Evaluation and comparison on the wettability of three root canal sealers after three different irrigant activation techniques: An in vitro study

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Abstract

Background: Wettability of root canal sealers to the root canal wall plays a significant role in the attainment of a fluid-tight seal.

Aims: This study aimed to evaluate and compare the wettability of three different root canal sealers on the root canal walls after three different irrigant activation techniques using the contact angle meter.

Subjects and Methods: Thirty-six single-rooted mandibular premolars after decoronation and cleaning and shaping up to size #35 were randomly divided into three groups with 12 samples in each group (n = 12) based on the different activation techniques: Group I (passive irrigation with side-vented needle), Group II (manual dynamic agitation), and Group III (passive ultrasonic irrigation). Root segments were split longitudinally and were subdivided into three subgroups based on the root canal sealers tested with four samples in each subgroup (n = 4): Subgroup A (Tubliseal EWT), Subgroup B (AH Plus), and Subgroup C (Endosequence BC sealer). A controlled volume droplet of sealer was placed on each specimen and was subjected to the contact angle meter.

Statistical Analysis: Data were statistically analyzed using the one-way ANOVA and Tukey’s post hoc test at a significance level of 0.05 (P < 0.05).

Results: A statistically significant difference was seen among all the groups and subgroups with the highest contact angle value for Group III and Subgroup C and the least value for Group I and Subgroup A.

Conclusions: Passive irrigation with side-vented needle and Tubli-Seal EWT showed better wettability on dentin.

Keywords: AH plus; contact angle meter; contact angle; endosequence BC sealer; manual dynamic agitation; passive ultrasonic irrigation; scanning electron microscopy; side vented needle; tubliseal EWT; wettability

INTRODUCTION

Success of endodontic therapy rely on proper cleaning, shaping, obturation, and maintenance of coronal seal in establishing a fluid impervious seal.[1] Satisfactory wetting and adequate flow are the essential properties for root canal sealers to establish fluid impervious seal.[2] Wetting means that solid-liquid interface is formed with simultaneous air expulsion and is expressed as contact angle.[3] Low contact angle indicates that the liquid (such as a sealer) wets well, whereas high values indicate poor wetting.

A large variety of sealer materials such as zinc oxide eugenol-based sealers, glass-ionomer cement sealers, and resin-based sealers are available. Bioceramic sealers with...
outstanding physicochemical and biological characteristics have recently drawn interest.

The surface tension of the sealer and the presence of smear layer on the root canal walls affect the contact angle. A lower contact angle of sealer represents a greater surface free energy and wettability of dentine and suggests a tendency for better flow and adhesion of the sealer to the dentine surface.\cite{10} Smear layer acts as a barrier to the penetration of intracanal disinfectants and sealers into dentinal tubules, resulting in microleakage between the root canal walls and filling materials.\cite{11} For these reasons, irrigation is a critical component of cleaning of the root canal system as they reach the areas inaccessible to instruments. To increase the efficiency of syringe irrigation, different needle types such as side-vented, double- and multi-vented needles are used. Variety of irrigant activation techniques are also employed to enhance irrigant distribution within the root canal system, categorized as manual agitation devices (using hand files, gutta percha points, and canal brushes), and machine-assisted agitation (sonic and ultrasonic devices, rotary brushes, and pressure alternation devices).\cite{12}

The present study evaluated and compared the wettability of three different root canal sealers on the root canal walls after three different irrigant activation techniques using the contact angle meter.

The null hypothesis was that there would be no significant difference in the wettability of different root canal sealers on the radicular dentin after using the irrigant activation technique.

**SUBJECTS AND METHODS**

Thirty-six extracted single-rooted mandibular premolars were collected and disinfected with 6% hydrogen peroxide [Figure 1a]. Teeth were examined using an operating microscope (Labomed Dental Microscope, Prima DNT, USA) at ×20 magnification, and those with immature apices, caries, restorations, fractures, or cracks were excluded from the study. Canal curvature of more than 10° was also excluded. It was determined by measuring the Schneider angle using the periapical radiographic images.

The teeth were decoronated with a 0.3-mm diamond disc (Diamant, Horico, Germany) to standardize the root length to 17 mm from the apex. The root apices were covered with sticky wax simulating clinical condition.\cite{13} Apical patency was maintained using ISO No 10 K file (Mani, Inc., Japan). Canal preparation was done by the step-back technique using stainless steel K files (Mani, Inc, Japan) and apex enlarged to file size 35 with working length 1 mm short of the root length using the Ingle’s method.\cite{14} The canals were irrigated with a standardized regimen of 2 ml of 5.25% NaOCl using 27 G needle between the instruments.\cite{15} The final irrigant activation was performed with various techniques using 3 ml of 17% ethylenediaminetetraacetic acid for 1 min followed by a final rinse of 3 ml of 5.25% NaOCl for 1 min.\cite{16}

The samples were divided into Group I, II, and III with 12 samples in each group (n = 12) based on the activation techniques.

- **Group I** - Passive irrigation with side-vented needle (Ammdent CANAL CLEAN –30 G needle)\cite{17}
- **Group II** - Manual dynamic agitation (MDA) using 25 size gutta percha (Three push and pull stroke in 3 s, Amplitude of 5 mm is used with the GP cone grasped 5 mm set back from the working length)\cite{18}
- **Group III** - Passive ultrasonic irrigation (PUI). (Three cycles of 20 s activation, 25 power setting in E mode, 28 kHz. Ultrasonic tip of size 20, taper 0.02 placed to 1 mm short of working length without touching the walls).\cite{19}

Following irrigation, apical third was resected using high-speed diamond abrasives (Mani, Inc, Japan), and the remaining root segments were split longitudinally in the bucco-lingual direction with diamond disk (Diamant, Horico, Germany) at low speed.\cite{20} For each specimen, the half containing the most visible part of the root canal wall was selected and stored in saline until use.

Groups I, II, and III were randomly subdivided into three subgroups A, B, and C with four samples in each subgroup (n = 4) based on the type of root canal sealer.

- **Subgroup A** – Tubliseal EWT (Sybron Endo, Kerr, USA)
- **Subgroup B** – AH plus (Dentsply, De Trey, Germany)
- **Subgroup C** – Endosequence BC sealer (Brasseler, Savannah, USA).

The specimens were blot dried\cite{21} and stabilized on a flat glass surface using cyanoacrylate glue. The sealers were manipulated and a controlled volume droplet of sealer were placed on each specimen using an endodontic spreader.\cite{22} Each specimen was then subjected to contact angle meter (SEO Phoenix) using FTA software to determine the contact angle in degree (°), to determine the wettability of different sealers\cite{23} [Figure 1b].

The mean values of contact angles of each group were measured, subjected to statistical analysis using the one-way ANOVA test and intergroup comparison with Tukey’s post hoc test using SPSS version 24 (IBM Corp, Armonk, USA). A confidence level of 95% was set (P < 0.05).

**RESULTS**

Highest contact angle was recorded for Group III (PUI) with mean value of 90.8994 followed by Group II (MDA)
with a mean value of 56.1230. Least value was observed for Group I (side vented needle) with a mean value of 44.843 [Figure 2a]. One-way ANOVA shows statistically significant difference among all the groups and subgroups [Table 1]. On Tukey’s post hoc analysis [Table 2], there is statistically significant difference between Group I (side vented needle) and Group III (PUI) as well as between Group II (MDA) and Group III (PUI). There is no significant difference between Group I (side vented needle) and Group II (MDA) with \( P = 0.489 > 0.05 \).

Highest contact angle was recorded for Subgroup C (Endosequence BC sealer) with mean value of 94.7517 followed by Subgroup B (AH Plus sealer) with a mean value of 54.2212. Least value was observed for Subgroup A (Tubliseal EWT) with a mean value of 42.8933 [Table 1 and Figure 2b].

On Tukey’s post hoc analysis [Table 2], there is statistically significant difference between Subgroup A (Tubliseal EWT) and Subgroup C (Endosequence BC sealer) as well as between Subgroup B (AH Plus sealer) and Subgroup C (Endosequence BC sealer). There is no significant difference between Subgroup A (Tubliseal EWT) and Subgroup B (AH Plus sealer) with \( P = 0.403 > 0.05 \).

**DISCUSSION**

Fluid impervious seal of the root canal system stops bacteria and their products from entering the periapical tissues, avoiding reinfection, ensuring long-term success of endodontic treatment.\(^{14}\) Solid core root filling materials do not reach the irregularities of the root canal system. Therefore, root canal sealers are used with solid core obturating materials to fill these irregularities.

Proper adaptation of the root canal sealer to the root canal wall is important in attaining fluid tight seal.\(^{15}\) Wettability of root canal sealers, measured by contact angle, influences its adaptability to the radicular dentin.\(^{16}\) Contact angle (\( \theta \)) is an angle of intersection formed by a liquid at the three-phase boundary where a liquid, gas, and solid intersect which can be measured from the solid surface through the liquid to the liquid/vapour tangent line originating at the terminus of the liquid/solid interface.\(^{16}\) Contact angle \( <90^\circ \); the liquid (sealer) wet the substrate, greater than 90° is nonwetting and 0° represents complete wetting.

Conventional syringe and needle irrigation fails to reach the difficult areas such as apical and isthmus regions.
Therefore, in this study, passive irrigation with 30 G side-vented endodontic needles (endodontic needles) were used for reproducible outcomes. MDA is more effective because they produce effective hydrodynamic activation of the solution and constant renewal of the spent irrigant. PUI employs “noncutting” action of ultrasonically activated file, transmitting acoustic energy from oscillating file or smooth wire to the irrigant in the canal inducing acoustic streaming of the irrigant. PUI has been shown to be superior to needle delivery of irrigants.

The objective of this study was to evaluate and compare the wettability of root canal sealers after various irrigant activation techniques. Significant difference in wettability was observed in all the irrigant activation techniques used. Therefore, the present study data rejected the null hypothesis.

On multiple comparisons, wettability showed significant difference between passive irrigation with side-vented needle and PUI. This was in accordance with the study done by Dhaimy et al. In addition, significant difference was observed between manually activated irrigation and PUI, in accordance with the study done by Saber and Hashem. The results of this study showed no significant difference between passive and manually activated irrigation. This was in conformance with the study by Boutsioukis et al.

In this study, passive irrigation with side-vented needles showed better wettability when compared to other groups. The increased wettability may be attributed to the fact that they create more pressure on the walls of the root canal, helping the irrigant to reflux and coronally displace debris while preventing the irrigant’s inadvertent flow into periapical tissues. Decreased wettability of MDA may be due to the less number of strokes used compared to other studies.

Poor result obtained with PUI may be because of low power intensity of ultrasonic activation (28 kHz) used in the study. Jiang et al. have found that the best cleaning results were achieved in the group subjected to the greatest output. Mozo et al. in their study suggested the power intensity to be 5.5 W for the irrigation to be more effective.

Root canal sealers can be grouped based on their primary constituents, such as zinc oxide eugenol, resin, and bioceramics. In this study, we used a zinc oxide eugenol-based sealer (Tubli-Seal EWT), resin-based sealer (AH Plus), and bioceramic sealer (Endosequence BC sealer).

Tubli-Seal EWT is a zinc oxide eugenol-based sealer that has served as a reference with which other sealers are compared, as they meet most of Grossman requirements. AH Plus is an improved epoxy resin-based sealer which penetrates better into the microirregularities, increasing the mechanical interlocking between the sealer and root dentin.

Bioceramics include alumina, zirconia, bioactive glass, glass ceramics, hydroxyapatite, and calcium phosphates. Endosequence BC sealer is a recently introduced bioceramic sealer based on calcium silicate, available as premixed, injectable paste with excellent flow, and dimensional stability. It utilizes the moisture present within the dentinal tubules for setting.

When subgroups with different sealers were compared, there was a significant difference among the three subgroups, in which Tubliseal EWT showed greater wettability followed by AH Plus and least wettability by Endosequence BC sealer regardless of the irrigation activation techniques used. This may be explained by its comparatively lower intermolecular attraction and surface tension. Low wettability of AH Plus could be due to its hydrophobic characteristic. The results obtained with Endosequence BC sealer in this study did not meet the expectations, probably due to the low surface energy which resulted in decreased wettability. According to Ha et al., in their study, the surface energy parameters were calculated by treating the materials as if they were solids, which made it possible for Endosequence BC sealer to measure less contact angle. Pretreatments were not done in this study to simulate the clinical conditions. No
literature, up to this date, has described the wettability of BC sealer on dentin after different irrigation techniques.

On multiple comparisons, wettability showed significant difference between Tubliseal EWT and Endosequence BC sealer, in contradiction with Zhang et al.[24] However, they measured the contact angle of sterile water on the BC sealer, which represents wettability of water with sealer, not sealer to dentin. In addition, significant difference was observed between AH Plus and Endosequence BC sealer, contradicting the study done by Ha et al.[23] The results also showed no significant difference between Tubliseal EWT and AH Plus contradicting the study done by Mulay et al.[25]

The limitations of the present study include:
1. Root canals were prepared with K files rather than rotary files producing decreased taper, decreased smear layer removal and lesser wettability
2. Root surfaces were not polished after splitting to simulate clinical scenario. However, they were polished in earlier studies[22]
3. Lesser number of strokes for MDA could have resulted in decreased smear layer removal
4. Low power intensity was used for PUI
5. No load was applied to the sealer. Sealers may behave differently when pressure is applied during root canal obturation.

**CONCLUSIONS**

Within the limitations of this in vitro study, it was concluded that passive irrigation with side-vented needle contributed to more wettability on dentin than MDA and PUI and zinc oxide eugenol-based sealer (Tubli-Seal EWT) showed better wettability on dentin than resin-based sealer (AH plus) and bioceramic sealer (Endosequence BC sealer).

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**Conflicts of interest**
There are no conflicts of interest.

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