Original Article

Assessment of the impact of XP-Endo Finisher file on push-out bond strength of various endodontic sealers

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Abstract

Background: An endodontic treatment is considered a success after thorough chemomechanical debridement coupled with obturating root canals in a concrete way thereby providing hermetic seal. Gutta-percha being nonadherent necessitates use of a sealer to achieve hermetic seal. Adequate adhesion of root canal sealer with gutta-percha core and radicular dentin ensures lack of apical leakage.

Materials and Methods: Sixty extracted mandibular premolars with single root canal decoronated at cementoenamel junction were selected and randomly allocated to two groups ($n = 30$). Samples in Group 1 were prepared with BT Race file, while Group 2 samples were prepared with BT Race alongwith XP Endo file. Absorbent paper points were used for canal drying and samples were randomly divided into six subgroups. In Subgroup I, obturation was done with bio-ceramic (BC) sealer (Endosequence BC) and BC gutta-percha. In Subgroup II, resin-based (AH plus) sealer and gutta-percha were used. In Subgroup III, calcium hydroxide-based (Sealapex) sealer and gutta-percha were used. Sectioning of root samples was done perpendicularly into coronal, middle, and apical segments of 3 mm each. A universal testing machine was used for sample testing, in which push-out bond strength corresponded to the highest value obtained. Stereomicroscopic (×20) study of the samples determined the failure mode at dentin/sealer/main cone interface.

Statistical Analysis: Analysis of variance and *post hoc* Tukey's tests were used for data analysis.

Results: Endosequence BC with XP-Endo files showed the highest mean push-out bond strength (16.31 MPa), whereas Sealapex without XP-Endo file had the lowest values (12.76 MPa). Mixed failure of adhesive and cohesive mode was observed for most samples.

Conclusion: Adjunctive irrigation agitation technique utilizing XP-Endo Finisher facilitates biofilm eradication from difficult niches in root canals, thereby improving adhesion of sealer and subsequently the sealer bond strength.

Keywords: AH plus; apical leakage; Endosequence; root canal sealer; Sealapex

INTRODUCTION

Eliminating pathogenic microorganisms through chemomechanical debridement accompanied by three-dimensional sealing of the root canals ensures the success of endodontic treatment.[1]

Obtaining a hermetic seal of root canals with the help of chemically unreactive, biocompatible material is the major

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aim of successful endodontic treatment. Gutta-percha which is the most commonly used core material does not readily adhere to dentinal wall and hence necessitates the use of sealer to obtain an ideal seal. Prevention of microleakage and achieving a hermetic seal requires proper adhesion of root canal sealer to radicular dentin and gutta-percha. The two interfaces, namely, the core sealer and dentin sealer can lead to microleakage. A complete adhesion between sealer, gutta-percha, and dentine can help prevent apical leakage.[2]

Adhesiveness is defined as the ability of root canal sealer to attach to radicular dentinal wall as well as gutta-percha. This property does not allow the percolation of fluids at the interface and reduces voids. Sealers must also exhibit cohesiveness in order to hold the obturation together.[3]

Cohesiveness between root canal wall, gutta-percha and sealer is guaged by "push-out test". It acts as an assessment tool for determining level to which the sealer and main cone are formed into a single unit along with bond strength to canal wall.[1]

The present study assessed the extent to which the various sealers and the main cone are bonded to root canal wall in canals prepared with BT Race and XP Endo file using a push-out design. The failure modes were also analyzed using a stereomicroscope.

MATERIALS AND METHODS

Sixty extracted human lower premolars were visually inspected, cleaned with pumice and water and stored in 10% formalin. Exclusion criteria were root resorption, root caries, cracks, calcification, root fracture and open apex). Decoronation at cementoenamel junction was done using low speed contra-angled handpiece and disc with water coolant supply. Confirmation of patency of root canals was achieved through a number 10 K-file, unless file became visible at apical foramen. Random allocation of samples into two groups ($n = 30$) was done.

Group 1: Study samples were prepared with BT Race.

For all the canals, working length (WL) was measured using a #10 K-file and was kept till the apical foramen. Glide path establishment was done with number 10 K-file, and canal instrumentation was done by BT-RaCe files implementing crown-down technique of cleaning and shaping. Endodontic motor settings were at 800 rpm and 1.5 N/cm torque. The same operator accomplished the biomechanical preparation in all the samples in a subtle in-out motion up to complete WL. Sequential instrumentation was done: BT1 (#10, 6%); BT2 (#35, 0%); and BT3 (#35, 4%). Frequent irrigation was performed with 5% NaOCl.

Group 2: Samples were prepared with BT Race and XP Endo.

After the preparation with BT RaCe was completed, XP Endo file was activated at 800 rpm and 1 N/cm torque for 1 min after insertion into canal employing slow and gentle parietal movements of 7–8-mm till the WL. Continuous supply of 1 mL 5% NaOCl was maintained during the entire length of procedure. Removal of the instrument from the canal was done in its rotation phase itself. Rinsing of canal was done for 30 s using 0.5 mL 5% NaOCl. After usage in each specimen, each XP-Endo Finisher file was discarded.

After preparation was completed in both the groups, drying of the canals was done by absorbent paper points. Groups were further split randomly into three subgroups each ($n = 10$), depending on root canal sealer used for obturation. Sealer application was done using Lentulo spiral. Obturation was carried out with single cone #35, 0.04 taper master cone.

- Subgroup I: Roots filled with Endosequence sealer and bioceramic (BC) gutta-percha
- Subgroup II: AH Plus sealer and gutta-percha
- Subgroup III: Sealapex sealer and gutta-percha.

Preparation for push-out bond testing

Each sample length was calculated followed by their split up into three segments: coronal, middle, and apical uniformly. 3 mm thick slice (n=30 Slice/subgroup) were obtained from each segment by cutting the root samples perpendicular to their long axes using a diamond coated blade. Copious water coolant was supplied during this procedure.

For the confirmation of circular canal anatomy and absence of voids in obturation, examination of all the samples was carried out under a stereomicroscope before testing. The tests were conducted on a universal testing machine; 0.5 mm/min was its velocity of operation and 100 N load cell was used. Mode of failure determination was done by examining samples at both sides, which included master cone and sealer plug under ×20 magnification using a stereomicroscope.

(i) Lack of adhesion at dentin/sealer interface
(ii) Amalgamation of adhesive failure mechanism at both dentin/sealer and sealer/main cone junction
(iii) Both adhesive and cohesive modes failure.

ANOVA was followed by *post hoc* Tukey's test for carrying out the multiple group comparison.

RESULTS

Intragroup comparison

Compared to all the subgroups, the highest push-out bond strength was seen in the apical section (Mean value 16.31 MPa) of Subgroup I (Endosequence sealer with XP- Endo file). The lowest mean value of 12.76 MPa was exhibited by subgroup VI (Sealapex sealer without XP-Endo file). Inter group comparison with respect to push-out bond strength when done by Tukey's multiple post hoc procedures has shown statistically insignificant values for coronal section [Table 1] and statistically significant values for middle section (Subgroup III and VI) [Table 2] and apical sections [Table 3].

Intergroup comparison (coronal, middle, and apical sections)

Push-out bond strength was the highest in Subgroup I (Endosequence sealer with XP Endo file), followed by Subgroup II (AH-Plus sealer with XP Endo), Subgroup III (Sealapex sealer with XP Endo file), Subgroup IV (Endosequence sealer without XP Endo file), Subgroup V (AH-Plus sealer without XP Endo), and Subgroup VI (Sealapex sealer without XP Endo file) [Table 4].

Under a stereomicroscope at ×20 magnification, the following failure modes were noticed:

- Subgroup I (Endosequence sealer with XP Endo file): 100% failure at adhesive and cohesive modes
- Subgroup II (AH Plus sealer with XP Endo file): 83% failure at adhesive and cohesive modes [Figure 1a]. Seventeen percent combined failure both at dentin/sealer and sealer/main cone junction [Figure 1b]
- Subgroup III (Sealapex sealer with XP Endo file): 75% combined failure at adhesive and cohesive modes.

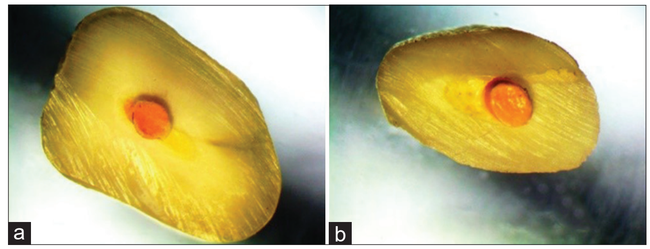

Figure 1: (a) Mixed failure in both adhesive and cohesive modes, (b) Amalgamation of adhesive failure mechanism at both D/S and S/M junction

Table 1: Pair-wise comparison of six groups with respect to push-out bond strength (MPa) in coronal side by Tukey's multiple *post hoc* procedures

Groups	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Mean	7.75200	7.34800	6.95200	7.42800	7.16200	6.88300
SD	2.043721	2.131800	1.522723	1.698554	2.019559	1.358758
Group I						
Group II	0.996					
Group III	0.924	0.997	-			
Group IV	0.999	1.000	0.992	-		
Group V	0.978	1.000	1.000	0.999	-	
Group VI	0.893	0.992	1.000	0.984	0.999	-

P<0.05 Statistically Significant

Table 2: Pair-wise comparison of six groups with respect to push-out bond strength (MPa) in middle side by Tukey's multiple *post hoc* procedures

Groups	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Mean	12.39500	10.74300	9.26100	10.92900	10.67000	8.88000
SD	2.175639	1.444792	0.911914	1.820991	2.192335	1.244356
Group I						
Group II	0.268					
Group III	0.002**	0.388	-			
Group IV	0.414	1.000	1.000	-		
Group V	0.224	1.000	1.000	0.446	-	
Group VI	<0.001**	0.158	0.158	0.996	0.087	-

P<0.05 Statistically Significant, **Green statistically significant. SD: Standard deviation

Table 3: Pair-wise comparison of six groups with respect to push-out bond strength (MPa) in apical side by Tukey's multiple *post hoc* procedures

Groups	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Mean	16.31200	14.41200	13.41000	16.050	13.75800	12.76900
SD	1.912960	1.068340	0.931498	0.334104	1.018515	0.948466
Group I						
Group II	0.010**					
Group III	0.000**	0.438	-			
Group IV	0.022**	1.000	0.288	-		
Group V	<0.001**	0.828	0.987	0.676	-	
Group VI	<0.001**	0.039**	0.840	0.019**	0.453	-

P<0.05 Statistically Significant, **Green statistically significant. SD: Standard deviation

Table 4: Push bond strength in coronal, middle, and apical sections in the six groups

Group	Position	Mean	SD
Group I: Endosequence sealer with XP endo file	Coronal	7.75200	2.043721
	Middle	12.39500	2.175639
	Apical	16.31200	1.912960
	Total	12.153	2.044107
Group II: AH plus sealer with XP endo file	Coronal	7.34800	2.131800
	Middle	10.74300	1.444792
	Apical	14.41200	1.068340
	Total	10.83433	1.548311
Group III: Sealapex sealer with XP endo file	Coronal	6.95200	1.522723
	Middle	9.26100	0.911914
	Apical	13.41000	0.931498
	Total	9.874333	1.122045
Group IV: Endosequence sealer without XP endo file	Coronal	7.42800	1.698554
	Middle	10.92900	1.820991
	Apical	14.56100	1.056529
	Total	7.42800	1.525358
Group V: AH plus sealer without XP endo file	Coronal	7.16200	2.019559
	Middle	10.67000	2.192335
	Apical	13.75800	1.018515
	Total	10.53	1.74347
Group VI: Sealapex sealer without XP endo file	Coronal	6.88300	1.358758
	Middle	8.88000	1.244356
	Apical	12.76900	0.948466
	Total	6.88300	1.358758

SD: Standard deviation

Twenty-five percent combined failure both at dentin/sealer and sealer/main cone junction

- Subgroup IV (Endosequence sealer without XP Endo file): 89% adhesive and cohesive modes failure. Eleven percent combined adhesive failure both at dentin/sealer and sealer/main cone junction
- Subgroup V (AH Plus sealer without XP Endo file): 79% combined adhesive and cohesive modes failure. Twenty-one percent combined adhesive failure both at dentin/sealer and sealer/main cone junction
- Subroup VI (Sealapex sealer without XP Endo file): 71% adhesive and cohesive modes failure. Twenty-nine percent combined adhesive failure both at dentin/sealer and sealer/main cone junction.

DISCUSSION

Maintaining a microorganism free environment and avoiding re-contamination of an endodontic apparatus could be ensured only with a successful root canal filling. The aim must be prevention of leakage not only in canal but also in apical region. This is possible when there is a close conformity of root canal filling material to dentinal walls. The efficacy of root canal filling is assessed by correlation between bond strength of filling materials and leakage. Strength of bond between endodontic sealer and dentin holds paramount importance as it helps to obtain adequate root canal seal thereby lowering the probability of filling detachment from dentinal wall during restorative procedures or mastication.[4] This plays a vital role in static conditions preventing fluid movement into dentin and filling material as well as dynamic situations resisting displacement of filling material during multiple procedures.[5]

Push-out test method was applied in the present study to examine the dentin bond strengths of various root canal sealer. Even when bond strengths are low in value, evaluation of root canal sealers is possible. Since push-out test is based on shear stresses, it can imitate the clinical conditions. It is considered a better method for evaluating bond strength in comparison to conventional tests as parallel fractures are induced in interfacial area at the dentin bonding.[6] It can be used in the measurement of shear strength developing between different surfaces, which provides additional knowledge on adhesive properties. Orstavik reported the usage of universal testing machine for testing root canal sealer adhesion.

DeLong *et al*. reported higher mean bond strengths compared to other techniques, when single cone obturation method was used for BC and calcium silicate sealers.[7]

BT-Race is a newly introduced endodontic file system, which has scarce literature information and hence was preferably used in the present study for preparing samples. Three sequences of files are included: BT1 (#10, 6%), BT2 (#35, 0%), and BT3 (#35, 4%). In the present study, preparation was done up to BT3 (#35, 4%). Tip design of the file being non-screwing facilitates their introduction and removal without the application of excessive force and torque.[8]

The bond strength was measured in coronal, middle, and apical third segment of each root and it has been shown that apical third has shown the highest bond strength among all groups. In the present study, the mean value for apical section of all the groups was 14.45 MPa, while for middle and coronal, it was 10.47 and 7.25 MPa, respectively.

The values obtained in this study were in relation with the results of study done by Renata Baldiseera *et al*.[9] and Hamid Abbas Hamid *et al*.[10] They concluded that apical third has the highest bond strength compared to middle and coronal thirds. They suggested that the high magnitude of lateral condensation forces in apical third led to deeper sealer penetrations. They also related it to the presence of irregular dentin and lack of tubules in apical part of roots which increases the surface area of adhesion.[10]

In the present study, the highest push out bond strength was observed for Endosequence BC sealer with XP Endo file (Subgroup I) than all other root canal sealers in all the three sections with the mean bond strength of 7.75 MPa in the coronal section, 12.39 MPa in the middle section, and 16.31 MPa in the apical section.

The values obtained in present study were higher than values obtained by Pawar *et al*.,[11] who also used Endosequence BC in their study. The values difference may be due to the use of XP Endo file for irrigation in the present study. Failure is mostly due to cohesiveness of sealer as sealer has shown good adhesion to dentin as well as gutta-percha. It shows true self-adhesive nature forming a chemical bond (through production of hydroxyapatite during setting) with dentin. It provides good adaptation and hermetic seal as it gets easily spread over the canal walls due to its hydrophilic nature and low contact angle.[12,13] The hydrophilic nature of sealer might have resulted in better intimate contact with canal walls than AH Plus sealer, which is of hydrophobic nature.[11] BC cones imbibe water from the tooth environment, expanding laterally and hermetically sealing the root canal. In the subgroup IV XP Endo file was not used for irrigation agitation which may be the possible reason for inferior results as compared to subgroup I. XP Endo ensures effectual debris and smear layer removal. Smear layer is formed from organic as well as inorganic material present on the interface between root canal walls and sealing material and are weakly attached to them. The production of smear layer during biomechanical preparation acts as a negative factor during obturation of root canals as there is interference with adhesion of sealing material to radicular walls.[5]

XP-Endo Finisher, used for irrigant agitation was launched as an adjunct to improve the efficacy of irrigation in endodontics. It is manufactured with a characteristic alloy type, the Ni-Ti MaxWire (Martensite-Austenite Electropolish-FleX, FKG). This alloy composition imparts phase transformation and shape changing ability to the file. From being straight at room temperature (martensite phase), it transforms to being austenitic at body temperature and assumes a spoon shape when worked within the canal. Expansion and contraction of the file agitates the irrigant and cleans the inaccessible niches of root canal. Recent studies showed higher effectiveness of XP-Endo Finisher against needle irrigation in debris and smear layer elimination.[14-16] Leoni *et al*.[17] concluded that the use of XP-Endo eliminated 89.7% of hard tissue debris which they attributed to its alloy properties, small core size, and zero taper.

AH-Plus is a type of epoxy resin sealer having properties like lower solubility, less shrinkage, higher radiopacity, better biocompatibility, no formaldehyde release, and dimensional stability. However, its sealing ability remains partially controversial partly as it does not bond to gutta-percha.[18] In the group of AH Plus sealer with XP Endo file, dentin and sealer had shown good adhesion. The failure is due to noncohesiveness of the sealer and lack of bonding between sealer and gutta-percha. A covalent bond formation occurs between the epoxide rings of AH Plus and exposed amino groups in dentinal collagen, thus adhering the two entities together.[19] Good flowability of epoxy resin sealers allows them for deep penetration into micro-irregularities, which increases their mechanical interlocking with dentin.[20]

Increased resistance to displacement of material from dentin surfaces occurs from cohesion between sealer molecules as a result of which adhesion is improved (Nunes *et al*. 2008).[21]

Result of this study resembles the studies conducted by Shoukouhinejad *et al*.[22] Seyda Ersahan *et al*.[23] Fuad Jacob Abi Rached Junior *et al*.[24] and H.M. Abada *et al*.[25] who had compared AH-Plus sealer with other sealers

Shoukouhinejad *et al*. on comparing the push-out bond strength of AH-Plus with Bioceramic (BC) sealer found no significant differences at any level. High push-out bond strength was because of chemical and mechanical adhesion at BC sealer/dentin junction alongwith chemical bonding at sealer/BC core material interface.[22]

In this subgroup V XP Endo file was not used for the irrigation. Thus smear layer and debris were not removed completely and it affected the adhesiveness of AH Plus sealer. In this group, XP Endo file was not used for the irrigation, so it is possible that complete smear layer and debris was not removed and it affected the adhesiveness of AH Plus sealer.

Sealapex being a calcium hydroxide-based sealer does not exhibit adhesion with dentin. The study finding suggests that the bond strength of Sealapex was low as compared dentin. This probably could be due to minimal tensile cohesion strength of self-cured calcium hydroxide sealers.[26]

Least bond strength in the subgroup Sealapex sealer without XP Endo file can be explained based on the facts that Sealapex does not bond to dentin and XP Endo file was not used for complete removal of debris through its irrigation process.

CONCLUSION

The present study highlights the importance of irrigant activation with XP Endo file which has direct positive impact on the adhesiveness of root canal sealers. Within the study limitations, with effective adhesion, the push-out bond strength of the sealers increases.

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Conflicts of interest

There are no conflicts of interest.

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