

Original Research

Evaluation of Sealing Ability and Flow Properties of Three Root Canal Sealers: An In Vitro Analysis

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ABSTRACT:

Aim: The study aimed to compare the sealing ability, flow characteristics, and dimensional stability of three different root canal sealers: AH Plus, MTA Fillapex, and Bio-C® Sealer. **Materials and methods:** In this study, 75 freshly extracted mandibular incisors with straight, single root canals were selected. To ensure consistency, the teeth were decoronated to a standardized length of 11.5 mm. The root canals were prepared to the working length using a size 60 K file, with continuous irrigation using a 2.5% sodium hypochlorite solution and normal saline. Following instrumentation, the smear layer was removed by treating the canals with a 17% ethylenediaminetetraacetic acid (EDTA) solution for one minute. The prepared specimens were then randomly divided into three groups of 15 teeth each, with obturation performed using one of three sealers: Bio-C® Sealer, AH Plus, or MTA Fillapex. All sealers were prepared according to the manufacturer's instructions. The collected data were analyzed using SPSS software. **Results:** The study evaluated the mean sealer penetration depth, flow characteristics, setting time, and solubility of three different endodontic sealers: Bio-C® Sealer, AH Plus, and MTA Fillapex. Among the tested materials, Bio-C® Sealer exhibited the lowest mean penetration depth ($311.23 \pm 49.45 \mu\text{m}$), whereas AH Plus and MTA Fillapex showed significantly higher penetration depths of $483.22 \pm 67.21 \mu\text{m}$ and $472.32 \pm 43.22 \mu\text{m}$, respectively. A statistically significant difference was observed ($p < 0.005$), indicating that Bio-C® Sealer had significantly lower penetration than the other sealers. In terms of flow characteristics, Bio-C® Sealer demonstrated a flow of 23.14 mm, a setting time of less than 201 minutes, and a solubility of 2.10%. AH Plus exhibited the highest flow among the sealers ($30.11 \pm 5.51 \text{ mm}$), a notably shorter setting time ($7.02 \pm 5.73 \text{ minutes}$), and a solubility of 1.8%. MTA Fillapex had a flow of 27.22 mm, a setting time of $111 \pm 18.21 \text{ minutes}$, and the lowest solubility ($1.11 \pm 1.62\%$). **Conclusion:** Root canal sealers are essential in endodontic treatment, impacting both sealing ability and biocompatibility.

Keywords: Sealers, endodontic, obturation

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INTRODUCTION

Endodontic treatment aims to eliminate root canal infections and achieve a three-dimensional fill of the canal space to prevent the infiltration of liquids and microorganisms from both apical and coronal directions. Root canals are typically filled using gutta-percha points in conjunction with an endodontic sealer, which plays a crucial role in establishing a fluid-tight seal.^{1,2}

The primary function of a sealer is to fill the gaps between the core material and the canal walls, as well as between gutta-percha cones, ensuring a void-free obturation. Additionally, sealers help seal irregularities, minor discrepancies, accessory canals, and multiple foramina. Their germicidal properties aid in eliminating residual bacteria after the cleaning and shaping process. Despite efforts to confine the sealer within the root canal, some extrusion may

inadvertently occur during obturation. When in contact with periapical soft and hard tissues, sealer extrusion can lead to persistent inflammation, causing pain, tenderness, and swelling, ultimately delaying wound healing.^{4,5,6}

Therefore the study aimed to compare the sealing ability, flow characteristics, and dimensional stability of three different root canal sealers: AH Plus, MTA Fillapex, and Bio-C® Sealer.

MATERIALS AND METHODS

In this study, 75 freshly extracted mandibular incisors with straight, single root canals were selected. To ensure consistency, the teeth were decoronated to a standardized length of 11.5 mm. The root canals were prepared to the working length using a size 60 K file, with continuous irrigation using a 2.5% sodium hypochlorite solution and normal saline. Following

instrumentation, the smear layer was removed by treating the canals with a 17% ethylenediaminetetraacetic acid (EDTA) solution for one minute. The prepared specimens were then randomly divided into three groups of 15 teeth each,

with obturation performed using one of three sealers: Bio-C® Sealer, AH Plus, or MTA Fillapex. All sealers were prepared according to the manufacturer's instructions. The collected data were analyzed using SPSS software.

RESULTS

Table 1: Sealing ability of all three sealers

Sealer name	N	Mean (μm)	Std deviation	p- value
Bio C Sealer	25	311.23	49.45	<.005
AH Plus	25	483.22	67.21	
MTA Fillapex	25	472.32	43.22	

The study compared the mean sealer penetration depth (in micrometers) among three different endodontic sealers: Bio C Sealer, AH Plus, and MTA Fillapex. Bio C Sealer exhibited the lowest mean penetration depth ($311.23 \pm 49.45 \mu\text{m}$) among the tested materials, while AH Plus and MTA Fillapex demonstrated significantly higher mean penetration depths of $483.22 \pm 67.21 \mu\text{m}$ and $472.32 \pm 43.22 \mu\text{m}$, respectively. A statistically significant difference was observed ($p < 0.005$), indicating that Bio C Sealer exhibited significantly lower penetration compared to the other sealers.

Table 2: Flow Characteristics, Setting Time, and Solubility of Various Endodontic Sealers

Sealer name	Flow(mm)	Setting time(minutes)	Solubility (%)
Bio C Sealer	23.14	<201	2.10
AH Plus	30.11 ± 5.51	7.02 ± 5.73	1.8
MTA Fillapex	27.22	111 ± 18.21	1.11 ± 1.62

The flow characteristics, setting time, and solubility of various endodontic sealers were evaluated in this study. Bio C Sealer demonstrated a flow of 23.14 mm, a setting time of less than 201 minutes, and a solubility of 2.10%. AH Plus exhibited the highest flow among the tested sealers (30.11 ± 5.51 mm), a significantly shorter setting time (7.02 ± 5.73 minutes), and a solubility of 1.8%. MTA Fillapex showed a flow of 27.22 mm, a setting time of 111 ± 18.21 minutes, and the lowest solubility ($1.11 \pm 1.62\%$). These findings indicate variations in the physicochemical properties of the tested sealers, which may influence their clinical performance.

DISCUSSION

Successful endodontic treatment relies on thorough cleaning, shaping, and complete three-dimensional obturation of the root canal system to prevent microbial infiltration and reinfection. Root canal sealers play a crucial role in achieving a hermetic seal by filling voids between the core filling material and canal walls, sealing accessory canals, and enhancing the overall stability of the obturation. An ideal sealer should exhibit excellent sealing ability, flow characteristics, dimensional stability, and biocompatibility while minimizing cytotoxic effects on periapical tissues.^{6,7}

Various types of root canal sealers, including epoxy resin-based, calcium silicate-based, and MTA-based sealers, have been developed to enhance endodontic outcomes. AH Plus, a widely used epoxy resin-based sealer, is known for its excellent adhesion and low solubility. MTA Fillapex, a mineral trioxide aggregate-based sealer, offers bioactivity and promotes periapical healing, while Bio-C® Sealer, a bioceramic-based material, is designed to provide superior biocompatibility and dimensional stability.^{8,9} This in vitro study aims to compare the sealing ability, flow characteristics, and dimensional stability of three distinct root canal sealers—AH Plus, MTA Fillapex, and Bio-C® Sealer—to evaluate their performance in clinical endodontic applications.

Our study evaluated the mean sealer penetration depth, flow characteristics, setting time, and solubility of three different endodontic sealers: Bio-C® Sealer, AH Plus, and MTA Fillapex. Among the tested materials, Bio-C® Sealer exhibited the lowest mean penetration depth ($311.23 \pm 49.45 \mu\text{m}$), whereas AH Plus and MTA Fillapex showed significantly higher penetration depths of $483.22 \pm 67.21 \mu\text{m}$ and $472.32 \pm 43.22 \mu\text{m}$, respectively. A statistically significant difference was observed ($p < 0.005$), indicating that Bio-C® Sealer had significantly lower penetration than the other sealers.

In terms of flow characteristics, Bio-C® Sealer demonstrated a flow of 23.14 mm, a setting time of less than 201 minutes, and a solubility of 2.10%. AH Plus exhibited the highest flow among the sealers (30.11 ± 5.51 mm), a notably shorter setting time (7.02 ± 5.73 minutes), and a solubility of 1.8%. MTA Fillapex had a flow of 27.22 mm, a setting time of 111 ± 18.21 minutes, and the lowest solubility ($1.11 \pm 1.62\%$).

In the study by Setya et al.¹⁰ aimed to compare sealer distribution within the root canal using three different sealers in combination with three distinct obturation techniques. Ninety maxillary central incisors were prepared, and the root canals were filled with AH Plus, Fuji-1, or Tubliseal Extended Working Time (EWT) using a lentulospiral. The results revealed a significant difference in the mean PSCP values among

the three sealers ($P < 0.000$), with Tubliseal EWT demonstrating the highest PSCP values, followed by AH Plus and Fuji-1. Additionally, differences were observed between the obturation techniques ($P < 0.00$), where the single cone technique exhibited the highest PSCP values, followed by lateral condensation and vertical condensation. However, no significant difference was noted between the 3 mm and 6 mm sections ($P < 0.945$). The study concluded that Tubliseal EWT provided the highest PSCP values, and the single cone technique resulted in greater sealer distribution compared to lateral and vertical condensation techniques at both sectioning levels.

A study by Miletić I et al.¹¹ aimed to evaluate the apical sealing ability of five different root canal sealers using a fluid transport model. Sixty single-rooted teeth were selected, with the coronal portion removed at the amelo-cemento junction and 3 mm of the root tip resected. Root canals were prepared using the step-back technique with Gates Glidden drills and irrigated with 2.5% sodium hypochlorite. The specimens were divided into five groups of 10 samples each and obturated with gutta-percha and one of the test sealers—AH26, AH Plus, Diaket, Apexit, or Ketac-Endo—using the cold lateral condensation technique. A control group of 10 teeth was included, with five serving as negative and five as positive controls. Apical leakage was assessed by measuring the movement of an air bubble in a capillary glass tube connected to the experimental root section. The results showed no statistically significant differences in leakage among the tested sealers, with mean leakage values recorded as Ketac-Endo (0.318 μ L; SD 0.084), AH26 (0.319 μ L; SD 0.075), AH Plus (0.330 μ L; SD 0.085), Apexit (0.360 μ L; SD 0.127), and Diaket (0.387 μ L; SD 0.140) ($P > 0.05$). The study concluded that under the given experimental conditions, all five root canal sealers provided a satisfactory apical seal.

A study by Sousa CJ et al.¹² evaluated the intraosseous biocompatibility of AH Plus, EndoREZ, and Epiphany root canal sealers following the guidelines of the Fédération Dentaire Internationale (FDI) Technical Report #9. Thirty guinea pigs were divided into three groups (10 per sealer) and observed over 4- and 12-week periods. Each animal received an implant on both sides of the lower jaw symphysis. After the designated periods, the animals were euthanized, and histological analysis was performed. The results showed that EndoREZ induced a severe inflammatory reaction at both time points. AH Plus initially caused a severe response, which reduced to moderate over time. In contrast, Epiphany exhibited the highest biocompatibility, promoting bone formation with none to slight inflammatory reactions. The study concluded that Epiphany was the only root canal sealer demonstrating intraosseous biocompatibility across both evaluation periods.

A limitation of this study was the relatively small sample size, which may impact the generalizability of the findings. Additionally, variations in results could occur with a larger sample or under different clinical conditions. Future studies with a greater number of samples and extended evaluation parameters are recommended to validate these findings.

CONCLUSION

Root canal sealers are essential in endodontic treatment, impacting both sealing ability and biocompatibility.

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