Comparison of Sealing Ability in the Apical Third of Tooth Root Canals after Post Preparation and Obturation with MTA Sealer and Epoxy Sealer

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Abstract: The success of endodontic treatment is largely dependent on the sealing achieved by root canal obturation. Some endodontically treated teeth require restoration using posts and cores. This involves partial removal of the root canal filling to create adequate space for the retention of the intracanal post. Root canal sealers, such as epoxy and Minerale Trioxide Aggregate (MTA) sealers that have excellent adhesive properties and sealing ability, are commonly used to maintain the obturation seal. The aim of this study was to compare the sealing ability of MTA and epoxy sealers in the apical third of the root canal after post preparation. Root canal preparation was carried out in 40 human teeth using a crown-down technique. Irrigation was performed using 2.5% NaOCl and 17% EDTA, and RC-Prep was used for lubrication. The canals were then filled with gutta percha and root canal sealers (MTA Fillapex or AH Plus) using a cold lateral condensation technique. The teeth were then decalcified using the Robertson technique and examined under a stereomicroscope. Post preparation was performed 7 days after obturation using a peeso reamer. The residual seal was measured by examining the extent of dye leakage, where a score of 1 indicated ink penetration up to 0–0.5 mm, a score of 2 indicated ink penetration up to 0.51–1 mm, and a score of 3 indicated ink penetration of >1 mm. The distribution of dye leakage scores in the SE group was 35%, 30%, and 35% for scores 1, 2, and 3, respectively. The corresponding distribution in the SM group was 25%, 30%, and 45% for scores 1, 2, and 3, respectively. Chi-square test showed no significant differences between the two groups. The extent of dye leakage observed suggested that the both types of root canal sealers (MTA Fillapex or AH Plus) exhibited similar sealability.

1. Introduction
Adequate sealing of the root canal by obturation is necessary as it acts as a barrier and prevents bacterial infiltration [1]. Disturbance of the apical sealing can lead to bacterial invasion through the root canal, often resulting in reinfection and failure of the root canal treatment [1,2]. Therefore, root canal sealers are
often used in combination with gutta percha to ensure satisfactory filling of persistent irregularities and gaps in the root canals. Teeth that have undergone root canal treatment often exhibit extensive loss of tooth structure and require restoration using posts. Effective removal of gutta percha for post preparation is critical for the success of this treatment [2,3]. However, this procedure (gutta percha removal and post preparation) often exerts forces on the root canal filling material and disrupts its bonding and sealing ability in the apical third of the canal [4]. This weak bonding with the sealers on the walls of the root canal can subsequently lead to dislodgement of the filling material during post preparation, resulting in apical leakage of the residual filling material [5,6].

Several studies have supported the use of epoxy sealers as root canal filling materials because of their stable dimensions and good adhesive properties with dentin, which lead to effective sealing of the canals [5,7,8].

The newly developed MTA Fillapex sealer contains MTA powders and salicylate resins, which makes its consistency ideal for use as a root canal sealer [9,10]. This is further supported by its excellent sealing ability, as reported by the manufacturers. The MTA powders present in these sealers support healing and formation of hard tissue, especially when used for endodontic treatment of teeth with periapical abnormalities [11]. Moreover, the MTA sealer also exhibits long-term antimicrobial effects by slowly releasing Ca(OH)2 over a long period [10,11]. In 2013, Poedyaningrum et al. examined the apical third of the root canal and reported no difference in the sealing ability of MTA and epoxy filling materials [12].

The main objective of this study was to compare the sealing ability of MTA and epoxy sealers in the apical third of the root canal after post preparation. The hypothesis was that there would be no difference in the sealing ability of the two sealers.

2. Methods
This laboratory-based, experimental study was carried out at the Conservation Clinic in Teaching Dental Hospital, Dental Materials Laboratory, and Oral Biology Laboratory of Faculty of Dentistry Universitas Indonesia. The study sample included 40 human extracted teeth with single root canals, and other materials used were MTA (Fillapex, Angelus) sealer; epoxy sealer (AH Plus); 2.5% NaOCl; 17% EDTA; aquades; gutta percha; nail varnish; Indian ink; glass ionomer cement; 5% nitric acid; 80%, 90%, and 100% alcohol; and 100% methyl salicylate. The tools required for this study included endomotor units with rotary ProTaper instruments, peeso reamers, petri caps, incubators, and a stereo microscope.

2.1 Sample Preparation
The samples were cleaned and stored in 0.9% NaCl solution until treatment. Root canal preparation was carried out using a ProTaper rotary instrument up to size F3. The working length, estimated to extend to 1 mm above the apical foramen, was created using K-File #15. The canals were irrigated using 2.5% NaOCl and 17% liquid EDTA, followed by 2.5% NaOCl solution. The canals were flushed with aquades between every solution. The root canals were dried using endodontic suction and paper points (#30) before obturation.

The prepared samples were then randomly divided into two groups, namely the SE group (epoxy AH Plus sealer) and the SM group (MTA Fillapex sealer). The lateral condensation technique was used to fill the samples in the SE group with epoxy sealer and those in the SM group with MTA sealer. All samples were incubated in 0.9% NaCl solution at 37°C and 100% humidity for 7 days. The post preparation was carried out using a peeso reamer, and the filling material in the apical section of the tooth was left to be 5 mm long. The coronal part of the tooth was filled using glass ionomer cement. Two layers of nail varnish were applied to the entire outer surface of the tooth except 1 mm above the apical end part [13]. After 1
day, all of the samples were immersed in Indian ink at 37°C for 7 days. Thereafter, the samples were removed from the Indian ink solution, washed under running water, and the nail varnish was removed using a scalpel. The samples were then decalcified and made transparent using the Robertson method [13].

2.2 Sample Transparency
The samples were immersed in 5% nitric acid solution, which was shaken three times a day and replaced daily. On the third day, the coronal parts of the samples were checked using a needle and were considered to be ready for the next stage of treatment if found to be soft. The teeth were rinsed with running water for 4 h and then immersed in 80% alcohol for 12 h, 90% alcohol for 1 h, and 100% alcohol for 3 h. The alcoholic solutions were replaced every hour. Finally, the samples were immersed in 100% methyl salicylate for 2 h at a temperature of 37°C to achieve transparency.

2.3 Assessment of Sealability on Apical Third
The samples were observed using a stereo microscope (Discovery v12, Carl Zeiss AxioCam ICc 1, Germany) at a magnification of 20X. The extent of dye penetration in the root canal of each tooth was measured using a millimeter grid. The Pathomvanich score was used to grade these measurements, with a score of 1 indicating 0–0.5 mm of ink penetration; a score of 2 indicating 0.51–1.0 mm of ink penetration; and a score of 3 indicating ink penetration exceeding 1 mm.

3. Results
The groups were compared using a nonparametric chi-square test (Table 1). All statistical analyses were performed using the statistical package, SPSS 16, the level of significance was set at $\alpha = 0.05$. The chi-square test showed no statistically significant differences between the two groups.

| Sample group | Leakage level | Total | $p$-value |
|--------------|---------------|-------|-----------|
|              | 1  | 2     | 3     |       |
| SE           | 7  | 35    | 6     | 30    | 7  | 35    | 20   |
| SM           | 5  | 25    | 6     | 30    | 9  | 45    | 20   |
| Total        | 12 | 12    | 16    | 40    |     |       | 0.747|

Table 1. Leakage level of SE and SM groups

4. Discussion
Forces exerted during post preparation often disrupt the sealing achieved by root canal obturation. Epoxy sealers exhibit fairly good sealability as they contain adhesive epoxy resins and can enter into the dentinal tubules. MTA sealers, in contrast, contain disalicylate resin, which also exhibit good physical properties and are suitable for use as a sealer.

Upon mixing the two AH Plus pastes of epoxy sealers, a polyaddition thermal reaction is seen to occur. Monomers, diepoxides, and amines react with the oligomers, which have epoxy and amino-tipped groups, and they may join the remaining monomers or other oligomers [8]. This reaction ultimately leads to the
formation of a high molecular weight addition polymer and also produces no waste products using up almost all of the monomer present [8]. The amines contained in these sealers undergo polymerization by deposition to form copolymers. Diamine plays a role in the formation of a thermoplastic material with stable dimensions and high flexural strength, thus allowing it to absorb the pressures created by changes in the temperature or mechanical stress [8]. Upon setting, the epoxy sealer first expands and then begins to shrink after approximately 2 years [14].

The MTA Fillapex sealers contain nanoparticles of MTA powders and rosins (resin), resulting in good flowability that allows penetration of the material into the main and lateral root canals and dentinal tubules [10]. The hydration reaction forms several other products including calcium silicate hydrate (CSH) gel, ettringite (hydrate hexacalcium aluminate trisulfate), portlandite (calcium hydroxide), and calcium monosulfoaluminate/calcium monocarboaluminate [10,11,15]. The CSH gel, which is sticky and porous, has good flowability and can bind to the gutta percha easily, allowing it to flow into the main and lateral root canals and dentinal tubules. It hardens within 4–6 h, and the setting reaction is completed within several days [11]. Phosphate is seen to form on the dentin–MTA interface, and radiographic and SEM examinations of this interstitial adherent layer shows a resemblance to hydroxy apatite, albeit with a slightly different ratio of calcium and phosphate. This layer indicates superior marginal adaptation [11,15], eparation of the root canal also plays an important role in achieving effective sealing, with the crown-down technique facilitating irrigation and clearance of the canal [16]. In this study, irrigation of the root canal was carried out using 2.5% NaOCl and 17% EDTA, which remove the organic and inorganic substances from the root canals, respectively [17,18,19]. Each turnover between NaOCl and EDTA was interspersed with aquades as the reaction between the two can lead to harmful interactions [18]. Final irrigation with sodium hypochlorite created an alkaline environment that was conducive for the hydration reaction of calcium silicate. This was necessary as the acidic environment created upon irrigation with EDTA could negatively affect the MTA sealer by increasing its porosity and decreasing and weakening its microstructure [11].

Post preparation was carried out mechanically using a peeso reamer instrument. Although there are several ways to remove gutta percha from the canals, including chemical, mechanical, and thermal, this study used the mechanical techniques as it was easier to control the working length. Yadav et al. (2011) reported that mechanical removal of gutta percha produced better results compared to removal using heat or chloroform [5].

The apical sealing can be examined for leakage using the fluid filtration method, polymicrobial penetration method, dye penetration calculation using longitudinal cutting, or the transparency technique. In this study, the apical sealing was examined using the dental transparency technique, per the Robertson method, to allow visualization of the extent of ink penetration into the root canal through the apical foramen [13]. The main advantages of this technique included easy execution using chemicals that were commonly available and no need for any form of cutting. The latter prevented disruption of the filling or biasing of the results due to random cutting directions [20]. Moreover, this technique also allowed visualization of the extent of ink penetration in three dimensions.

5. Conclusion
The results of this study showed no significant differences in the seal ability of MTA and epoxy sealers when used to fill the apical third of the tooth root canals.
References

[1] Slutzky-Goldberg I, Slutzky H, Gorfil C and Smidt A 2009 Restoration of endodontically treated teeth review and treatment recommendations Int. J. Dent. 2009 1-9.
[2] Grecca F S, Rosa Â R G, Gomes M S, Parolo C F, Bemfica J R D, Frasca L C D F and Maltz M 2009 Effect of Timing and Method of Post Space Preparation on Sealing Ability of Remaining Root Filling Material: In Vitro Microbiological Study JCDR. 75 583i-e.
[3] Pesce A L C, López S G and Rodriguez M P G 2007 Effect of post space preparation on apical seal: Influence of time interval and sealer Med. Oral Patol. Oral Cir. Bucal. 12 E464-68.
[4] Yadav H, Yadav S, Chowdhary P and Malik M 2011 An Electrochemical Study of the Effect of Partial Removal of the Root Canal Filling Material on the Periapical Seal Prior to Post and Core Preparation J OHCD. 5 142-4.
[5] Ersahan S and Aydin C 2010 Dislocation resistance of iRoot SP, a calcium silicate-based sealer, from radicular dentin J. Endod. 36 2000-2002.
[6] Khedmat S and Sedaghati M 2006 Comparison of the tensile bond strength of four root canal sealers J. Dent. 3 1-5.
[7] AH Plus Root canal sealer. In: DeTrey D, editor.: Dentsply DeTrey.
[8] Mambodoo A 2006 Shear bond strength measurement of different root canal sealers to gutta percha J. Bagh. College of Dentistry 18 21-25.
[9] MTA Fillapex Endodontic Sealer Scientific Profile. In: Technology ASa, editor. Brazil.
[10] Meidyawanti R, Suprastiwi E 2017 Comparison sealing ability of MTA sealer and resin epoxy sealer J Int Dent Med Res 10 134-8
[11] Rawritya M, Verma K, Singh S, Munuga S and Khan S 2013 MTA-based root canal sealers J. Orofac. Res. 3 16-21.
[12] Poedyaningrum F, Suprastiwi E and Usman M 2013 Perbandingan kebocoran mikro pengisian saluran akar dengan semen resin epoki dan MTA pada sepertiga apeks (eksperimental laboratori) Thesis Paper
[13] Robertson D, Lee J, McKee M and Brewer E A 1980 Clearing Technique for the Study of Root Canal systems J. Endod. 8 431-4.
[14] Schmalz G and Hørsted-Bindslev P 2010 Textbook of Endodontology. 2 ed. In Bergenholtz G, Hørsted-Bindslev P, Reit C, editors. (United Kingdom: Wiley-Blackwell) p 202-13.
[15] Chang S W 2012 Chemical characteristics of mineral trioxide aggregate and its hydration reaction [188-93 pp.].
[16] Bermans L, Cleynenbreugel J V, Wevers M and Lambrechts P 2001 Mechanical root canal preparation with NiTi rotary instruments: Rationale, performance and safety Am. J. Dent. 14 324-33.
[17] Shokouhinejad N, Hoseini A, Gorjestani H and Shamshiri A R 2013 The effect of different irrigation protocols for smear layer removal on bond strength of a new bioceramic sealer Iran. Endod. J. 8 10-3.
[18] Haapasalo M, Shen Y and Gao W Q 2010 Irrigation in Endodontics. Dent. Clin. N. Am. 54 291-12.
[19] Khan T, Hassan M, Babarahad and Shafiq N 2011 Smear layer and sealing ability of three root canal sealers Pak. Oral Dental J. 31 178-82.
[20] Verissimo D M and Vale M S D 2006 Methodologies for assessment of apical and coronal leakage in endodontic filling materials: a critical review J. Oral Sci. 48 93-8.