International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Dentin Pretreatment using Doxycycline Hydrochloride for Improving Push Out Bond Strength

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Abstract: ***Aim: The aim of this study was to assess and compare the effect of Doxycycline hydrochloride pretreatment of root dentin on pushout bond strength (POBS) of fiber post luted using self-adhesive resin cement. The effect of DXC at 0.2% on the mean Push out Bond Strength of the adhesive-dentin interface was evaluated. Data was analysed by applying independent student "t" test with a level of significance set at P<0.001. Dentin pretreatment with Doxycycline hydrochloride has shown a statistically significant increase in the push out bond strength.***

Keywords: Dentin pretreatment, Doxycycline hydrochloride, Push out bond strength, Self-adhesive resin

1. Introduction

Cases where endodontically treated teeth have insufficient remaining coronal tooth structure, fiber posts are commonly used to provide additional retention and support for restorations like crowns (Schwartz, 2004). These posts are typically bonded to the tooth using dual-cure resin cements, which have the advantage of curing both chemically and through light exposure. An example of such a cement is Calibra Universal Self-Adhesive Resin Cement, which is designed to bond the fiber post to the root canal dentin while offering fluoride release, which can help in preventing secondary caries and improving the longevity of the restoration (Attar, 2003).

However, post failure may occur due to several factors, including the hydrolytic degradation of the resin in the cement, collagen breakdown triggered by matrix metalloproteinases (MMPs) released from dentin, and the use of intracanal irrigants like sodium hypochlorite. Furthermore, acidic monomers in resin cements can activate dentin MMPs (Liu, 2011).

To enhance bonding, pretreatment of the dentinal surface with natural crosslinking agents such as proanthocyanidin and riboflavin phosphate is recommended (Castellan, 2010). Doxycycline hydrochloride, a semi-synthetic tetracycline antibiotic, also acts as a non-competitive inhibitor of MMPs and a crosslinking agent (Mazzoni, 2007). Therefore, using crosslinking agents can improve bond strength.

The study aimed to assess and compare the effect of doxycycline hydrochloride pretreatment of root dentin on the push-out bond strength (POBS) of fiber posts cemented with self-adhesive resin cement.

2. Materials and Methods

30 single rooted premolars extracted for orthodontic reasons were collected (Figure 1) and stored in 0.5% chloramine solution. The extracted teeth were decoronated at the level of CEJ (Figure 2). The root canals were prepared with Protaper rotary files (up to F3 size using 3% Na0Cl, 17% EDTA followed by final irrigation with distilled water.

Figure 1: Single rooted premolars

Figure 2: Decoronated samples

The samples were divided randomly into two groups according to the pretreatment of radicular dentin. Group 1 was the no pretreatment group that is - Postspace debris was cleared with distilled water, in Group 2 Postspace debris was cleared with distilled water which was followed by pretreatment of radicular dentin with 1mL of 100mg/mL of doxycycline hydrochloride solution for 1 min.

Following dentin pretreatment, post space was dried using absorbent paper points, after which the Fiber post was luted using self adhesive resin cement and light cured for 40s and stored in distilled water for 24 hours (Figure 3).

Figure 3: Fiber post

For testing the push out bond strength (POBS), the samples were stored in resin blocks and sectioned transversely into multiple sections. One section from each sample was stored in distilled water for 24 hours after which POBS was determined using a universal testing machine by applying force at the cross head speed of 1mm/min using plunger of 1mm diameter in apico coronal direction (Figure 4).

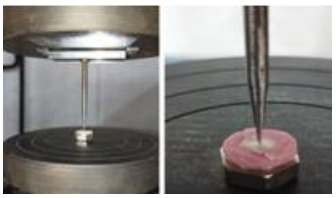

Figure 4: POBS testing

Statistical analysis

The comparison of POBS (MPa) among the groups was done by applying independent student "t" test with the level of significance set at $P < 0.001$.

3. Results

Independent Student t test results demonstrates that the mean Push out Bond Strength among Doxycycline hydrochloride samples showed significantly higher values (9.645 ± 0.127) as compared to Distilled Water group (9.228 ± 0.281) with a statistically significant mean difference of 0.417 (95% CI, 0.612 to 0.293)

Table 1: Comparison of mean Push out Bond Strength (in Mpa) between 2 groups using Independent Student t Test

Group	N	Mean	SD	Mean Diff	95% CI of the diff.		t	p- Value
					Lower	Upper		
Distilled Water	15	9.228	0.281	-0.417	-0.612	-0.293	-5.812	<0.001
Doxycycline Hydrochloride	15	9.645	0.127					

4. Discussion

The structural integrity of teeth can be severely compromised by caries, trauma, or large previous restorations, often leading to the loss of significant coronal tooth structure. In cases where there is horizontal loss of the clinical crown, the remaining tooth structure may be insufficient to retain a final restoration without additional support. A fiber post and core build-up, luted with resin cement after endodontic treatment, can provide essential reinforcement, especially when only a minimal ferrule effect is achievable. The fiber post, which distributes stress along the tooth, aids in retaining the restoration and improving fracture resistance in compromised teeth (Lamichhane, 2014).

Several factors influence the retention of fiber posts, including post shape (conical or cylindrical), dimensions (length and diameter), intracanal preparation, surface texture (serrated, smooth, or screw), and the clinician's skill. The type of cement also plays a crucial role in determining post retention (Thanikachalam, 2023). Resin cements, especially those containing phosphoric acid methacrylates, promote strong physical interactions. With the aid of adhesive monomers, these cements can form robust and long-lasting bonds with the tooth structure (Mann, 2023).

However, the durability of the bond at the resin-dentin interface has been questioned due to the steep decline in interfacial adhesion over time. One major cause is the incomplete impregnation of resin into the collagen matrix, particularly when strong acidic agents such as phosphoric acid are used during dentin surface preparation. These acids may leave a zone of unprotected collagen, which is prone to degradation. The resultant exposed collagen fibrils are vulnerable to hydrolytic deterioration, leading to a weakening of the resin-dentin bond (Aljifan, 2023). This weakened bond may also be susceptible to nanoleakage, a phenomenon where oral fluids infiltrate the hybrid layer (HL), further compromising the adhesion over time. The heat generated during the polymerization of the adhesive resin may contribute to a "water-treeing" effect, where convective fluid movement from the dentin causes further breakdown along the bonding interface (Bedran-Russo, 2008).

Moreover, the proteolytic degradation of collagen fibrils by matrix metalloproteinases (MMPs) and other host-derived enzymes has been identified as another major factor contributing to bond failure. These enzymes, including those released by leukocytes, salivary glands, and plaque bacteria, break down the collagen matrix, compromising the bond's integrity. Additionally, endogenous dentinal proteinases, activated by the acidic nature of adhesive systems, can accelerate the breakdown of collagen fibrils within the hybrid layer (Castellan, 2010)

Given the degradation patterns observed in the hybrid layer—such as the loss of resin from interfibrillar spaces and the disorganization of collagen fibrils—preventing this breakdown has become an area of active research. Crosslinking agents have been proposed as a solution to reinforce the collagen network and improve the durability of resin-dentin bonds. These agents work by forming intra- and inter-molecular crosslinks within the collagen structure, which stabilizes the collagen matrix, enhances its biomechanical properties, and inhibits MMP activity (Mazzoni, 2007). Polyphenols such as proanthocyanidin, riboflavin, and quercetin are examples of natural crosslinkers that interact with the collagen matrix, forming hydrogen bonds between protein amide groups and phenolic hydroxyl groups (Liu, 2013).

Another promising crosslinking agent is doxycycline hydrochloride, a readily available semi-synthetic tetracycline. It exhibits both antimicrobial properties and potent MMP inhibition. Doxycycline inhibits MMPs by denaturing proteins or chelating calcium and zinc ions essential to MMP function. Additionally, it can block the activation of pro-MMPs, making it a particularly effective inhibitor of MMP-mediated collagen degradation (Bedran-Russo, 2014).

In this study, doxycycline hydrochloride was used as a dentin pretreatment agent to evaluate its effect on the push-out bond strength (POBS) of resin-dentin interfaces. The results showed a significant improvement in POBS when dentin was pretreated with doxycycline hydrochloride. The mean bond strength in the doxycycline group was significantly higher (9.645 ± 0.127 MPa) compared to the control group treated with distilled water (9.228 ± 0.281 MPa), with a statistically significant difference of 0.417 MPa (95% CI, 0.612 to 0.293) (Aljifan, 2023) These findings suggest that doxycycline pretreatment can enhance the long-term stability of resin-dentin bonds by inhibiting collagen degradation and increasing resistance to hydrolytic breakdown.

5. Conclusions

The use of fiber posts, resin cements, and crosslinking agents has revolutionized the restoration of endodontically treated teeth with significant structural loss. However, long-term adhesion is often compromised due to collagen degradation and hydrolytic processes. The use of crosslinking agents, particularly doxycycline hydrochloride, offers a promising approach to enhance bond strength and prevent degradation, ensuring the longevity of restorative treatments. Further research should focus on optimizing these pretreatment strategies to achieve even more durable outcomes in clinical practice.

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