Evaluation of Different Dentin Adhesive Systems and its Effect on Apical Microleakage: An In Vitro Study

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How to cite the article:
Pradeep PR, Kasti KJ, Ananthakrishna S, Raghu TN, Vikram R. Evaluation of different dentin adhesive systems and its effect on apical microleakage: An in vitro study. J Int Oral Health 2015;7(5):44-48.

Abstract:
Background: Regardless of the technique and the material used, the goal of obturation remained the same that is to seal every portal of exit in the root canal system. It’s not only the apical openings that need to be sealed but also lateral openings, coronal access openings and perforations if they exist failure of the adhesive root canal sealer has led to the idea of usage of dentin bonding agents (DBAs) in endodontics, to make a three dimensional seal.

Materials and Methods:
A total of 40 maxillary incisors teeth were decoronated at cemento-enamel junction. Instrumenting to size 40 they were randomly assigned to four groups (n = 10) according to the dentin adhesive system used for obturation in combination with AH Plus sealer and gutta-percha points. The hybrid layer formation was observed using scanning electron microscope and the extent of dye penetration was measured using a stereomicroscope.

Results:
Group I: Control group, no hybrid layer formation. Group II: Uniform thin hybrid layer, with short multiple resin tags and lateral branchings. Group III: Uniform hybrid layer with short and thick resin tag formations. Group IV: Hybrid layer with numerous long discontinuous resin tags.

Conclusions:
Group I, (without adhesive) showed the highest apical microleakage highlighting the need for dental adhesive.

Key Words: Apical microleakage, dentin bonding agent, stereomicroscope

Introduction
Endodontic obturation is of prime importance to endodontists for over 200 years. Regardless of the technique and the material used, the goal of obturation is to seal every lateral, furcal, accessory canals and the apex in the root canal system.¹

Gutta-percha though a good obturating core does not have adhesive property to dentin, leading to the usage of root canal sealers. Sealers form good adhesion with the root canal wall, but none is able to bond to the gutta-percha cones.² On setting, the sealers pulls away from gutta-percha cones, leaving a gap leading to microleakage.³

Failure of the adhesive root canal sealer has led to the idea of usage of dentin bonding agents (DBAs) in endodontics, to have a fluid tight seal in the root canal system. Low viscosity resin may possibly be advantageous in the obturation of root canal system, if they flow into all the intricacies of canal system and form a perfect seal reducing microleakage.⁴ Etch and rinse adhesives form intimate micromechanical entanglement of resin monomers with etched dentin resulting in better marginal fit, may act as elastic buffer and increased enamel and dentin bond strengths.⁵ Self-etch adhesives though simplified the bonding procedures, allow movement of water across bonded interface which potentially leads to hydrolytic degradation, resulting in compromised bond strength over time.⁶ Hence, etch and rinse dentin bonding system is being used in this study.

In our study, we used traditional gutta-percha, time-tested epoxy resin and DBA to make the root canal leak-proof.

Materials and Methods
Forty extracted maxillary incisors with straight root canals were collected, decoronated at cement-enamel junction and stored in deionized water. Four groups were made containing 10 teeth each.

Biomechanical preparation of the root canals was carried out using step back technique. NaOCl was used as irrigant. Apical preparation was done to size 40. Final irrigation was done with deionized water and dried with paper points. Obturation was carried out as follows:

- Group I: Water based adhesive (One Coat SI) was applied inside the root canal using a Leur-lock syringe with 27 gauge endodontic needle. Excess bonding agent was aspirated with a syringe followed by paper points, and light cured. AH
Plus sealer coated master cone was seated to full working length, and lateral condensation carried out with accessory cones

- Group II: Acetone based adhesive (Prime and Bond NT) and the same procedure as in Group I
- Group III: Ethanol based adhesive (Excite DSC) and same procedure as in Group I
- Group IV (control group): No adhesive used and same procedure as in Group I.

Access cavities were sealed with Cavit-G and stored in saline for 48 h at 37°C.

External surface of the stored specimens were wiped dry with cotton swabs and was double coated with nail polish, except the apical 3 mm. After the nail polish dried, the specimens were immersed in 2% methylene blue for 48 h at 37°C. The specimens was washed under running tap water, dried and sectioned longitudinally, parallel the long axis of the tooth.

Evaluation of resin penetration into dentin by scanning electron microscope (SEM)

One specimen from each group was subjected to SEM for evaluation of resin penetration into dentin. Longitudinal grooves were cut at buccal and lingual surfaces of the roots. The sections were separated from each other with sharpened blade. The specimens were then mounted on aluminum stubs and sputter coated with gold for examination. Samples were observed for the presence of the hybrid layer, penetration of resin into dentinal tubules and presence of dentin–resin gaps.

Evaluation of apical dye leakage

Using stereomicroscope of ×40 magnification, each specimen were photographed and with the help of special computer software, apical dye leakage was measured from the apex to the point where dye no longer penetrated filling material, or dentinal tubules on both halves of each root. Scoring pattern was done according to Ozata et al.

Results

Group 1 (control: No adhesive used)

Stereomicroscopic: Maximum amount of leakage was measured in this group (Figure 1).

Group II specimen (Prime and Bond NT), showing the apical dye penetration

SEM: Uniform thin hybrid layer, with short multiple resin tags and lateral branchings (Figure 2).

Stereomicroscopic: Least apical microleakage was obtained in this group (Figure 3).

Group III (Excite DSC – Ethanol based DBA)

SEM: Uniform hybrid layer with short and thick resin tag formations (Figure 4).

Results

Group 1 (control: No adhesive used)

Stereomicroscopic: Maximum amount of leakage was measured in this group (Figure 1).

Group II specimen (Prime and Bond NT), showing the apical dye penetration

SEM: Uniform thin hybrid layer, with short multiple resin tags and lateral branchings (Figure 2).

Stereomicroscopic: Least apical microleakage was obtained in this group (Figure 3).

Group III (Excite DSC – Ethanol based DBA)

SEM: Uniform hybrid layer with short and thick resin tag formations (Figure 4).
Group IV (One Coat SL – water based DBA)

SEM: Hybrid layer with numerous long discontinuous resin tags (Figure 6).

Stereomicroscopic: Among the dentin adhesive containing Groups, Group IV showed highest leakage (Figure 7).

Statistical analysis

One-way ANOVA test was used to test the difference between groups. Mean dye penetration of 5.421 ± 2.9297 in the control group mean dye penetration of 0.219 ± 0.3283 in the Prime and Bond NT group mean dye penetration of 0.845 ± 0.5334 in the Excite DSC group mean dye penetration of 1.607 ± 2.6848 in the One Coat SL group. The differences observed between the groups are statistically significant.

Control group showed statistically significant difference from the other groups. Prime and Bond NT showed the least microleakage values which are statistically significant when compared to the values from Excite DSC and One Coat SL group. Excite DSC group in comparison with One Coat SL showed lower values. However they were not statistically significant (Table 1).

Discussion

Adhesion of root canal filling to the dentinal walls is advantageous for two main reasons. That is:

| Table 1: Distribution of dye leakage according to the scoring pattern. |
|-----------------|-----|-----|-----|-----|-----|
| Group           | 0   | 1   | 2   | 3   | Total |
| Control         | 0%  | 0%  | 0%  | 100%| 10%   |
| Prime and Bond NT | 50% | 30% | 20% | 0%  | 100%  |
| Excite          | 0%  | 60% | 10% | 30% | 100%  |
| One Coat SL     | 0%  | 30% | 20% | 40% | 100%  |
| Total           | 15% | 30% | 12.5% | 42.5% | 100% |
1. In a static situation, it would eliminate any space that allows percolation of fluids between the filling and root dentin and
2. In a dynamic situation, it resists filling dislodgment.

With the intention of obtaining fluid tight seal in root canal system, the sealer gutta-percha – adhesive combination have been carried out, which showed reduced microleakage after the usage of DBA.\textsuperscript{9,10} Drawbacks for not using resin were questionable results, difficult and unpredictable method of delivery into the root canal system and feasibility of re-treatment of canals. The materials do have the potential to increase the endoseal by reducing the microleakage thereby contributing to the success of orthograde endo treatment.

This study aimed at obtaining a fluid tight seal using the monoblock concept. That is the usage of different materials (gutta-percha, Ah plus sealer and dentin adhesive) in the root canal, which functions as one single unit in the root canal. The monoblock concept utilized in this study can be classified as tertiary monoblocks as there is three circumferential interfaces: one between the root dentin and the adhesive, two between the adhesive and the sealer and third between the sealer and gutta-percha.\textsuperscript{11} The use of dentin adhesive cannot be overlooked as it helps prevent leakage at all exits of root canal system. Ideally if adhesion works the entire length of the canal, the concept of bonding an impermeable resinous material in the root canal system seems appealing. However, until date, no study has proven the presence of such a monoblock within the root canal.

Studies reveal that there exists, the difference in the penetrating ability of the adhesive system and the scalability of different adhesive systems. Hence, this study was undertaken to evaluate different dentin adhesive systems with resin based sealer on apical microleakage.\textsuperscript{11-13}

Using SEM Jeol - JSM 5600LV specimens were observed for hybrid layer, resin tags and gaps between resin dentin interfaces.\textsuperscript{6,14} SEM study confirms the conclusions of previous studies\textsuperscript{10,15-17} about the resin tag formation and presence of the hybrid layer, found in most of the sections observed. Presence of gaps between resin dentin interface was also confirmed with that of other study.\textsuperscript{10}

Acetone based adhesive system exhibited good morphological features such as uniform, thin hybrid layer without breaks in resin tags due to its low viscosity and volatile nature. Ethanol based adhesive system showed thick hybrid layer with short resin tags probably due to its viscous nature. Water based adhesive system showed thin hybrid layer with long resin tags, which was often associated with breaks in between, which could be due incomplete polymerization as it was only light curable and not dual curable as the other dentin adhesive containing group and thus could have fragmented during specimen preparation.

Zidan’s comparative study\textsuperscript{18} showed that usage of dentin bonding as sealer with that of regular sealer (tubli-seal) and DBA did reduce the apical leakage. Similar result was obtained in the present study, which showed reduced leakage when compared with control group.

Karadag in her study\textsuperscript{11} found that the acetone-based adhesive (Prime and Bond NT) showed the least linear dye penetration when compared with that of water based dentin adhesive (Syntac single Component). The present study confirms with that done by Karadag.

Groups are containing dentin adhesive performed significantly better than the group without the adhesive that also confirms with previous studies done by Mannocci and Ferrari, Karadag et al., Ivona.\textsuperscript{9,15-17,19}

Conclusion

Under the conditions of the present study it can be concluded that: There was a significant difference (\(P < 0.001\)) in the apical sealing ability among the experimental groups when compared to that of the control group.

DBA, ERBS and GP does reduce apical microleakage Group I, (control group – without adhesive) showed the highest apical microleakage highlighting the need for dental adhesive. Followed by Group IV (water based DBS), Group III (ethanol based DBS) and Group II (acetone – based DBS).

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