ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 3, Issue – 3, June - 2020, Page No. : 376 - 384

Evaluation of Different Irrigants on the Bond Strength of Fiber Posts To Dentine

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Citation of this Article: Dr Dasari Vineela, Dr Ananthakrishna S , Dr Veenakumari R , Dr Pradeep Pr, Dr Sakasham Narainia, "Evaluation of Different Irrigants on the Bond Strength of Fiber Posts To Dentine ", IJDSIR- June - 2020, Vol. – 3, Issue -3, P. No. 376 -384.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background And Objectives: The aim of this in vitro study was to compare the effect of following irrigating solutions i.e.,3% Sodium hypochlorite (NaOCl), 17% Ethylenediamine tetra acetic acid (EDTA) + 3% Sodium hypochlorite (NaOCl), 7% Maleic Acid + 3% Sodium hypochlorite (NaOCl), 10% Boric Acid as a Post space irrigating solutions on the bond strength of fiber post to root dentine using Universal Testing Machine and to evaluate the failure modes of fiber posts under stereomicroscope.

Methods: Sixty, single rooted mandibular premolars were endodontically treated and post spaces were prepared. The specimens were randomly assigned to four groups based on the irrigating solution: Group 1-3% sodium hypochlorite (NaOCl); Group 2-17% Ethylene diamine tetra acetic acid (EDTA) followed by 3% NaOCl; Group 3- 7% Maleic acid followed by 3% NaOCl; and Group 4- 10% Boric acid. Self-adhesive resin cement was used to lute the fiber posts and to test the adhesion of a glass-fiber post to the root dentine through a push-out test using universal testing machine. The failure modes of fiber posts were assessed using stereomicroscopy.

Results: Maleic acid exhibited the highest mean push out bond strength values(17.13MPa) in the apical third of the root canal compared to all the groups. Maleic acid has showed statistically significant results among all groups.

Most common failures were seen as adhesive type of failures between the resin cement and dentin.

Interpretation And Conclusion: As a post space irrigant, Maleic acid is an effective irrigant in increasing the bond strength of fiber post to root dentin of the root canal.

Keywords: Push-out bond strength, Maleic acid, Boric acid, EDTA, NaOCl, Stereomicroscope.

Introduction

Root canal treatment is a common dental procedure, the success of which depends on chemico-mechanical debridement of the root canal system through the use of instruments and effective irrigating solutions followed by three dimensional obturation.[1]

Endodontically treated teeth are structurally different from non-restored vital teeth, and they require specialized restorative treatment. The loss of dentin, including anatomic structures such as cusps and the arched roof of the pulp chamber, can result in tooth tissue fracture after the final restoration. In such cases, the use of intra-radicular posts is recommended to promote the retention of the final restoration.[2]

Glass fiber reinforced resin post systems were introduced in 1992. These posts are composed of unidirectional glass fibers embedded in a resin matrix. Matrix polymers are commonly epoxy polymers with a high degree of monomer conversion and a highly crosslinked structure. Fiber-reinforced posts are reported to reduce the risk of tooth fractures and display higher survival rates than teeth restored with rigid zirconia posts.[3]

Fiber posts frequently fail because of debonding. When fiber posts are attached with a resin cement, two interfaces are formed i.e., the dentin – resin cement and the resin cement and the fiber post. The weak point is the dentin-resin cement at either side of the interface. This interface could be affected by factors such as dentin conditions, orientation of dentinal tubules, irrigation solutions, depth of the intra radicular area, type of adhesive system, and endodontic sealer.

The recent introduction of self-adhesive resin based cements has allowed clinicians to lute fiber posts using a simple and standardized approach that reduces technique sensitivity, despite limited access to the endodontic space. Although several studies have indicated that the bond strength values of self-adhesive cements are comparable to, or even higher than, those of conventional luting strategies, their limited etching capability in the presence of compact smear layer created with in the endodontic space is a matter of concern.[4]

Chemical irrigants, such as solutions of sodium hypochlorite (NaOCl), or EDTA in combination with NaOCl, have been used in previous studies to clean the post space. [5]

Maleic acid is a mild organic acid used as an acid conditioner in adhesive dentistry. It has been found to possess the smear layer removing quality when used as an acid etchant in restorative dentistry.[6] Because of its strong physicochemical action on both organic and inorganic particles, MA has been suggested as a potential irrigating solution.[7]

Boric acid, or orthoboric acid (H_3BO_3), is a weak acid of the non-metallic element boron. Boric acid has bacteriostatic and mild antiseptic effects on many bacteria. With its proven biocompatibility with tissue and strong antibacterial effect against many forms of bacteria, boric acid solutions represent an ideal irrigating solution. As a new product for root canal disinfection, a concentration of 6% boric acid was found to be significantly effective against E.faecalis biofilms, exhibiting the same anti-bacterial effect as NaOCl.[8]

Hence, the aim of this study is to compare the effect of 3% Sodium hypochlorite (NaOCl), 17% Ethylenediamine tetra acitic acid (EDTA) + 3% Sodium hypochlorite (NaOCl), 7% Maleic acid +3% Sodium hypochlorite (NaOCl) and 10% Boric acid on the bond strength of fiber post to root dentin.

Materials and Methods

Sixty single rooted mandibular premolar teeth that are caries free were collected. Teeth were cleaned and stored in 0.9% saline. OSHA and CDC guidelines were followed

The study samples were decoronated apical to the cemento-enamel junction with a diamond disc under water coolant.

The samples were mounted in impression wax to stabilize and to ensure standardization in procedure.

The canal patency was determined by passing a no. 10 size K- file in narrow canals and 15 K – file in medium sized root canals until the tip of the file was visible at the apical foramen. Working lengths were established by subtracting 1mm from the measurement obtained when a size 15 file was placed into the canal until its tip was visible at the apex.

The working length of the samples were 14mm - 15 mm. Initial negotiation of root canal space was performed using a size 15 manual K-file used in a watch-winding motion to assure the presence of a glide path. 2ml of NaOCl (3%) was used as an irrigant intermittently during instrumentation of all canals.

All the samples were prepared up to size 40 (F4) with ProTaper Universal rotary files (Dentsply-Maillefer, Ballaigues, Switzerland). When changing between instruments, the root canals were irrigated with 2 ml of 3% NaOCl. Then, the root canals were dried with absorbent paper points and filled with gutta-percha and AH-plus sealer by single cone technique, sealed with Glass ionomer cement and stored in 100% humidity for 7 days at 37°C. The roots were prepared for post placement by removing the gutta-percha from the canal using the Peeso reamers till size 5. The length of the post space was standardized to a length of 9mm. To preserve the apical seal, 4 to 5 mm of the gutta percha was retained at the apical level. Then, the roots were randomly divided into four groups (n = 15) based on the irrigating solution used.

Group 1: 3% Sodium hypochlorite (NaOCl)

Group 2: 17% Ethylenediamine Tetra acitic acid (EDTA) + 3% Sodium hypochlorite (NaOCl)

The canals of the samples were irrigated with the respective solutions of 5ml for 1min.

Group 3: canals were rinsed with 5ml of 7% Maleic acid for 45s followed by 5ml of 3% Sodium hypochlorite (NaOCl) for 1 min

Group 4: canals were rinsed with 10ml of 10% Boric acid solution for 1 min. (The Boric acid solution is supersaturated at room temperature; therefore, it should be heated prior to use)

The canals were dried with paper points. Ten study samples were randomly selected in each group. Glass fiber posts which are parallel and radiopaque were relined with a self -adhesive resin cement was inserted and seated inside the root canal and kept under the finger pressure for 20 seconds before the excess cement was removed. The cement was then polymerized using light cure unit for 30 seconds on each surface. After the cementation procedures, the coronal part of the exposed dentine was completely covered with composite resin. Finally, the samples were stored at 100% humidity for 7 days at 37℃.

Measurement of Push out Bond Strength Test

After 7 days, each of the coronal, middle, and apical parts of the samples were serially sectioned into two slices of approximately 1.00 ± 0.05 mm thickness using water cooled Mini tom diamond saw, and a total of six sections per root were obtained. The thickness of the slice was individually measured using a digital calliper with 0.01 mm accuracy. The samples were subjected to micropush-out bond strength tests using an electronic universal testing machine. During the testing, the apical surface of the slice was positioned facing the punch pin, so that the loading force was applied in an apicocoronal direction with a speed of 1 mm min^{-1} until failure or until the fiber post gets dislodged from the root slice. The push-out bond strength was observed and measured in newtons (N). Bond strength was converted from N to MPa by dividing the load at failure in N by the bonded surface area (SL) in mm^2, where SL was calculated at the lateral surface of a truncated cone using the formula:

$$SL = \pi(R+r)\,[h^2 + (R-r)^2]^{0.5}$$

where R is the coronal post radius, r is the apical post radius, and h is the thickness of the slice.

Failure Mode Observation

The samples of all groups were assessed for failure modes under a stereomicroscope at magnifications of 10X and 30X and classified according to Cecchin et al

Type 1 – adhesive failure between resin cement and post, Type 2 – adhesive failure between resin cement and dentin,Type 3 – mixed failure,Type 4 – cohesive in dentin.

Statistical Analysis: Data was analyzed using the statistical package **SPSS 22.0** (SPSS Inc., Chicago, IL) and level of significance was set at **p<0.05**.

Descriptive statistics was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using **Shapiro Wilkinson test**. **Inferential statistics** to find out the difference between the groups was done using **Oneway ANOVA test and followed by Tukey's Post Hoc analysis.**

Failure model analysis was done by **chi square test.**

Table 1: Comparison Of Bond Strength With Different Irrigants At Apical Third

	Bond strength (MPa)		P value(ONE WAY ANOVA)
NaOCL(N=20)	MEAN	9.353	0.0013*(F=6.433)
	SD	3.843	
EDTA & NaOCL(N=20)	MEAN	11.23	
	SD	6.439	
MALEIC ACID &NaOCL(N=20)	MEAN	17.13	
	SD	2.888	
BORIC ACID(N=20)	MEAN	8.924	
	SD	4.944	

Table 1: The highest pushout bond strength was seen in group 3, followed by group 2 and group 1. The lowest pushout bond strength was seen in group 4.

Multiple comparison of mean difference in the pushout bond strength between the groups in the apical third of the root canal was done using oneway anova and tukeys post hoc analysis, revealed that when group 3 was compared with other groups, it showed lower mean bond strength which is statistically significant. (P < 0.05)

Table 2: Comparison Of Bond Strength With Different Irrigants At Middle Third

	Bond strength (MPa)		P value(ONE WAY ANOVA)
NaOCl(N=20)	MEAN	13.274	0.0000*(F=15.873)
	SD	4.9796	
EDTA & NaOCl(N=20)	MEAN	14.704	
	SD	4.2085	
MALEIC ACID &NaOCl(N=20)	MEAN	15.43	
	SD	7.502	
BORIC ACID(N=20)	MEAN	13.425	
	SD	5.7721	

Table 2:The highest pushout bond strength was seen in group 3, followed by group 2. The lowest pushout bond strength was seen in group 4 and group 1.

Multiple comparison of mean difference in the pushout bond strength between the groups in the middle third of the root canal was done using oneway anova and tukeys post hoc analysis, revealed that there is significant difference between group 1 and group 4 with group 2 and group 3. (P<0.05). There is no significant difference between Group 2 and group 3.

Table 3: Comparison Of Bond Strength With Diffent Irrigants At Coronal Third

NaOCl(N=20)	MEAN	18.157	0.0108*(F=3.9838)
	SD	4.3773	
EDTA & NaOCl(N=20)	MEAN	19.441	
	SD	4.9470	
MALEIC ACID &NaOCl(N=20)	MEAN	19.512	
	SD	7.5892	
BORIC ACID(N=20)	MEAN	14.811	
	SD	3.3786	

Table 3: The highest pushout bond strength was seen in group 3, followed by group 2 and group 1. The lowest pushout bond strength was seen in group 4.

Multiple comparison of mean difference in the pushout bond strength between the groups in the coronal third of the root canal was done using oneway anova and tukeys post hoc analysis, revealed that there is significant difference between group 1, group 2 and group 3 with group 4.

Table 4: Types of Failures

FAILURE TYPES	GROUP 1			GROUP 2			GROUP 3			GROUP 4		
	C	M	A	C	M	A	C	M	A	C	M	A
TYPE 1	20	10	0	60	20	0	70	20	60	60	10	0
TYPE 2	60	70	80	20	60	70	20 20		50	10	60	80
TYPE 3	20	20	20	20	20	30	10 20		30	30 20		30
P VALUE	0.59			0.08			0.043			0.0001		

Table 4: Types of failures in all groups (in %). Most failures observed were type 2. Type 1 failures were seen significantly in group 3.

Stereomicroscope Images

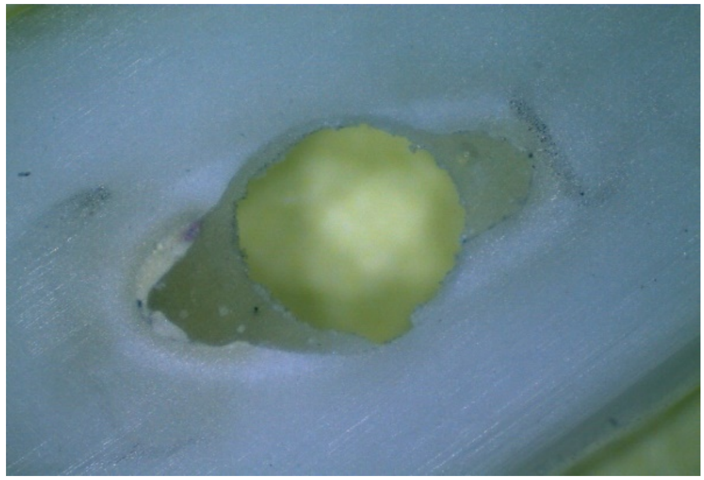

Figure 1: Type 1 Failure Mode At 30x

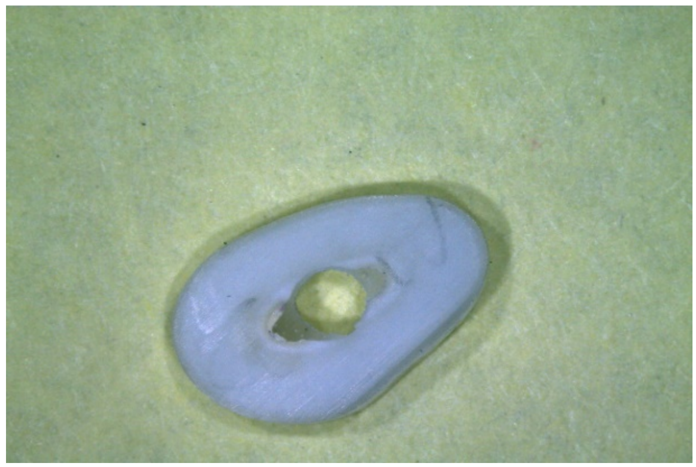

Figure 2: Type 1 Failure Mode At 10x

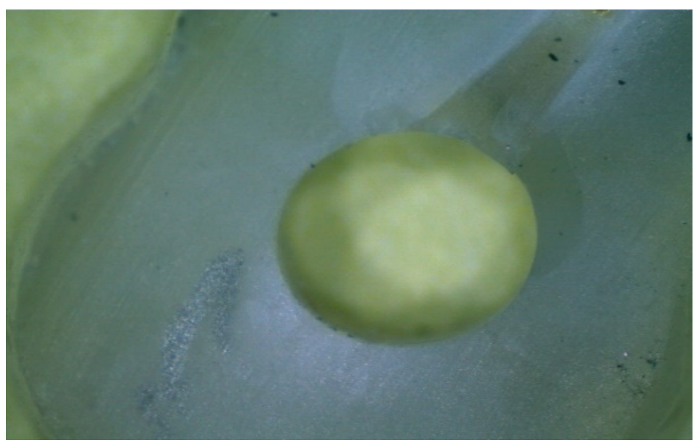

Figure 3: Type 2 Failure Modes at 30x

Figure 4 : Type 2 Failure Mode At 10x

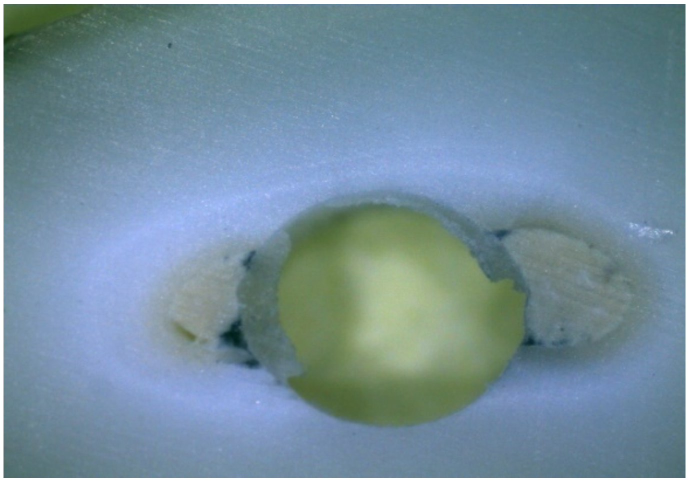

Figure 5: Type 3 Failure Mode At 30x

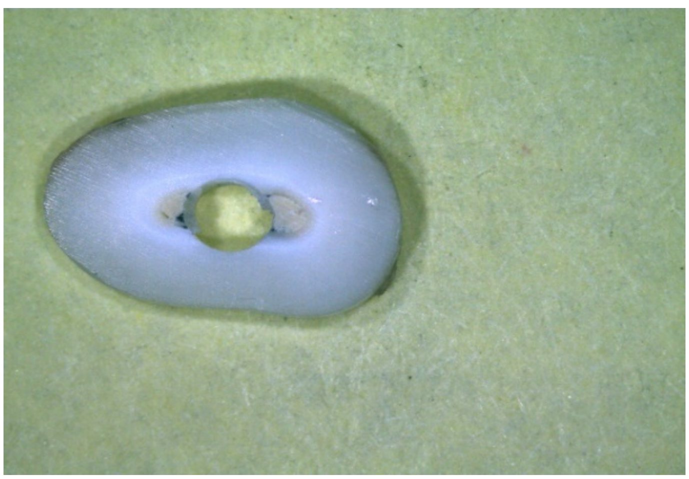

Figure 6 : Type 3 Failure Mode At 10x

Discussion

For determining the bond strength of fiber post to root dentin with self-adhesive resin cement after using different post space irrigants push out bond strength has been used by various authors.[9,10]

The push out test, first used for evaluating bonding of the root canal dentin in 1996, provides a better estimation of bonding strength than the conventional shear test. It is because with the push out test, the fracture occurs parallel to the dentin bonding interface, which makes it a true shear test.[11]

Results of the present study showed that in group 1, where 3% NaOCl was used as a post space irrigant, coronal third areas showed highest mean bond strength values than the middle and apical third (18.15, 13.27, 9.35MPa respectively). This might be because of the greater dentine permeability in this region making it more susceptible to action of the chemical irrigants.[12] The decreased bond strength in different root regions is due to the adverse effect of sodium hypochlorite on dentin bonding.[13]

NaOCl decreased the calcium and phosphorous contents and the mechanical properties of dentin, such as elastic modulus, microhardness and flexural strength, which can contribute to reduction in the micromechanical interaction between the adhesive resins and NaOCl treated dentin. It partially removes the smear layer, and also causes dentin deproteinization, creating a hydrophilic surface that may hinder the interaction of more hydrophobhic materials such as SARCs. The results are also consistent with the findings of Elnaghy,[14] silva et al,[15]

In group 2, 17% EDTA+3%NaOCl was used. The reason for difference in the push-out bond strength results were reported by Hayashi et al,[16] Zhang et al[5]. It was reported that the effect of EDTA+NaOCl irrigation on the adhesion of resin cement to intraradicular dentin depended on the type of adhesive systems. The negative effect of oxygen liberated from NaOCl, may contribute to the lower apical pushout strength. The effect of residual irrigants in the root canal should also be taken into account. The residual chemical irrigants and their products are likely to diffuse into the dentin tubules, which may affect the infiltration of the resin into the demineralized dentin or interfere with the complete polymerization of adhesive systems. When EDTA/NaOCl was used in combination with ultrasonic agitation, the apical push-out strength was significantly improved. This may be explained by the cleaning ability of ultrasound treatment in combination with EDTA/NaOCl irrigation.

Maleic acid (MA), is a mild organic acid which has been found to possess smear layer removing quality when used as an acid etchant in restorative dentistry. At different concentrations it has been found to remove the endodontic smear layer, indicating that it can be used as an alternative to routine use of 17% EDTA at concentrations of 5 and 7%.[17]

The results of the present study had showed highest bond strength values in all regions of the root canal. This is in accordance with the study done by Fan et al,[7] where MA had showed better results in all the root regions compared with EDTA and NaOCl. As MA removed the smear layer more efficiently than other irrigants used in this study, based on the number of the fully opened dentinal tubules and the efficacy of the smear layer removal along the root canal after post space preparation. Hence, MA improved the penetration of the cement into the dentinal tubules and created more resin tags. This strong performance may have contributed to the highest bond strength values observed in MA treatment.

When comparing NaOCl and EDTA+NaOCl with MA, MA has given the best results of all the groups in all different regions of the root canal. MA has showed statistically significant difference with all the irrigants used in the present study. Though there was no statistically significant difference between the MA and EDTA+NaOCl groups in the middle third, push-out bond strength value was seen more in the MA group. This may be attributed to the strong physicochemical action of Maleic acid on both organic and inorganic particles which results in complete removal of the smear layer and hence improved penetration the resin cement into the dentinal tubules forming more resin tags. This might have contributed to the highest bond strength values observed in MA group.[7]

Results of the present study are in agreement with the study done by Fan et al,[7] where MA was showed better smear layer removal in the apical third, there by exhibiting highest bond strength.

10% boric acid which is used as a post space irrigant in the present study has shown the least bond strength values among all other irrigants in coronal, middle and apical thirds of the root canal system. This results are contradictory to the findings given by culhaoglu et al,[8] in which 5% and 10% concentration of boric acid was used in comparison with conventional irrigation (2% CHX, 5.25% NaOCl, 17% EDTA) and was concluded that boric acid solutions at a concentration of 10% can be a viable alternative to the conventional irrigants used during endodontic treatment. It was stated that boric acid solution is supersaturated at room temperature and it was heated prior to use to temperature of 55^{o}C. In the present study 10% boric acid solution was used. The variation in the results might be due to the temperature differences while heating the boric acid salts. In the present study the supersaturated boric acid solution was kept in hot water bath till the salts were dissolved which might not have temperature of 55^{o}C. This could be the reason for the compromised efficacy of boric acid in smear layer removal and hence the bond strength.

All the failure mode findings were consistent with the results found for the bond strength.

With the above mentioned findings and results, it was suggested that the bond between the luting material and the root canal dentin was improved because of the effects of different irrigants.

Conclusion

Within the limitations of the present study, it can be concluded that Maleic acid as a post space irrigant is effective in removing smear layer, thereby increasing the bond strength.

Among the irrigating solutions used in the present study, Maleic acid yielded the best overall result and showed the highest bond strength as compared with 17% EDTA, 10% Boric acid and 3% NaOCl.

Further studies are required to evaluate the effect of these irrigants as post space irrigating solutions and their bond strength to root dentin.

Acknowledgement: I hereby acknowledge Central Manufacturing Technology Institute (CMTI), Bangalore, and Indian Institute of science (IISc), Bangalore for helping in this study

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