth structure, and ease of removal using rotating tools. The post's diameter and shape, the cementing agent, and the preparation of the dentin and post surface are the factors, which may have an impact on these posts' retention [2]. The failure mode was established by analysis under a light microscope at a 30X magnification and classified as given Figure 2 [7].

Theoretically, without increasing the risk of fracture, these posts could reinforce the weakened roots. The frictional retention provided by the hygroscopic expansion that occurs after cement maturation and helps the self-sealing at the dentin-cement interface may be the reason for the retention of posts looted with RMGIC [8].
In this study both the groups showed adhesive failure whereas relined fiber post showed 70% of Adhesive 1&2 failures (combination adhesive type 1 + type 2; post and composite interface + composite and Cement interface) and 30% of Adhesive-2 failure (composite and Cement interface) whereas non relined post showed 100% of Adhesive-3 failure (post and cement interface). Fiber post with relining has performed better than without relining, so relining of fiber post is recommended. Within the limitation of the present study, surface treatment is needed to enhance bond failure. Hence further studies are recommended after surface treatment of relined fiber posts.

5. Conclusion

Within the limitations of the present study, the following conclusions can be drawn.

- Group 1 (fibre posts with relining) showed better tensile strength than Group 2 (fibre posts without relining). Therefore, the fiber post-relining could effectively improve the retention of fibre posts to the root canals.
- Group 1 showed adhesive failure (Type 1&2: 70% & Type 2: 30%), and Group 2 showed adhesive failure (Type 3: 100%), hence, to reduce the bond failures, surface treatment (chemical/ mechanical) of fiber post is recommended.

Conflicts of interest: Authors declared no conflicts of interest.

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