In vitro comparative assessment of bond strength of three different root canal sealers after root canal drying by different techniques

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ABSTRACT

Introduction: The durability and biocompatibility of a root canal filling material along with three-dimensional obturation of the root canal system plays an important role to achieve successful treatment outcomes. Among various factors that affect the success of endodontic sealers, one is the push out bond strength for which residual dentin moisture is an influencing factor.

Objectives: To compare and assess the bond strength of three different root canal sealers after root canal drying by different techniques.

Materials and Method: 132 samples were cut and prepared. Then, they were assigned into 4 groups based on different drying technique and 3 subgroups based on the type of sealer:
Group I : Absorbent paper point.
Group II : 95% Ethanol.
Group III : 70% Isopropyl Alcohol.
Group IV : Control (wet)
Sub group-1 : MTA-Fillapex
Sub group-2 : Bioactive RCS sealer
Sub group-3 : AH plus

Two transverse sections were made and each disc was mounted on a jig followed by placement of cylindrical plugger. Then the load was applied in a universal testing machine and force required for debonding of filling material from root canal wall was recorded as push out bond strength (PBS). Also, mode of failure was evaluated under dental operating microscope.

Result: The maximum mean PBS was noted in Isopropyl alcohol and Paper point followed by Ethanol groups but difference in mean PBS was not significant among 3 experimental groups ($P < .001$). However the mean PBS of Isopropyl alcohol, Ethanol and Paper point group was significantly higher than control group ($P > .001$). Thus, Isopropyl group, Paper point, Ethanol equally ranked in best drying techniques.

Conclusion: Different drying techniques with Paper point, Ethanol and Isopropyl alcohol enhanced the PBS of AH plus and Bioactive RCS sealers to root dentin without significant difference and exhibited superior performance than in MTA Fillapex.

Keywords: Push-out bond strength, Paper point, Ethanol, Isopropyl alcohol, Sealer, Moisture.

INTRODUCTION

The root canal treatment procedure consists of cleaning, shaping, disinfection and obturation of root canal system. To achieve the successful treatment outcomes, the durability and biocompatibility of root canal filling materials along with the three dimentional obturation of root canal system is very essential. The root canal sealers are applied to seal the gap between the root dentin and gutta percha, to fill the root canal wall irregularities, accessory canals and void between gutta percha points and to serve as lubricants.[1]

The sealers employed in root canal obturation should exhibit certain properties such as insolubitity in tissue fluids, biocompatibility, flow ability, suitable setting time, anti bacterial activity and dentin wall adhesion.[2]

One of the influential factor in determining the success rate of endodontic sealers is the push-out bond strength of sealers to root dentinal walls.[1,3,4] Different sealers have variable adhesive properties in bonding to dentine. A number of factors are responsible for different adhesive properties of sealer such as the differences in dentin

structure of different teeth or even different parts of same tooth, presence/absence of smear layer, chemical reaction of sealer and dentin reaction.[5,6,7]

Another influential factor on the bond strength of sealer to dentine is level of dentin moisture before application of sealer in root canal.[8] The residual moisture in the canal adversely affects the adhesion of resin based sealers however, it does not mean that the root canal walls should be completely dried out. Root dentin should remain slightly moist so that sealer can exhibit its hydrophilic property for attachment to dentin.

Different techniques are implemented to dry the canals like: Use of paper points, 95% Ethanol, 70% Isopropyl alcohol, Air vacuum. Among them, Paper point is most commonly practiced to dry the root canal as it is the simplest technique that highly absorbs moisture from the canal.

Ethanol increases the evaporation of water and hence decreases the residual moisture that expedites the root canal drying process.[10,11]

Isopropyl alcohol has lower polarity than ethanol and promotes less removal of water from the dentinal tubules. This will enhance the dentin wettability hence increase the degree of conversion of sealer and consequently improving their adhesion.[12]

Several endodontic sealers are available in market and they are popular by different chemical composition and properties. MTA sealer is responsible for the optimal biocompatibility, Bioceramic sealer is hydrophilic and Resin based sealer has low shrinkage.

There was very limited study, which has been documented and concluded in together that assessed and compared the bond strength of three different root canal sealers after root canal drying by different techniques . So, this study helps in assessment of excellency of bond strength of three different root canal sealers after root canal drying by different techniques.

MATERIALS AND METHOD

This Study was carried out in the Department of Conservative Dentistry and Endodontics of Kantipur Dental College Teaching Hospital and Research Center Basundhara, Kathmandu and Geo Technical Lab of Pulchowk Engineering College, Pulchowk, Lalitpur. The samples for this study were collected from Department of Oral and Maxillofacial Surgery, Kantipur Dental College Teaching Hospital and Research Center Basundhara and different Dental Clinics in Kathmandu.

The collected samples were immersed in 5.25% Sodium hypochlorite solution (CanalPro, Coltene) for 24 hrs to remove adhered tissues. Calculus and surface deposits were removed by ultrasonic scaler. All collected samples were examined under x 25 magnification using a dental operative microscope (Labomed-Magna). Samples with root resorption, cracks, fractures were excluded. For each sample, two radiographs were taken in buccolingual and mesiodistal projection to view root canal anatomy and radiographic apex. Teeth with more than one canal were excluded.

Finally, one hundred thirty two teeth were selected for the study. The anatomical crown of selected samples were cut at the cementoenamel junction by a fissure carbide bur (Mani). The root canal of samples were negotiated by # 10 K-file (Mani) and final working length of samples were determined by #20 K-file (Mani). Then, the root canal of samples were prepared upto # F3 with Pro Taper-Gold rotary system (Densply). The root canal of samples were irrigated with 10 ml of 5.25% sodium hypochloride (CanalPro, Coltene) after using each file. The smear layer were removed by using 17% ethylenediaminetetraacetic acid (Endoclean, Vishal) for 1 minute followed by a final rinse with 10 ml of distilled water to eliminate the chemical agents from root canal system.

Then, samples were randomly divided into 4 groups with 33 samples each (n=33).
Group I (n=33) : Root canal of samples were kept dry by using absorbent paper point (META).
Group II (n=33) : Root canal of samples were kept dry by using 95% Ethanol (Endodry, Endosure, DentaLife).
Group III (n=33): Root canal of samples were kept dry by using 70% Isopropyl Alcohol (equate TM).
Group IV (n=33): Root canal of samples were kept wet.
Then, depending on the type of sealer, each group was randomly divided into 3 sub groups with 11 samples each (n=11).
Sub group-1: MTA-Fillapex (Angelus)
Sub group-2: Bioactive RCS sealer (SafeEndo)
Sub group-3: AH plus (Dentsply

Thus, a total of 12 sub-groups were evaluated. The obturation was performed with single cone gutta percha # F3 (Dentsply) obturation technique in all groups.

After completion of obturation, the roots were incubated at 37°C and 100% humidity for 24 hrs. Then, tranverse sections was made of 1mm height (thickness) at the middle third of the roots by a low-speed diamond disc (Mani) under water coolent.

To measure the push out bond strength, each disc was mounted on a jig such that the coronal surface of the disc faced the metal surface of the jig. A cylindrical plugger with a 1mm diameter was positioned at the center of the root

canal space in each disc to prevent the contact of metal with dentin surrounding the root filling material (Figure 1). The load was applied by the tip of the cylindrical plugger to the disc in apicocoronal direction in a universal testing machine with a 200 kg load cell at a crosshead speed of 1 mm/minute.

Fig.1 PBS test by Jig and Cylindrical disc

The minimum force required for dislodgement of filling material and its debonding from the root canal wall was recorded as push out bond strength. We obtained our data in unit of Kg. Value of data was converted into Newton by using formula: 1Kg=9.81N. Then, final data was recorded by using formula: MPa = $N/(mm)^2$.

Here, MPa means Mega Pascal, N means Newton, cross section diameter = 1mm So, data was calculated by using formula: MPa= $N/(1)^2$ ie. MPa =N

The mode of failure was evaluated under dental operating microscope at x 25 magnification:
Adhesive failure: Debonding at the bonding interface
Cohesive failure: Fracture within the dentin structure or root filling material.
Mixed failure: A combination of adhesive and cohesive failures.

The frequency of different modes of failure were recorded for each group in percentage. Data were analyzed by SPSS (Statistical Package for the Social Sciences) software. The Kolmogorov- Smirnov test was used to assess the normality of data distribution, which showed a non normal distribution of data ($p < .05$). So, the groups were compared with the Kruskal-Wallis test followed by the Games-Howell test for pairwise comparisons at $p < .05$ level of significance.

RESULT

Mean and standard deviation of push-out bond strength of the experimental groups are in Table No 1.

A. Comparison of PBS of different drying technique irrespective of sealer type:
The maximum mean PBS was noted in drying with paper point and Isopropyl alcohol followed by Ethanol groups but difference in mean PBS was not significant among 3 experimental groups ($P < .001$). However the mean PBS of Isopropyl alcohol, Ethanol and Paper point group was significantly higher than that of control (wet) group (P, .001). Thus Isopropyl group, Paper point, Ethanol equally ranked in best drying techniques.

B. Comparison of PBS of different drying technique based on the sealer type:
In case of MTA Fillapex Sealer, lowest mean PBS was recorded in drying with Ethanol in comparison to paper point, Isopropyl alcohol but in comparison to control (wet) group, it showed high mean PBS. In Kruskal-Wallis test, the difference in mean PBS of different drying techniques was not significant.

In case of BioActive RCS sealer, highest mean PBS shown in both drying techniques Ethanol and paper point followed by Isopropyl but lowest PBS shown in control (Wet) group. In Kruskal-wallis test, the difference in mean PBS of different drying techniques was not significant whereas these were significantly different from Control group (Wet).

In case of AH Plus, highest mean PBS shown equal in drying with Paper point and Isopropyl alcohol followed by Ethanol but lowest PBS was shown in control (wet) group. In Kruskal-wallis test, the difference in the mean PBS of different drying techniques was not significant in the AH Plus sealer but was significantly different with Control (Wet) group.

C. Comparison of PBS of different sealers irrespective to drying technique:
The maximum mean PBS was recorded in AH Plus and Bioactive RCS sealers followed by MTA Fillapex Among these 3 sealers, there was significant difference as shown by Kruskal-wallis test ($p< .001$). Pairwise comparison was done by Games-Howell test in which the mean PBS of AH plus and Bioactive RCS sealers was shown to be significantly higher than MTA Fillapex but no significant difference was found between AH Plus and Bioactive RCS sealer ($P< .05$).

D. Comparison of PBS of different sealers in use of each drying technique:
In Paper point group, the maximum PBS was found in case of AH Plus followed ny Bioactive RCS and MTA Fillapex sealers. Kruskal-Wallis test showed that the difference in PBS was significant among three sealers. The mean PBS in AH Plus and Bioactive RCS sealers were significantly higher than MTA Fillapex but there was no significant difference between AH plus and Bioactive RCS Sealers.

In case of Ethanol group, the equal maximum PBS was

found in Bioactive RCS and AH plus but less PBS was found in MTA Fillapex. Kruskal-Wallis test showed that the mean PBS of both AH plus and Bioactive RCS was significant higher than MTA Fillapex.

In case of Isopropyl Alcohol group, the maximum PBS was found in AH plus followed by Bioactive RCS and MTA Fillapex sealers. Kruskal-wllis test showed significant difference among 3 sealers and the difference in PBS in AH plus and Bioactive RCS sealers was significantly higher then MTA Fillapex but there was no significant difference between AH plus and Bioactive RCS sealers.

In case of Control (Wet) group, Kruskal-Wallis test indicated significant difference in PBS of different sealers.

Table 1

	Paper point	Ethanol	Isopropyl alcohol	Wet environment
MTA sealer	2.206364 ± .4675526	1.896364 ± .6175965	2.303636 ± .6334236	.529318 ± .2354864
Bioceramic sealer	3.798636 ± .3577296	3.798636 ± .3577296	3.611818 ± .4429688	1.120909 ± .1599815
Resin sealer	3.860909 ± .5541923	3.798636 ± .3577296	3.860909 ± .3455996	1.120909 ± .1599815

Table 2

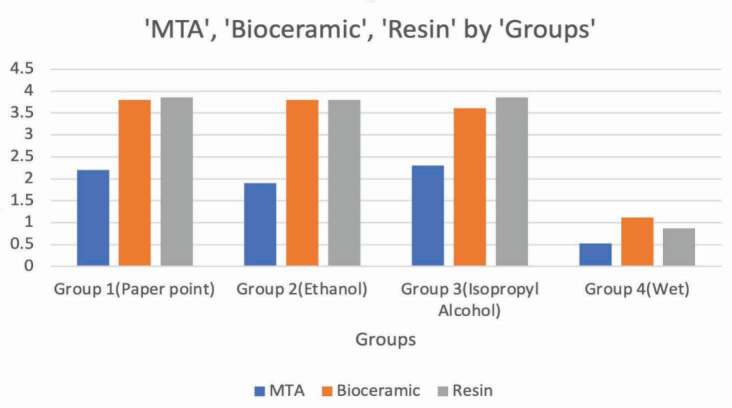

Table 3: Mode of Failure:

Group	Failure mode	MTA	Bioceramic	Resin	Total
Paper point	Adhesive	4	1	6	11
	Cohesive	4	7	0	11
	Mixed	3	3	5	11
Ethanol	Adhesive	1	0	4	5
	Cohesive	3	6	0	9
	Mixed	6	5	8	19
Isopropyl Alcohol	Adhesive	0	0	5	5
	Cohesive	2	7	0	9
	Mixed	9	4	6	19
Wet environment	Adhesive	2	6	8	16
	Cohesive	0	0	0	0
	Mixed	9	5	3	17

The mode of failure presented in this study is shown in Table 3. In this study, mixed types of failure was most common whereas, adhesive failure was found least followed by cohesive failure. In case of Bioactive RCS sealer, there was no or minimal adhesive failure in three different drying techniques.

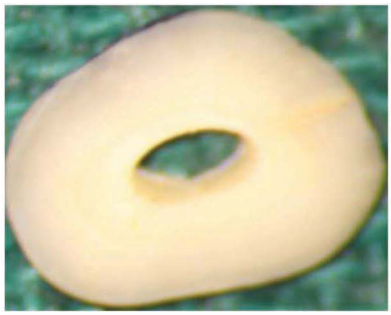

Fig.2.a) Adhesive Failure

Fig.2.b) Cohesive Failure

Fig.2.c) Mixed Failure

DISCUSSION

In endodontic treatment, well cleaned and prepared root canal system should be sealed three dimensionally by gutta percha and sealer. Gutta percha has no adhesion to the dentin surface so, sealer should be used that has adequate flow for filling the gaps between gutta percha cones and canal walls and thus contributing to the bond strength to root dentin. Commercially, various types of Root canal sealers such as Calcium based, Eugenol based, Epoxy-Resin based, Silicon based, Calcium Silicate based sealers are available in market. The sealer should have adhesive strength and cohesive strength to hold the obturation together.[13]

Optimal Push-out bond strength of sealer to root dentin enhances the tensile strength, prevents microleakage and stabilizes the root filling material thereby influencing the success rate of endodontic sealers.[1,3,4] Various factors like differences in dentin structure of different teeth or even different parts of same tooth, presence/absence of smear layer, chemical composition of sealer and dentin reaction are responsible for different adhesive properties of sealers.[5,6]

Epoxy-resin based sealer are frequenty used in endodontic practice but, the sealing ability of AH plus remains controversial partly because it does not bond to gutta percha and Bisphenol resin based AH26 releases formaldehyde during polymerization.[14,15] It is available in 2-tube mix or auto-mix syrinse in market. In this study, 2 tube mix AH Plus was used to evaluate push-out bond strength. Epoxy resin-based sealer can penetrate deeper into dentin irregularities and have higher displacement resistance resulting higher PBS and better adaptation at adhesive interface.[5,6,16,17]

MTA based sealer consists of resins, bismuth oxide, silica nanoparticles and dyes. This sealer has high sealing ability, radiopacity, low solubilty as well as low setting expansion, bactericidal effect and biocompatibility.[18] MTA based sealers are available in two paste mix and auto mix syrinse. In this study, two paste form MTA Fillapex was used for evaluation of Push-out bond strength.

Bioceramic sealer is composed of spherical nano-particles with maximum dimension $1.9x10^3$ micro-meter which is considered to penetrate into the dentinal tubules and interact with dentin moisture resulting in dimensionally stability with minimal shrinkage.[19] Bioceramic sealer is an insoluble, radioque, aluminum-free hydrophilic calcium silicate, which requires the presence of water to set and harden which is commercially supplied in premixed syringe.[8] In this study, premixed form Bioactive RCS sealer was used for evaluation of PBS. Bioceramic sealer released higher amounts of calcium ions which enhances greater biomineralization at dentin-cement interface resulting higher PBS. Epoxy resin based and calcium silicate based sealer demonstrated higher PBS than MTA based sealer.[8,20] The present study have also shown similar results.

Evidence shows that the residual moisture in the canal adversely affects the adhesion of resin sealers but, it does not mean that the root canal walls should be completely dried out.[11] Recent studies have shown that excessive removal of the water in the dentinal tubules may in turn hamper the effectiveness of hydrophilic sealers and adhesion to root dentin.[14,21] Level of dentin moisture before sealer application plays an influential factor on the bond strength of sealers to dentin.[8] Root dentin should remain slightly moist so that sealer can use its hydrophilic property for attachment to root dentin.[10]

There are no clear protocol to achieve an ideal state of residual moisture in the root canal and also manufacturers are not still able to provide precise clinical instructions to achieve an ideal level of residual moisture before application of their product.[22] Various chemical agents of different concentrations of alcohol have been tested to remove dentin moisture from root canals. In this study, 95% Ethanol, 70% Isopropyl alcohol and # F3 paper points were used to dry the root canal system.

Paper points are the simplest and most commonly practiced technique to dry the root canal. The use of paper points follows the principle of direct contact and capillary action for absorbing water but some moisture may be still left in root canal system because of complex anatomies.[10] Ethanol increases the evaporation of water and hence decreases the residual moisture from the canal.[10,11]

Isopropyl alcohol has lower polarity than ethanol and promotes less removal of water from dentinal tubules. This

ultimately enhances the dentin wettability and increases the degree of conversion of sealer thereby improving their adhesion.[12] Present study demonstrated that three drying technique-paper point, Ethanol and Isopropyl alcohol exhibited maximum PBS in AH plus and Bioactive sealers but there was no significant difference.

In push-out test, fracture occurs parallel to dentin-bonding interface, which makes it a true shear test for parallel- sided samples. So, the push-out test provides a better evaluation of bonding strength than conventional shear test.

Regarding mode of failure, present study revealed that, cohesive and mixed failure were most common in Resin based and MTA based groups. There was no or minimal adhesive failure in Bioceramic sealer and no cohesive failure in AH plus which was different with previous studies in which adhesive and mixed failure were more common in AH plus, adhesive and cohesive failure in Endo Sequence BC and MTA Fillapex and in AH 26 and MTA Fillapex, cohesive and mixed failure were most common failure.[8,9]

CONCLUSION

In present study, different drying techniques with Paper point, Ethanol and Isopropyl alcohol enhanced the Push out bond strength of AH plus and Bioactive RCS sealers to root dentin without a significant difference and exhibited an equal performance than in MTA Fillapex

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