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Official Publication of Istanbul University Faculty of Dentistry

Eur Oral Res 2018; 52(3): 117-21

Original research

Comparative evaluation of apical sealing ability of different root canal sealers

Purpose
The aim of this study was to compare the short and long term apical sealing ability of different root canal sealers.

Materials and methods
Fifty-five extracted human anterior single-root teeth were used. The coronal part of each tooth was removed and the root canals were prepared with NiTi rotary instruments. Teeth were divided into 5 study groups; Group I: MTA Fillapex (Angelus, Brazil); Group II: Sealapex (Sybron-Kerr, Romulus, MI, USA) and Group III: AH Plus (Dentsply, Konstanz, Germany) (n=15) and negative and positive control groups (n=5). The quality of root canal sealing was assessed by a fluid filtration method performed at 24 h and 180-day time intervals. Kruskal Wallis and Mann Whitney U tests were used to compare the groups.

Results
At 24 h evaluation, MTA Fillapex presented significantly less microleakage than the Sealapex and AH Plus (p<0.05). At long term interval (180-day), Sealapex and AH Plus presented significantly less microleakage than the MTA Fillapex (p<0.05).

Conclusion
Sealapex and AH Plus showed significantly better sealing abilities than MTA Fillapex in the long term.

Keywords: *MTA fillapex; AH plus; Sealapex; microleakage; fluid filtration method*

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Received: 12 December 2016
Revised: 10 March 2017
Accepted: 05 April 2017

DOI: 10.26650/eor.2018.438

Introduction

The predictable outcomes of endodontic treatment rely on mechanical instrumentation and cleaning of the root canal system, elimination of the microorganisms and organic debris, as well as filling the entire root canal (1). It is commonly accepted that microleakage between the root canal walls and root canal filling might adversely affect the outcome of the endodontic treatment (2). Consequently, sealing the entire root canal system after cleaning and shaping is of utmost importance to prevent oral pathogens from colonizing and re-infecting the root and periapical tissues (3).

In endodontic treatment, sealers are principally used to fill the irregularities of the root canal system, to provide lubricating or to attach the gutta-percha to the root canal walls (1). Endodontic sealers should meet some requirements, such as biocompatibility, dimensional stability, insolubility in oral fluids, radiopacity, ease of application, antibacterial properties, adaptability to the root canal walls, as well as the ability to produce a hermetic seal (4). However, none of the sealers currently available have all characteristics of the ideal sealer (5-7).

How to cite: *Altan H, Göztaş Z, İnci G, Tosun G. Comparative evaluation of apical sealing ability of different root canal sealers. Eur Oral Res 2018; 52(3): 117-21.*

Based on the superior biocompatibility and high alkaline activity of mineral trioxide aggregate (MTA), root canal sealers were manufactured (8-10). An MTA-based root canal sealer, MTA Fillapex (Angelus, Londrina, Brazil), has been introduced and is composed of synthetic Portland cement, which are dark gray nodular materials (11). According to the manufacturer's description, MTA Fillapex exhibited high radiopacity, slow setting time, sufficient working time, perfect flow to allow the filling of accessory canals, low solubility, effortless removal if re-entry is required, and easy handling with small auto mixing tips (11). MTA Fillapex was introduced in last years, but only a limited number of studies have determined the microleakage of this MTA-based sealer (12, 13). The present study was designed to compare the short-term and long-term apical sealing ability of MTA Fillapex using fluid filtration technique. The null hypothesis of this study was that there is no difference in apical sealing ability among the all tested sealers at short term and long term intervals.

Materials and methods

Ethics committee approval was obtained in conjunction with study approval by the Ethics Committee of Selçuk Universiy, Faculty of Dentistry (No: 2013/05, Date: 02.05.2013).

Canal preparation and obturation

Fifty-five single-root human anterior teeth were divided at the cervical plane to get 15-mm long sequence of root. The working length of each root was determined by a 15 K-file (Kerr Corporation, Orange, CA, USA). The canal space was enlarged with ProTaper system rotated at 250 rpm (Dentsply, Ballaigues, Siwtzerland) under a continuous 5% NaOCl irrigation. The apical length was confirmed with a size 15 K-file manually between each ProTaper instrument. Preparation of the apical third portion was finished using Ni-Ti manual instruments (Dentsply, Ballaigues, Siwtzerland) to a size 40 K-file. All samples were prepared to the same final apical size, and the same operator handled both the preparation and filling steps. After preparation was carried out, the root canals were irrigated with 17% ethylenediaminetetraacetic acid (EDTA) for 1 min. to eliminate the smear layer. After EDTA solution, 5% NaOCl used for neutralization, afterward the canal was rinsed with distilled water (5 mL) and dried with paper points.

Sealapex (Sybron-Kerr, Romulus, MI, USA), AH Plus (Dentsply, Konstanz, Germany), and MTA Fillapex were applied according to the manufacturers' instructions and located into the root canals with a Lentulo (Dentsply Maillefer, Ballaigues, Switzerland) (n=15). The composition of tested root canal sealers are listed in Table 1.

Gutta-percha points (Dia Dent, Cheongju-si, Korea) were placed at the working length (15 mm), and root canals were filled using the cold lateral compaction technique. Thereafter, excess material was removed using a heated instrument 1 mm below access opening. Five samples filled with only gutta-percha and not coated with nail varnish were used as positive controls, and five other samples filled with only gutta-percha and apical end completely covered with two coat nail varnish as negative controls. After the obturation procedures, the filled samples were stored at 37°C and 100% humidity for 24 hours to allow setting of the sealer.

Assesment of microleakage

Nail varnish was used to block the transition of fluid across the dentinal tubules and provide that any liquid flow measured was caused by flow along the interface between the root canal walls and sealer. The outer surface of roots was double coated using nail varnish except at the end of the root. Twenty-four hours after the root canal filling procedures completed, the teeth were subjected to the first fluid flow measurements. For long term evaluation, the teeth were stored in distilled water for six months at 37°C. After this artificial aging, fluid filtration measurement was carried out in a similar way, as identified above.

Fluid filtration technique

The method for measuring the fluid transition through the root canal as a demonstration of apical microleakage has been previously described (14). For microleakage measurements a fluid flowmeter was used (Figure 1). A segment of 18-gauge stainless-steel tubing was attached through the space in a Plexiglas block 2.1 x 2.1 x 0.6 cm in size and sealed to the Plexiglas with cyanoacrylate adhesive (Pattex, Henkel Gmbh, Dusseldorf, Germany). The diameter of the 18-gauge tubing enabled it to be directly connected to the root canal orifices.

With this method, the whole root canal filling and dentin interface is kept under pressure. The coronal part of each root was bonded to the other side of the Plexiglas block using cyanoacrylate adhesive. Each pattern was then connected to the fluid filtration system with polyethylene tubing (Fisher Scientific, Chicago, IL, USA). A ceiling-suspended deionized water syringe provided the hydrostatic pressure of 70 cm H_2O (6.895 kPa) through a 25-μL micropipette to the coronal part of the root canal (15). The linear movement of a 1.0 mm air bubble in the micropipette was measured in mm with an endodontic ruler graduated in 0.5 mm increments. A Gilmont microsyringe (Gilmont Instruments, Barrington, IL, USA) was used to location the air bubble in the hydraulic system (Figure 2). After procedure stabilization, the fluid transition rate of each root canal was measured for 4 min (measurement time) and repeated three times in consecution (total 12 min). The fluid flow rate was measured at 24 h and 180 days following root canal obturation. Between measurements, the samples remained fixed to the Plexiglas block and were kept in deionized water at 37°C. To avoid any contamination of the coronal part of root canal by remnants of temporary filling material, temporary filling was not used. Linear measurements were converted to microliters per minute (μL min^{-1}).

Statistical analysis

The statistical analysis was performed using IBM Statistical Package for the Social Sciences Statistics for Windows, (Version 20.0. IBM Corp.; Armonk, NY, USA). As the data did not meet the assumptions of normal distribution, the Kruskal-Wallis test and Mann Whitney-U tests were used for multiple and pairwise comparisons, respectively. The confidence level set to 95% and p values less than 0.05 were considered significant.

Table 1. *Composition of tested root canal materials*

Materials		**Composition**
AH Plus® (Dentsply, Konstanz, Germany)	Epoxide paste (paste A) Amine paste (paste B)	Calcium tungstate, epoxy resins, silica, zirconium oxide, iron oxide pigments 1-adamantane amine, N,N'-dibenzyl-5-oxanonandiamine-1,9, TCD-Diamine, zirconium oxide, calcium tungstate, silica, silicone oil
Sealapex® (Sybron-Kerr, Romulus, MI, USA)		Catalyst Base Isobutyl salicylate resin N-ethyltoluenesulfonamideresin Bismuth trioxide Fumed silica (silicon dioxide) Zinc oxide Titanium dioxide Calcium oxide pigment
MTA Fillapex® (Angelus, Londrina, Brasil)		Natural resin, Nanoparticulate silica, Salicylate resin, Resin Particles in Diluting MTA, Bismuth oxide

Figure 1. *Fluid flowmeter used for microleakage measurements.*

Table 2. *Apical leakage mean (µl/min), standard deviations (SD) and means in 24h and 180 days*

Groups	**24 hours (Mean±SD µL min^{-1})**	**180 days (Mean±SD µL min^{-1})**
MTA Fillapex	0.040±0.014^{a*}	0.039±0.102^{a*}
Sealapex	0.058±0.017^{b*}	0.026±0.011^{b**}
Ah Plus	0.060±0.026^{b*}	0.032±0.011^{b**}
Negative control	0.00^{c}	0.00^{c}
Positive control	0.5^{d}	0.5^{d}

MTA: mineral trioxide aggregate
Different letters indicate stastically significant differences between sealers, significance level is p<0.05
Different number of * indicates stastically differences between periods, significance level is p<0.05

Results

Table 2 shows the apical leakage mean and standard deviations of the experimental and control groups over time. For negative control group (completely coated with varnish), measurable fluid flow was not observed within the detection limits of the model after the 24 h measurements. The positive control group, which filled with only gutta-percha, leaked significantly under pressure. All materials allowed fluid to flow throughout the sealer-root dentine interface at the short term and long term intervals.

There were significant differences in fluid leakage amongst the groups at the two time intervals ($p<0.05$). At first measurement, MTA Fillapex presented less microleakage (0.040±0.014 µL min^{-1}), statistically different than the Sealapex (0.058±0.01 µL min^{-1}) and AH Plus (0.06±0.026 µL min^{-1}) ($p<0.05$). No statistically significant difference in microleakage was observed between Sealapex and AH Plus (Table 2).

After six months of storage, Sealapex (0.026±0.011 µL min^{-1}) and AH Plus (0.032±0.011 µL min^{-1}) presented less microleakage, statistically different than the MTA Fillapex (0.039±0.102 µL min^{-1}) ($p<0.05$). No statistically significant difference in microleakage was observed between Sealapex and AH Plus. Over time, no statistically significant difference in microleakage was observed in MTA Fillapex, but significant decreases were observed in Sealapex and AH Plus ($p<0.05$) (Table 2). The values were 0 µL/ min-^{1} for negative controls and extremely high 0.5 µL/ min^{-1} for the positive control.

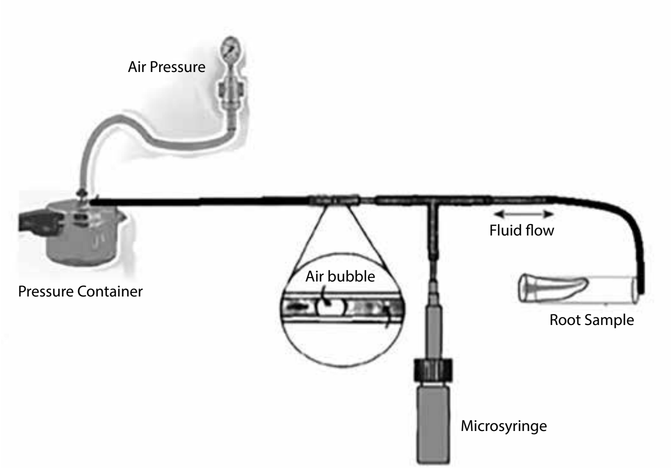

Figure 2. *Scheme of fluid filtration mechanism [adapted from Gandolfi&Prati].*

Discussion

Achieving a hermetical seal by entirely filling the root canal space decreases the risk that microorganisms left in the canal might come in contact with oral or periapical fluids (16, 17). Therefore, investigations on the sealing ability should proceed until the ideal endodontic sealer is found. In present study, the null hypothesis was rejected because MTA Fillapex showed a significant leakage from Sealapex and AH plus both at short term and long term intervals.

Sealapex is suggested as a root obturation material and includes calcium oxide which has the ability to induce hard tissue formation at the apex following root canal obturation (8).

Other sealer, the epoxy resin-based AH Plus, is well known for its sufficient flow, long-term dimensional stability, and expansive properties, and it is considered the gold standard of root canal sealers (15, 18, 19). In the present study, no significant difference was found between the apical leakage amounts of the groups filled with AH Plus and Sealapex in short term and long term intervals. Similarly, Xu *et al.* (20) reported no difference between the microleakage of Sealapex and AH Plus. Similarly, Sagsen *et al.* (21) found no difference between the apical leakages of AH Plus and Sealapex. In the other studies, different results were presented about the microleakage of AH Plus and Sealapex that were related with methodolgical differences used (15, 22, 23).

The results of the present study revealed a negative correlation between time and sealing ability of AH Plus / Sealapex. The microleakage of all sealers had high values at 24 h, but at 180 days AH Plus and Sealapex had better sealing ability than MTA Fillapex. Razavian *et al.* (24) compared apical microleakage of AH26 and MTA Fillapex, using a bacterial microleakage evaluation system. It was reported that microleakage of Fillapex increased over time and that the material had a lower sealing ability compared to AH26. Sönmez *et al.* (25) reported that MTA Fillapex had lower sealing ability than AH Plus and Pro Root MTA 7 days after obturation using dye penetration test. Different from this study; Asawaworarit *et al.* (26) reported that MTA Fillapex had more leakage than AH Plus at 7 days, but at 4 weeks, MTA Fillapex showed a better sealing ability than AH Plus. MTA Fillapex contains a high ratio salicylate resin, and which causes the long chemical reaction time (27). A possible explanation for the microleakage in short and long term may be related to extended setting time.

Sealing ability can be related to different factors such as micromechanic, bonding, chemical bonding (27). AH Plus and Sealapex produce rigid and strong cross-linked polymer with dentin collagens, in addition Sealapex hydration products derivate calcium hydroxide (27). Findings of the present study explain the similar ingredients in sealers have similar chemical bonding mechanism with dentinal wall.

Conclusion

Within the limitation of this study, MTA Fillapex showed the higher sealing ability in 24 hours, and Sealapex and AH Plus showed better sealing in long term. There is a correlation between sealing ability and time according to the contents of the sealer.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Selçuk University, Faculty of Dentistry (No: 2013/05, Date: 02.05.2013).

Informed Consent: Informed consent was not taken due to the in vitro study.

Peer-review: Externally peer-reviewed.

Author Contributions: ZG and Gİ designed the study. HA and Gİ generated the data. ZG and Gİ gathered the data. HA and ZG analyzed the data. HA wrote the majority of the original draft. ZG and GT participated in writing the paper. All authors approved the final version of the paper.

Acknowledgements: We thank Selçuk University Faculty of Dentistry laboratory for assistance.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Türkçe öz: *Farklı kök kanal patlarının apikal sızdırmazlık yeteneğinin karşılaştırmalı değerlendirmesi. Amaç: Bu çalışmanın amacı farklı kök kanal patlarının kısa dönem ve uzun dönem apikal mikrosızıntı özelliğinin karşılaştırılmasıdır. Gereç ve Yöntem: Çalışmada 55 çekilmiş tek köklü insan ön dişi kullanılmıştır. Dişlerin koronal kısmı kesilmiş, kök kanalları Ni-Ti döner aletler ile şekillendirilmiştir. Dişler Grup I: MTA Fillapex (Angelus, Brazil); Grup II: Sealapex (Sybron-Kerr, Romulus, MI, USA), Grup III: AH Plus (Dentsply, Konstanz, Germany) (n=15), negatif ve pozitif kontrol grubu (n=5) olmak üzere 5 gruba ayrılmıştır. Kök kanalların örtücülüğünün kalitesini değerlendirmek için 24 saat ve 180 gün aralıkla sıvı filtrasyon testi yapılmıştır. Grupların karşılaştırılmasında, Kruskall Wallis ve Mann Whitney U testi kullanılmıştır. Bulgular: Yirmi dört saatlik ölçümde, MTA Fillapex; Sealapex ve AH Plus'tan daha az mikrosızıntı sergilemiştir (p<0,05). Uzun dönemde (180 gün) Sealapex ve AH Plus, MTA Fillapex'ten daha az mikrosızıntı göstermiştir (p<0,05). Sonuç: Sealpex ve AH Plus uzun dönemde MTA Fillapex'ten daha iyi örtücü özellik sergilemiştir. Anahtar kelimeler: MTA fillapex; AH plus; Sealapex; mikrosızıntı; sıvı filtrasyon yöntemi.*

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