

Comparative evaluation of the apical sealing ability among different root canal obturation techniques and endodontic sealers by using fluid filtration method: A systematic review

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Abstract

Introduction: The target of many experimental studies was to appraise the sealing ability of the root canal filling materials. No systematic reviews are available to appraise such condition. The aim of current review is to appraise the sealing ability of different root canal obturation techniques and sealers using fluid filtration method.

Materials and Methods: Two automated databases (Google Scholar and PubMed using English-language literature) were used for this systematic review, using specific keywords together with inclusion & exclusion standards. In December 2018, such investigation was carried out & in March 2019, it was updated.

Results: Search detected twelve studies that achieved the present inclusion and exclusion criteria. These studies illustrated different aspects of apical sealing, including: sealing ability, obturation techniques, sealer types, and updating studies in fluid filtration evaluation method.

Conclusions: AH Plus had the best sealing ability over all sealers with different obturation techniques when evaluated by fluid filtration device and more investigations should be performed regarding that.

Keywords: Apical sealing, Sealing ability, Obturation technique, Sealer, Fluid filtration.

Introduction

The main objective of any endodontic treatment whether performed in regular method (non-surgical) or (surgical) is three dimensional filling that maintains apical seal and follows the original root geometry.¹ On the other hand, the most common cause that lead to endodontic treatment failure is apical leakage that is affected by many factors like the obturation technique and poor sealing of root canal sealer.² The materials used for obturation have been rapidly changed over the past years³

The most common things used for filling of the root canal are the core material and sealer.⁴ For these two components, the current material that refers to core is gutta-percha and it's the most commonly used core material because of its tremendous advantages like: biocompatibility, cheap, and ease of use.⁴ The other available core in the market is Resilon.⁵ It is a resin-based material that can be softened with heat just like gutta-percha and is always used with an epiphany (resin- based sealer) and real seal.⁵ Monoblock within the root canal is the result of using resilon as a core filling with epiphany sealer.⁶

Another component of obturation material is the root canal sealer, which is important in filling the spaces between dentine and core material and is often expressed into lateral canals.⁷ Sealers are grouped based on the main chemical component, such as zinc oxide (Rickert sealer, Roth's Sealer), calcium hydroxide (SealApex, Apexit and Vitapex), silicone, resin (Diaket, AH26, AH Plus and epiphany) and glass ionomer (Ketac Endo).⁸ For several years, Zinc oxide based sealer has been used for its satisfactory physiochemical properties.⁹ The glass ionomer sealers has its own properties to adhesion to dentin so, it was used.¹⁰ At the recent time, sealers based on epoxy resins have an accepted apical sealing & also it has useful physical & biological characteristics.¹¹

Many systems such as: dyes, scanning electron microscopy (SEM), fluid filtration technique, electrochemical methods, and bacteria have been used to appraise the sealing properties of root canal filling materials.¹² However, none of the assessment methods have alone totally covered the intricate nature of root canal sealing.¹³ Results still questionable even with teeth clearing method using dye penetration to detect leakage.¹³ Meanwhile, In comparing the fluid filtration with dye method, fluid filtration is more reliable precise than dye method since it permits through-and-through detection of voids along the canal.¹⁴ Add to this, it is a non-destructive method since it permits reiterated observation of the same specimen over time.¹⁴ On the other hand, the SEM is a good means of assessing leakage because it gives a three-dimensional image with greater depth of field, higher resolution and multiple magnification but it requires sample destruction and may affect the accuracy of the collected data.¹³ However, there are new alternative techniques presented recently, for example: "artificial caries", "radioactive isotopes", "Micro Computed tomography", "neutron activation analysis", and "electrical conductivity".¹⁵ The fluid filtration technique appraises the sealing ability of different restorative and endodontic sealers.¹⁶⁻¹⁸ Consequently, this technique own accepted crdentialityin the research field of assessing the apical and coronal microleakage.¹⁹ Compared with dye method, the fluid filtration method depends on quantitative measurements of fluid passage within the interfaces as a result of this; both techniques gave the analogous outcomes in past investigations.²⁰

This method has multiple benefits when compared to the other techniques in-case of microleakage evaluation.²¹ These benefits include; samples are not destructed, No tracer, No intermediate materials required as in other

studies.²¹ Furthermore, Accurate outcomes could be gained together with avoiding any possible operator bias by fluid filtration method due to its automatic way of recording very small volumes.²¹ Also, results can be affected by some factors including: tube diameter, measurement time & bubble length.²¹

Although numerous experimental studies aimed to appraise the sealing ability of root canal fillings, there is no available systematic review study that evaluates the sealing abilities of different sealing materials. The aim of our study is to conduct a systematic review to appraise the sealing abilities of different obturation techniques and sealers using fluid filtration method.

Material and Methods

This review was appraised in conformity with the PRISMA statement.

Focused Question

“Is the fluid filtration as an evaluation method better than other methods to appraise apical sealing or No?”.

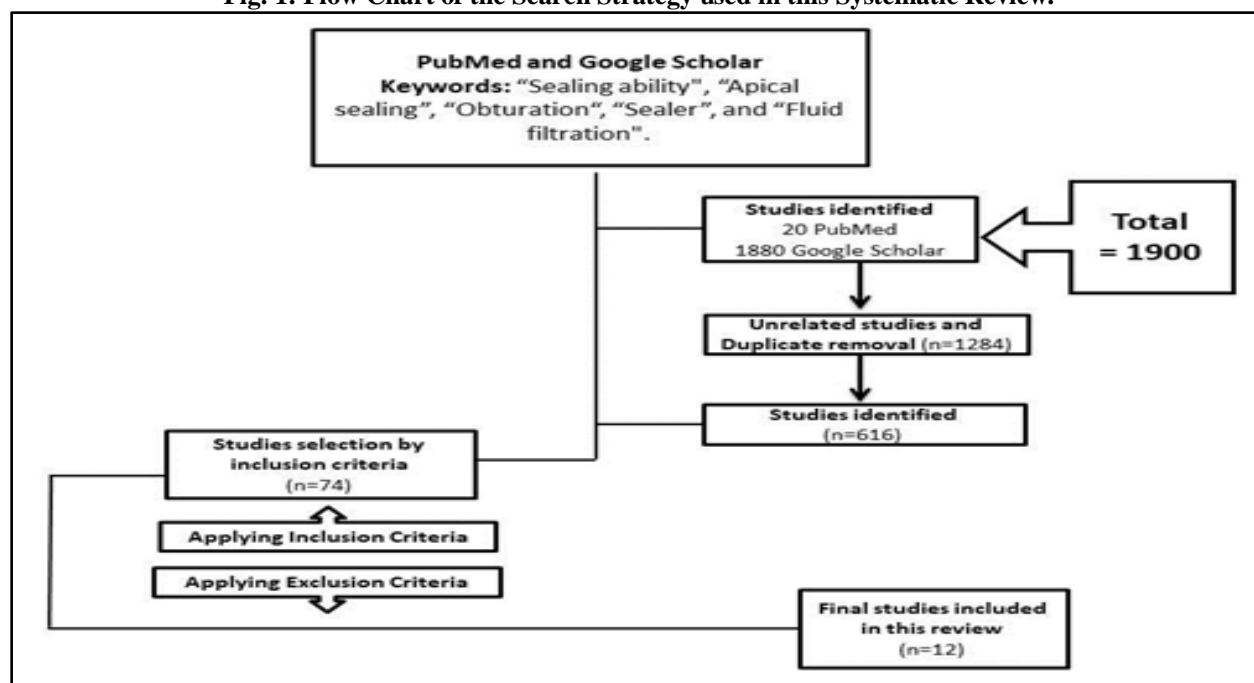
Search Strategy

Systematic way was performed to look-up for relevant information through several literatures & search engines with a great concern to the main question. Such study was accomplished in December 2018 and applauded with new information's until March 2019. A web search was done through PubMed (2008-2018) and Google Scholar (2008-2018) with MesH terms and/or in various combinations (“Sealing ability”, “Apical sealing”, “Obturation”, “Sealer”, and “Fluid filtration”).

Inclusion criteria were as follow: i). Original article released in the English language, ii). Articles released for a limit of 10 years from 2008 – 2018, iii). Studies performed on human subjects, and iv). Articles that measure apical sealing ability of different obturation techniques with sealers using fluid filtration method of evaluation. The exclusion criteria were as follow: i). Any articles measure the apical sealing ability by another method such as dyes penetration, and SEM methods of evaluation, ii). Any articles discuss root end filling and Retrograde / Orthograde root end filling iii). Any articles that evaluate the coronal sealing ability, iv). Any articles measure the sealing ability by percentage and samples taken from animals, and v). Review articles.

Relevant articles had been red & assessed by the introduction of the close meaning ideas by the study reviewers. Full articles were obtained for most of the titles and abstracts that met the inclusion criteria, full text was accessed. From each included article, Study design, population, interventions and controls, and findings were extracted. Articles used were categorized into two main groups (free & restricted). Free ones have been downloaded directly by the URLs generated from database. The restricted group has been downloaded by the institutional access of KAU library. Even though some articles weren't mach the main idea, they have been reviewed again & decided to be either relevant or irrelevant. An understanding was there between the authors in relation to suitability of the chosen articles. Even the reference was examined to identify any studies that haven't been covered by the electronic searches. A summary of this review search strategy was summarized in [Fig. 1].

Fig. 1: Flow Chart of the Search Strategy used in this Systematic Review.



Results

The search detected twelve studies that achieved the present inclusion and exclusion criteria. These studies scrupulously different aspects of apical sealing, including: sealing ability, obturation techniques, sealer types, and updating studies in fluid filtration evaluation method. All the studies included in this systematic review were "In vitro study". All the articles included extracted human teeth with different age and gender. All the selected articles used fluid filtration device and the pressure as a method of evaluating

apical sealing. In these studies, the intervals varied from one study to another and the time of storage the teeth segments in the solutions had different ranges. All the included studies in this systematic review divided into 3 categories as the following: Category 1: studies evaluated the sealers mainly, Category 2: studies evaluated the obturation techniques mainly, and Category 3: studies evaluated both the sealers and obturation techniques. All included studies were summarized in [Table 1].

Table 1. Summary of All Included Studies in this Systematic Review.

Authors / Study Design	Year	Number of subjects	Type of Obturation techniques and sealers	Main Results	Main Conclusions
Asaworarit W, et al. ²³ , Thailand (In-vitro study)	2016	(N =34) Extracted human upper anterior teeth.	Obturation by "Warm vertical compaction (WVC) technique". <ul style="list-style-type: none"> • "Tricalcium silicate-based (MTA Fillapex®)" • "Resin-based (AH Plus®)". 	MTA fillapex is not good for the short period of time compared to AH-plus (more leakage) at 7 days. But the opposite for long term period (4 weeks).	The tricalcium silicate based sealer showed to be a good sealing material.
Ulusoy OI, et al. ²⁸ , Turkey (In-vitro study)	2014	(N =90) Freshly extracted, single-rooted mandibular premolars.	Obturation by "Cold lateral compaction (CLC) technique". <ul style="list-style-type: none"> • "AH Plus" • "EndoREZ" • "IRoot SP" • "Hybrid Root SEAL" 	Microleakage was minimal with EndoREZ & AH-plus where it was high with hybrid root seal.	Good sealing ability would be found with EndoREZ & AH-plus types of sealer when compared with IRoot SP & Hybrid.
Genç Ö, et al. ³² , Turkey (in vitro study)	2011	(n= 85) Intact human mandibular permanent incisors	Obtured by "Cold lateral condensation (CLC) technique": <ul style="list-style-type: none"> • "AH Plus, Dentsply/DeTrey, Konstanz, Germany". 	Manual technique gave us the closest preparation to the predetermined level where S-apex gave us the farthest.	Same evidence of leakage was seen in all groups after obturation.
Vasconcelos BC, et al. ²⁴ , Brazil (in vitro study)	2011	(N =66) freshly extracted Human mandibular premolars.	Obturation by single cone Gutta-percha <ul style="list-style-type: none"> • AH Plus • Acroseal (resin based) • SealApex (CaoH based) • MBA (resin based) • MTA-Obtura 	Not all materials are the same at different time period. At 15 & 60 days, leakage values are equal for both MBP & AH-plus. But they are different at 30 days with significant reduction. Also, at 15 days, Acrosol & seal apex are the best but vice versa at 60 days (worst).	For longer observation periods, AH-plus & MBP showed the best results in leakage reduction. While the opposite condition for Acroseal, seal apex & MTA-obtura.
Hirai VH, et al. ²⁶ , Brazil (in vitro study)	2010	(N =64) extracted premolars	Obturation technique by "Cold lateral compaction technique". <ul style="list-style-type: none"> • AH Plus + gutta-percha • AH Plus + Resilon • Epiphany + Resilon • Epiphany + gutta-percha 	When you use a combination of gutta-percha cones & AH-plus, lower leakage values would be observed in comparison to other groups.	Best achievement would be seen with filling made with gutta-percha cones combined with AH-plus sealer.
Ari H, et al. ³³ , Turkey (in	2010	(N =68) Extracted	"Hyperied rootseal (meta	Not all obturation	The sealer

vitro study)		human mandibular straight single-rooted teeth.	seal) (methacrylat based sealer)” with Gutta-percha <ul style="list-style-type: none"> • “Lateral condensation” • “Vertical compaction” • “Thermafil” • “Ultrafil” 	techniques are the same.	behaves in different mode with different technique. It has less fluid movement with cold lateral & vertical in comparison with thermafil & ultrafil.
Yildirim T, et al. ³⁰ , Turkey (in vitro study)	2009	(N =50) single-rooted human teeth	<ul style="list-style-type: none"> • Lateral condensation Gutta-percha + AH Plus • Single cone Gutta-percha +AH 26 • System B /ObturaII + AH 26 • BeeFill 2 in 1+ 2 seal 	Both techniques showed leakage but in different conditions & time.	After 2weeks & after comparing all obturation techniques, the apical sealing efficiency of system B/obturaII & Beefill were inferior to others.
Yildirim T, et al. ²⁵ , Turkey (in vitro study)	2009	(N =70) single-rooted human teeth	<ul style="list-style-type: none"> • Single cone gutta-percha + AH-26 • Lateral compaction Gutta-percha + AH-26 • Single cone gutta-percha with apexit sealer (CaOH based) • Lateral compaction Gutta-percha + apexit sealer (CaOH based) • Single cone gutta-percha + sealite ultra • Lateral compaction Gutta-percha + sealite-ultra 	All types mentioned are equal in leakage with single cone. But actually one is more than the others in progression of leakage that is Sealite-Ultra.	Sealing effects are similar for both (protaper type of gutta-percha, single cone & lateral compaction technique).
Onay EO, et al. ²⁷ , Turkey (in vitro study)	2009	(N =120) Extracted human single-rooted teeth	<p>Obturation by “Warm vertical compaction” for Resilone, and herofil oven for herofil</p> <ul style="list-style-type: none"> • RealSeal (methacrylate-based sealers) +Resilon • RealSeal (methacrylate-based sealers) • +Herofill gutta-percha • HybridRootSeal (methacrylate-based sealers) + • Resilon • Hybrid RootSeal (methacrylate-based sealers)+Herofill gutta-percha • MM-Seal(epoxy-resin-based sealer) +Resilon • MM-Seal (epoxy-resin-based sealer) 	Hybrid root seal was combined with 2 materials. Once with Resilon & other with Herofill. But it showed less microleakage with Resilon than Herofill. But on the other hand, MM-seal combined with Herofill showed the least microleakage.	The end up by supporting the superior sealing property of epoxy-resin-based sealer (MM-seal) combined with gutta-percha (Herofill) compared to Methacrylate-based-sealer (Hybrid root seal) & real seal together.

			<ul style="list-style-type: none"> • +Herofill gutta-percha 		
Moradi S, et al. ²⁹ , Iran (in vitro study)	2009	(n= 86) Single-rooted lower premolars	Obturated by "Cold lateral condensation (CLC)". <ul style="list-style-type: none"> • Epoxy resin sealer (AH26). 	AH26 groups: showed significant reduction in microleakage (with & without smear layer).	Further studies using Different sealers and techniques are warranted.
Zhang W, et al. ²² , China (in vitro study)	2009	(N =68) Extracted human anterior single-root teeth	<ul style="list-style-type: none"> • iRoot SP sealer (calcium silicate based) + lateral condensation gutta-percha • iRoot SP sealer (calcium silicate based) + single cone gutta-percha • AH plus+ lateral condensation Gutta-percha 	Both the iRoot SP together with AH-plus sealer, are all were equal in apical sealing ability.	The 2 main types of sealers (iRoot SP & AH-plus) were the same in apical sealing ability.
Inan U, et al. ³¹ , Turkey (in vitro study)	2009	(N =66) Extracted human lower premolar teeth	<ul style="list-style-type: none"> • Single cone gutta-percha + AH Plus • Thermafil Gutta-percha + AH Plus • Lateral compaction Gutta-percha + AH Plus 	Both groups didn't show any statistical significance.	It could be possible for the apical sealing ability of matched-taper-single-cone technique to be comparable with other techniques

Category 1 - (studies evaluated the sealers mainly):

Various types of sealers were used in the previous studies and few numbers of them was used only one time in each study.

Calcium silicate sealers

The apical sealing of the iroot SP sealer was investigated by Zhang, et al.²² at 2009. They found no significant difference between the iRoot and AH plus when used with cold lateral condensation technique or single cone.²² Another study examined the apical sealing of the MTA Fillapex compared to AH plus when used with warm vertical compaction technique.²³ Evaluation of the apical leakage after four weeks showed that, The MTA Fillapex exhibited significantly better sealing ability than AH Plus did.²³

Calcium hydroxide based sealers

Conflict was shown in the results with calcium hydroxide based sealer. One investigation was used SealApex sealer (calcium hydroxide based) with single cone technique. They found the best result shown at day 15 and the worst result at day 60.²⁴ In the other side, another type of calcium hydroxide sealer (Apexit sealer) when using it with either by single cone technique or cold lateral condensation was no significant difference.²⁵

Epiphany sealers

The apical seal of Epiphany was investigated in one study (Hirai VH, et al).²⁶ at 2010. In this study, they found that the highest mean fluid leakage when used epiphany with resilon after two weeks interval.²⁶ In other hand, when used epiphany with gutta-percha, the mean least fluid leakage in all samples found with cold lateral condensation.²⁶ Also, compared "apical after obturation using gutta-percha and Resilon cones with AH Plus and Epiphany sealers".²⁶ The AH Plus with gutta-percha when used with cold lateral condensation demonstrated the least leakage value when evaluated after 2 weeks.²⁶ However, when used the same sealer with resilon by warm vertical compaction shows the highest level of leakage.²⁶

Resin sealers

An in vitro study was conducted by Onay, et al.²⁷ at 2009, to evaluate the apical sealing ability of new polymeric endodontic filling system found that when using MM Seal sealer (epoxy resin based sealer) with Heriofil result shows the least micro-leakage.²⁷ However, using the same sealer with resilon result shows the greatest micro-leakage.²⁷

A recent investigation conducted by Vasconcelos, et al.²⁴ at 2011. In this study, there was reduction in apical leakage in AH Plus in 15&60 days and less reduction in 30 days when compared with other sealers.²⁴ Also, this study used 2 types of (resin based) Acroseal & MBA sealers with single cone technique. MBA shows leakage at 15 & 60 days and reduction in 30 days, while the best result was in day 15

and worst result in day 60 with Acroseal sealer.²⁴ MTA-Obtura sealer with single cone technique was used in this study and shows significant difference between 15 and 60 days also between 30 and 60 days.²⁴ In the other side, Ulusoy OI, et al.²⁸ at 2014 found that AH Plus and EndoREZ sealers with cold lateral compaction present the lowest leakage value at ($p < 0.001$). However, one investigate done by Moradi S, et al.²⁹ at 2009; it shows a decreased microleakage significantly in AH26 groups (epoxy resin sealer) with and without smear layer at 3 months compared to 3 days when compare with other sealers.²⁹

Category 2 - (studies evaluated the obturation techniques mainly):

Combined cold lateral condensation with single cone obturation technique:

One investigation reported that no statistical difference when perform AH26 with single cone technique.²⁵ Yilmaz, et al.²⁵ at 2009 found no significant difference in comparison with other sealers when using AH 26 with cold lateral condensation after 7 days of evaluation. This investigation done in different sealer with either by single cone or lateral condensation technique shows more apical leakage when used Sealit-Ultra with single cone obturation technique.²⁵

Different types of obturation techniques:

One of the studies had done by Yildirim, et al.³⁰ at 2009, show no significant difference in apical leakage after different time of evaluation when using AH plus with cold lateral condensation technique in comparison to other sealers. Also, they found the greatest amount of leakage was observed after one week observed when using System B with the same sealer.³⁰ Regarding a study done by Inan, et al.³¹ at 2009; to appraise the apical sealing ability of AH Plus with 3 obturation techniques found that no significant difference either with single cone, cold lateral condensation or themafil. A recent investigation done by Genç Ö, et al.³² at 2011. In this study, they evaluate 3 instrumentation techniques to investigate the apical sealing ability following obturation and it was comparable when use AH Plus with cold lateral condensation at 1 week and 3 months of evaluation.³²

Category 3 - (studies evaluated both the sealers and obturation techniques):

Methacrylate based sealer with different types of obturation techniques:

Ari, et al.³³ study conducted at 2010 evaluate the sealing ability of Hybrid Root SEAL (MetaSEAL) (Methacrylate based sealer) in conjunction with different obturation techniques. The results shown less leakage Hybrid Root SEAL when used cold lateral condensation or warm vertical compaction than thermafil or ultrafil when appraised after 7 days. Also, thermafil shows the highest

fluid movement among all obturation technique.³³ In the other side, Onay, et al.²⁷ at 2009; the resilon (warm vertical compaction) was compared with gutta-percha (heriofil technique) using 2 type of Methacrylate based sealer (real seal sealer and hybrid root seal) with epoxy resin based (MM Seal sealer) after 7 days. The mean micro-leakage of hybrid root seal with resilon was significantly less than the mean micro-leakage of heriofil with the same sealer.²⁷ Real seal with heriofil graded as the 2nd sealer that shows least micro-leakage.²⁷

Discussion

Apical leakage is the most common cause of failure of endodontic treatment and many factors affect such condition like: technique of obturation and the sealing ability of root canal sealer.² After root canal treatment, it is very important to gain good outcomes of the apical sealing of obturation techniques and sealers as demonstrated by previous studies.³⁴ Many studies measuring apical sealing ability. Systematic review conducted to summarize, locate, appraise and synthesis all high quality research evidence scientific experimental studies relevant to scientific research question. The question of this review is "Is the fluid filtration as an evaluation method better than other methods to appraise apical sealing or No?". This review use an electronic search only and the result limited to articles that can found a full article. Consequently, the results of all relevant studies were not included in our systematic review. Furthermore, the current review included 12 studies that measure sealing ability by fluid filtration method. Most of investigations show no significant difference in apical leakage when using AH Plus sealer with different obturation techniques in comparison with other sealers.³⁰⁻³² Also, the same results were shown with AH26 sealer.²⁵ When using (Methacrylate based sealer) with, either cold lateral condensation, warm vertical or heriofil, less leakage was observed.^{27,33} Regarding other sealers like (resin based sealer, calcium silicate sealer, calcium hydroxide sealer, and epiphany sealer) a conflict results were shown.²²⁻²⁹ Two studies report, there are no correlation among results of different leakage tests. Pommel, et al.² stated that, when using single cone & vertical condensation technique regarding the evaluation of sealing ability, no correlation was found between fluid filtration, electro-chemical & dye leakage tests using the same teeth. On contrary, the second study concludes that the differences in the working principles of various tests together with the different nature of obturation materials in relation to assessing the leakage are responsible for the difference in the results.³⁵

The review established that there were written studies showing a significant difference between technique of obturation and sealer type, while others, show non-significant difference. These differences may link with different operator or different experience in root canal treatment. Finally, it's important to search a best method of obturation and sealer type through an experimental studies and systematic reviews. But, still we can't conclude that

other technique or other types of sealers were not given an appropriate apical seal and lead to endodontic failure.

Conclusion

Regarding the outcomes gained, it was concluded that perfect apical seal of the root canal is required, but there is no technique, obturation material or sealer type that maintain the physical or biological properties. In this review, AH Plus had the best sealing ability over all sealers with different obturation techniques when evaluated by fluid filtration device and more investigations should be performed regarding that.

Conflict of Interest: None.

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