Review Article

Comparative evaluation of sealing ability of gutta percha and resilon as root canal filling materials- a systematic review

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ARTICLE INFO

Keywords:

Gutta percha
Resilon
Sealing ability
Root canal filling
Fluid filtration

ABSTRACT

This systematic review aims to comparatively evaluate the sealing ability gutta-percha and resilon as root canal filling materials. A Medline search was conducted to identify in-vitro studies published between October 01, 2004 and October 01, 2019, conducted on human extracted teeth, published in English and testing the sealing ability of gutta-percha and resilon as root canal filling materials using fluid filtration method. The search identified fifty-five published articles. After a thorough screening, five articles meeting the selection, and validity assessment criteria were critically appraised. The results indicated that during the initial time-period, resilon/epiphany sealer has better sealing ability than gutta-percha. However, over a period of time the resilon system demonstrated increased fluid flow. Gutta-percha with AH plus sealer showed the best long term sealing ability.

1. Introduction

The long-term clinical success of root canal treatment depends on meticulous cleaning and shaping of the root canal followed by three-dimensional obturation of the canal resulting in a fluid-tight seal at the root canal apex.¹ The obturation of root canal is done by using a core obturating material and a root canal sealer. The sealer fills the voids between core filling material and radicular dentin.²

Bowman in 1867 introduced gutta-percha (GP) as a root canal filling material. Since then, it has been the most commonly used endodontic filling material worldwide.³ GP is a poly-isoprene based material and is considered as the “gold standard” for obturating root canals owing to its biocompatibility, inertness, compactibility, and retrievability.³ AH plus and AH 26, epoxy resin-based endodontic sealers are commonly used along with GP.⁴ Hergt et al. stated that AH plus fulfills the requirement of a root canal filling material as defined by the specifications for root canal filling materials and guidelines of the European Society of Endodontology (ESE).⁵

Microleakage followed by subsequent re-infection of the root canal accounts for approximately 60% of endodontic failures.⁶ Although GP is the most acceptable and popular obturating material, it lacks the potential of forming an adhesive bond with the root canal dentin or the

sealer.⁷ Lack of adhesion may lead to microleakage between the GP and sealer or through voids within the sealer or the GP itself. To overcome this disadvantage, many alternatives to the traditional GP-based systems have been suggested to obtain a better seal at sealer–core obturation material and sealer–radicular dentin interfaces. One popular and successful adhesive root canal obturation systems is a polycaprolactone based material, Resilon, used along with Epiphany sealer.⁷ Resilon (Resilon Research, LLC, Madison, Connecticut, USA), introduced in 2004, is a thermoplastic synthetic polymer-based root canal obturation material.⁸ It contains methacrylate resin, bioactive glass, barium sulfate, and bismuth oxychloride.⁸ It exhibits similar handling characteristics as GP and therefore can be compacted using the traditional obturation techniques. The accompanying sealant Epiphany/RealSeal is a dual-curable resin-based composite sealer. The matrix is a mixture of Bisphenol A epoxy (Bis-GMA), urethane dimethacrylate (UDMA) and hydrophilic dysfunctional methacrylates, while the filler consists of calcium hydroxide, barium sulfate, barium glass, and silica.⁷ Adhesion between the core obturation material Resilon and Epiphany sealer, the sealer and radicular dentin leads to the formation of what is referred to as “monoblock” in root canal obturation.⁹ A plethora of studies has been published comparing the sealing ability of these adhesive and the conventional, nonadhesive root canal obturating systems. However, the

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<https://doi.org/10.1016/j.jobcr.2019.12.004>

Received 31 October 2019; Received in revised form 25 December 2019; Accepted 27 December 2019

Available online 30 December 2019

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results obtained are inconsistent, with one study conflicting the results of another, which might be attributed to the small sample size and variations in the study methods.^{9–12} These varied studies are unable to provide well-defined guidance to the clinicians in making appropriate clinical choices. Therefore, this systematic review attempts to comparatively evaluate the sealing ability of two orthograde filling materials- GPwith AH plus or AH 26 sealer and resilon with Epiphany sealer, in-vitro, in extracted human teeth by fluid filtration microleakage testing method.

2. Materials and methods

The review has been conducted based on the guidelines given in Cochrane handbook for systematic reviews of interventions and followed the four steps for the flow chart of “Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement”.^{13,14} The review protocol was registered in PROSPERO- ID: 156321.

The study focused on answering the following patient, problem, population, product; intervention; comparison control or comparator; outcome (PICO) question.¹³

- P - (Product) - Human permanent extracted teeth
- I - (Intervention)- Root canal filling/obturation
- C - (Comparison)- In between GP with AH plus or AH 26 sealers and Resilon with Epiphany sealer
- O - (Outcome) - Sealing ability

2.1. Focused question

Which root canal filling material amongst gutta-percha or resilon shows better sealing ability when submitted to fluid filtration test for detecting microleakage in in-vitro human extracted teeth?

2.2. Search strategy

An electronic search was initiated to identify studies on the subject published in English between October 01, 2004 and October 01, 2019, using PubMed service of the National Library of Medicine and the U.S. National Institutes of Health. Boolean operators and filters were used with different combinations of the Mesh terms in the advanced PubMed search. Keywords used were “root canal filling materials”, “root canal obturation material”, “sealing ability”, “microleakage”, “resilon”, “epiphany”, “real seal” “gutta-percha/ah plus”, microleakage, “fluid filtration” along with OR & AND as Boolean Operators. Journal of Endodontics (JOE) and International Endodontic Journal (IEJ) were also hand searched for the last two years. The search strategy has been shown in Table 1.

2.3. Inclusion criteria

- 1 Articles published in English
- 2 In-vitro/ex-vivo studies on human permanent teeth
- 3 Inclusion of two groups in the study: one group obturated with gutta-percha/AH (AH 26 or AH plus) and other with resilon/

epiphany or real seal; articles comparing the sealing ability of these two groups.

4. Root canals in which the smear layer was removed before obturation.
5. The outcome measured as microleakage by fluid filtration method and data presented as mean and standard deviation (SD).

2.4. Exclusion criteria

Clinical studies and studies measuring the microleakage of root filling materials using techniques other than fluid filtration.

2.5. Study selection process

Two independent reviewers (PP and HA) reviewed all the identified titles. If the title was appropriate, abstracts were assessed to determine whether the studies met the inclusion criteria. Whenever the abstract did not provide enough information to make this determination, the article in full text was examined and the decision was taken for inclusion or exclusion. In case of discordance between the reviewers about the article inclusion, a third reviewer (RB) was consulted for final approval or disapproval.

All articles that met the inclusion criteria were then assessed for validity. Validity was determined on a seven-point scale based on validity assessment criteria originally given by Sackett for in-vitro studies.¹⁵ The criteria was modified according to the study objectives and is shown in Table 2. Studies not meeting five or more of the seven validity criteria were excluded. Two reviewers (PP and HA) did validation independently and the third reviewer resolved any differences if any (RB).

2.6. Data extraction and analysis

Data from the included studies were extracted and plotted as scatter plots and linear regression was used to compare the sealing ability using SPSS version 20.0.

3. Results

Fifty-five articles were identified through electronic search (Table 3). Twenty-nine were excluded on title reading and 18 studies were excluded after abstract reading. Full-text reading of 8 articles was done. 2 studies were excluded after full-text reading. Validity assessment criteria were done for the final 6 selected studies. Out of the six studies, five studies fulfilled the validity assessment criteria (Table 4). Finally, five studies met the selection and validity assessment criteria. Details of the included studies are presented in Table 5. The included study showed three groups-resilon with epiphany, GPwith AH plus and GPwith AH 26 and a range of testing periods.

The mean fluid flow of these materials is plotted in Fig. 1, Fig. 2 and Fig. 3. The linear regression is shown in Fig. 4.

The pairwise scatter diagram (Figs. 1–3) reveals that results from all the studies do not show much correlation between mean fluid leakage displacement and logarithmic transformation of time separately for all

Table 1
MEDLINE search strategy (55 articles).

#1	(((((“root canal filling material”) OR “root canal obturation material”) OR “resilon”) OR “epiphany”) OR “real seal”) OR “gutta percha”	4397
#2	(“sealing ability”) OR “microleakage”	3512
#3	(“fluid filtration”) OR “fluid transport”	2793
#1	(((((“fluid transport”) OR “fluid filtration”)) AND ((“sealing ability”) OR “microleakage”)) AND ((((((“root canal filling material”) OR “root canal obturation material”) OR “resilon”) OR “epiphany”) OR “real seal”) OR “gutta percha”)	112
AND #2 AND #3		
	Filters: Human, English, From 2004/10/01 to 2019/10/01	55

Table 2
Validity assessment criteria (modified).

1	Was the assignment of teeth of treatment randomized?
2	Were all teeth analyzed in the groups to which they were randomized?
3	Was the sample size calculated?
4	Aside from the experimental treatment, were the groups treated equally?
5	Were positive and negative controls taken?
6	Were the groups similar at the start of the trial?
7	Were the investigators blinded to the treatment being received?

three groups AH26, AH plus, and epiphany. On fitting simple linear model considering time as the independent variable and mean fluid leakage displacement as the dependent variable, the results showed that for GPwith AH plus, the model was able to explain the maximum variation of 83%, however, for GPwith AH26, 74% variation was explained by the model. For resilon/epiphany, the regression model was able to

Table 4
Studies assessed for validity criteria.

Author and Reference	Year	1	2	3	4	5	6	7
Onay et al. ¹⁶	2006	Y	Y	N	Y	Y	Y	N
Tunga et al. ¹⁷	2006	Y	Y	N	Y	Y	Y	Y
Santos et al. ²⁴	2010	Y	Y	N	Y	Y	Y	N
De-Deus et al. ²⁶	2008	Y	Y	N	Y	Y	Y	N
Sagsen et al. ²⁸	2006	N	Y	N	Y	Y	Y	N
Wedding et al. ²⁵	2007	Y	Y	Y	Y	Y	Y	N

explain around 59% variation. Beta Coefficients for subgroup – AH 26 is (–0.087) with p-value - 0.013, for AH plus is (–0.041) with p-value – 0.012 and for sub-group epiphany is (–0.036) with p-value – 0.010. GPwith AH 26 has better mean fluid leakage displacement in comparison to resilon with epiphany as the beta coefficient for GPwas found to be 0.087, which was significant.

Table 3
Flow chart of the article selection.^{17,28–31}

Table 5
Characteristics of each included study.

Author	Group	Subgroup(type of sealer)	Sample size	Time (Hours)	Mean	SD	Group	Sub type	Sample size	Time (hours)	Mean	SD
Onay et al.	gutta percha	AH +	14	168	0.15	0.069	Resilon	Epiphany	14	168	0.15	0.085
Tunga et al.	gutta percha	AH +	18	1	0.43	0.54	Resilon	Epiphany	18	1	0.41	0.49
Tunga et al.	gutta percha	AH +	18	2	0.53	0.613	Resilon	Epiphany	18	2	0.46	0.534
Tunga et al.	gutta percha	AH +	18	3	0.57	0.617	Resilon	Epiphany	18	3	0.52	0.561
Tunga et al.	gutta percha	AH 26	18	1	0.51	0.608						
Tunga et al.	gutta percha	AH 26	18	2	0.6	0.658						
Tunga et al.	gutta percha	AH 26	18	3	0.67	0.665						
Santos et al.	gutta percha	AH +	12	0	0.17	0.06	Resilon	Epiphany	12	0	0.23	0.1
Santos et al.	gutta percha	AH +	12	4320	0.1	0.07	Resilon	Epiphany	12	4320	0.15	0.08
Deus et al.	gutta percha	AH +	20	0	0.017	0.013	Resilon	Epiphany	20	0	0.025	0.017
Deus et al.	gutta percha	AH +	20	613201	0.02	0.013	Resilon	Epiphany	20	613201	0.05	0.025
Wedding et al.	gutta percha	AH 26	21	24	0.0223	0.6	Resilon	Epiphany	21	24	0.154	0.58
Wedding et al.	gutta percha	AH 26	21	168	0.0249	0.59	Resilon	Epiphany	21	168	0.017	0.63
Wedding et al.	gutta percha	AH 26	21	720	0.0254	0.55	Resilon	Epiphany	21	720	0.0186	0.68
Wedding et al.	gutta percha	AH 26	21	2160	0.0251	0.48	Resilon	Epiphany	21	2160	0.0196	0.69

4. Discussion

Leakage studies on the sealing potential of root canal filling materials are paramount. Numerous articles have been published appraising the sealing ability of the resilon system, however, to the best of our knowledge there has been no systematic review conducted so far to evaluate resilon system as an evidence-based alternative to GP for root canal filling.^{16,17}

This systematic review indicated that, during the initial time period, the sealing ability of resilon and GP when measured with fluid filtration, was as follows: resilon/epiphany > gutta-percha/AH plus > gutta-percha/AH 26. However, resilon system showed a diminished sealing ability over a period of time. Gutta-percha with AH plus provided the best long term sealing as illustrated in Fig. 4A recent clinical study by Payne et al., in 2019 also shows higher proportion of degradation of resilon when compared to gutta percha and AH plus sealer over a period of time, which might be attributed to the complications in intracanal adhesion caused by polymerization shrinkage of resilon.¹⁸

Variables were narrowed down in this review to standardize the results. Studies, which evaluated the sealing ability only by fluid

filtration method, were considered. Techniques used for evaluation of microleakage generally make use of a tracer, which penetrates the micro-gaps between sealer and core.¹⁹ The tracer can be a dye (most commonly used is methylene blue dye), radioisotope and bacteria or their endotoxins.²⁰ Most of the reported studies utilized dye-penetration method using methylene blue. Methylene blue dye is the most commonly used dye, as this is inexpensive, easily available and shows a high degree of staining.¹⁹ Although strictly speaking, among all techniques using a tracer, the use of bacteria as a tracer most closely simulates the clinical situation of micro-leakage. The problem in which all techniques using a tracer face is that the tooth has to be sacrificed into sections to evaluate the results. Moreover, the voids present along the root canal hinder the movement of the dye. The fluid filtration or fluid transport technique introduced by Pashley et al., in 1987, studies the sealing ability using the movement of a bubble in a capillary tube.²¹ This method has a major advantage over dye-penetration technique, as the samples are not destroyed, thus the leakage can be followed longitudinally. Also, the results are more precise, and the margin of human error is reduced as results are recorded automatically.¹⁹ As the fluid filtration method had multiple benefits and to avoid methodological

Fig. 1. Paired scatter for Gutta percha with AH 26.

Fig. 2. Paired scatter for Gutta percha with AH plus plus.

variations occurring from combining all studies detecting microleakage by some or the other method, only studies that used fluid filtration test were combined in this study.

Moreover, several studies comparing lateral condensation, single cone and warm vertical compaction techniques in regards to leakage found no difference between the techniques.^{22,23} In the present systematic review, three included studies, Tunga et al.,¹⁶ Onay et al.,¹⁷ Santos et al.,²⁴ used lateral compaction technique, one study by Wedding et al.²⁵ used warm vertical condensation for the GPgroup and De Deus et al.²⁶ used single cone technique for filling the prepared teeth. In all included studies, the irrigation protocol was a combination of

sodium hypochlorite and EDTA for smear layer removal followed by a final rinsing with saline or distilled water. The removal of the smear layer may be considered an essential step in the process of successful root canal treatment. Shahravan et al., in 2007 conducted a systematic review and meta-analysis on the effect of smear layer on the sealing ability of canal obturation.²⁷ He concluded that removal of the smear layer improves the fluid-tight seal of the root canal system, whereas other factors such as obturation technique used did not produce a significant effect. Considering the fact, studies in which the smear layer has been removed have been evaluated in this review regardless of obturation technique used.

Fig. 3. Paired scatter for Resilon with epiphany.

Fig. 4. Linear regression for each material.

Finally, there are certain limitations; firstly, in all these in vitro studies, sealing ability was evaluated only for a period of few days to months. In the study by De Deus et al. the maximum time period for testing the material was fourteen months.²⁶ Interestingly, most of the identified studies lasted less than six months. Infact in a study by Tunga et al., 2006, the root canal filled samples were stored for 48 h and then leakage was measured every hour for 3 h. As most articles only tested short term sealing ability compared to the actual time period of clinical use of these material, therefore the results obtained need to be cautiously evaluated prior to making any recommendations. Secondly, the result is the pooling of in-vitro studies and the result may not match with in-vivo studies. This systematic review is also limited to papers using fluid filtration method and published in English Language only.

Further, systematic reviews of long term randomized clinical trials are required to establish the sealing capabilities of the materials tested in the present systematic review.

5. Conclusion

Within the limitations of this systematic review, it can be concluded that during the initial time-period, resilon/epiphany sealer has better sealing ability than gutta-percha. However, over a period of time the resilon system demonstrated increased fluid flow. Gutta-percha with AH plus sealer showed the best long term sealing ability.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements

Not applicable.

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