The apical sealing effect of various on root canal fillings on isolated teeth: a systematic review

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Research Article

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Abstract

Background: Root canal filling materials that are commonly used include AH-Plus, GuttaFlow, and Resilon/Epiphany. In clinical practice, the apical closure performance of three root canal fillers is still debatable. The goal of this study was to conduct a meta-analysis to evaluate the effect of AH Plus, GuttaFlow, and Resilon/Epiphany on apical sealing in order to provide references for their clinical application.

Methods: Between January 1, 2000 and June 1, 2022, the computer database was searched for randomized controlled trials on the effects of AH Plus (AH group), GuttaFlow (GF group), and Resilon/Epiphany (RE Group) root canal filling materials on apical sealing. Two evaluators independently assessed the studies' quality and extracted the data. Review 5.4 software was used to conduct a meta-analysis of the included studies.

Results: A total of 10 literatures containing 452 isolated teeth were included. The meta-analysis results revealed a significant difference in apical microleakage between the RE group and the AH group [SMD = 1.45, 95% CI (1.20, 1.69), P<0.00001] and the GF group [SMD = 1.37, 95% CI (0.80, 1.95), P<0.00001]. There is no significant difference in apical microleakage between the AH and GF groups [SMD = 0.09, 95% CI (-0.21, 0.40), P = 0.55].

Conclusions: Based on existing research findings, Resilon/Epiphany has the best apical sealing effect in the short term (≤ 1 week) when compared to AH plus and GuttaFlow.

Background

The most common cause of pulpitis and periapical inflammation is bacterial and other microbial infections in the root canal system. Endodontic treatment today involves thoroughly cleaning and shaping the root canal before filling it with filling material to form a complete three-dimensional seal at the crown defect, the root canal, and the apical foramen [1]. It is currently the most widely used and effective treatment for pulpitis and periapical inflammation. A good filling material and technique can significantly reduce apical microleakage and determine the quality of the root canal filling.

The root canal system is complex and varied, particularly the 5–6 mm above the apical foramen, where lateral branching and apical divergence occur. Because cement-based filling materials are difficult to achieve a complete seal, and fluid endodontic filling pastes can better adapt to the root canal wall and reduce microleakage, it is necessary to investigate microleakage with root canal filling agents [2]. AH Plus is a resin-based root canal filling agent that has good fluidity, strong bonding, and low solubility, making it popular in clinical practice [3]. The GuttaFlow filling system operates at room temperature. GuttaFlow is a fluid root canal filler with a quick set time, low solubility, and minimal microleakage [4]. Resilon/Epiphany is a new resin-based material. Resilon/Epiphany is a new resin-based root canal filling material that is biocompatible and has high fracture resistance [5]. It consists primarily of the solid filling material Resilon and the sealing paste Epiphany.

The twenty-first century is an era of information explosion, and systematic evaluation can assist researchers in rapidly accessing comprehensive information in a given field in a limited amount of time, which can then be used to understand the frontiers of knowledge in that region of the world. Meta-analysis is a statistical test of heterogeneity and a combined analysis of multiple studies of the same type that integrates research findings to investigate inconsistencies, allows scientific conclusions to be drawn, and provides a systematic and simple method for clinical practice [6].

Root canal filling materials such as AH-Plus, GuttaFlow, and Resilon/Epiphany are commonly used, and the effects of these three materials on apical closure have been studied in vitro, but systematic evaluation of filler apical closure performance is less common. The purpose of this paper is to use meta-analysis to assess the efficacy of various root canal filling agents on apical closure, with the goal of providing theoretical guidance for clinical selection of appropriate filling materials.

Methods

Search strategies

The extensive searches of the relevant literature were conducted by PubMed, Cochrane Library, Medline, Embase, and Web of Science from1 January 2000 to 1 June 2022. The related literatures comparing the apical sealing effects of AH Plus, GuttaFlow, and Resilon/Epiphany root canal filling materials were included. The root canal filling materials were classified as AH Plus with cold lateral

condensation of gutta-percha (AH group), a cold flowable filling system i.e. GuttaFlow (GF group), and Resilon/Epiphany root canal filling system (RE Group).

The main key words included: “root canal filling material”, “root canal sealer”, “apical sealer”, “apical microleakage”, “root canal obturation material”, “AH Plus”, “GuttaFlow”, “Resilon/Epiphany”, “sealing ability, “microleakage”, “fluid filtration”along with OR & AND as Boolean Operators. The search strategy has been shown in Table 1.

Table 1
Search strategy (104 articles)

#1	**((((((“root canal filling material”) OR “root canal obturation material”) OR “root canal sealer”) OR “apical sealer”) OR “AH Plus”) OR “GuttaFlow”) OR “Resilon/Epiphany)**	**-**
#2	(“sealing ability”) OR “microleakage"	-
#3	(“fluid filtration”) OR “fluid transport"	-
#1	AND #2 AND #3	104

Literature selection criteria

Two researchers independently screened the literature on the effect of three root canal sealants on apical closure, performing a primary and secondary screening based on the inclusion and exclusion criteria. In the event of disagreement, the decision was reviewed by a third party. Table 2 displays the inclusion and elimination criteria.

Table 2
Selection Criteria

inclusion criteria	**(i) single root canal;** **(ii) intact root with no fissures or internal or external resorption;** **(iii) unobstructed root canal with mature apical development and no curved calcification.**
Exclusion criteria	(i) the literature was not in English; (ii) the quality of the literature was inadequate; (iii) the literature was published too long ago; (iv) it violated the inclusion criteria (v) the experimental results were not statistically analyzed; (vi) the data of the outcome indicators could not be used for Meta-analysis.

Assessment of risk of bias

The following items were evaluated based on the content of the article: sample content calculation, random allocation of teeth, completeness of outcome data, imaging examination to assess root canal filling perfection, experimental manipulation by the same practitioner, material filling according to the manufacturer's instructions, double-blind, and appropriate statistical analysis. The following items were used to determine the risk of bias groups.

i. high risk of bias: 1–3 items were identified;;
ii. medium risk of bias: 4–5 items were identified;t;
iii. low risk of bias: 6–8 items were identified;.

Statistical analysis

For data extraction and analysis, Review 5.4 software was used, and SMD (standardised mean difference) was used to avoid the effects of intervention measures and units. The 95% confidence interval CI (95%CI) was employed as the effect size indicator, and $P < 0.05$ was used as the statistical difference criteria. The χ^2 test was used to assess heterogeneity between included study results. If there was no statistical

heterogeneity between study outcomes ((P > 0.1 and $I^2 \leq 50\%$), a fixed-effects model was used; otherwise, a random-effects model was used.

Results

Study search

The first examination yielded a total of 104 publications, of which 10 were eventually included following thorough screening. Figure 1 depicts the literature search method and screening outcomes.

Description of studies

Following a thorough review of the literature, 10 publications satisfying the criteria with a total of 452 teeth were eventually included, and the fundamental features of the included studies are provided in Table 3.

Table 3
Basic characteristics of the included studies

Study	Study Subjects	Apical width	Irrigants	Groups	Penetration time	Ending indicators
Anantula 2011[7]	Single root canal mandibular premolar	30#	NaCLO/EDTA	AH, GF	None	□
Fang 2012[8]	Single root canal maxillary anterior teeth	30#	NaCLO/EDTA	AH, ER	7 days	□
Fathia 2012[9]	Single root canal permanent teeth	45#	NaCLO/EDTA	AH, ER	7 days	□
Kqiku 2010[10]	Single root canal anterior teeth	25#	Glyde/EDTA	AH, GF, ER	None	□
Kqiku 2011[11]	Single root canal permanent teeth	50#	NaCLO/EDTA	AH, ER	7 days	□
Lambor 2012[12]	Mandibular first premolar	20#	NaCLO/EDTA	AH, ER	3 days	□
Patil 2016[13]	Single root canal maxillary anterior teeth	60#	NaCLO/EDTA	AH, GF	3 days	□
Punia 2011[14]	Single root canal permanent teeth	50#	NaCLO/EDTA	AH, GF, ER	3 days	□
Sultana 2016[15]	Single root canal maxillary anterior teeth	40#	NaCLO/EDTA	AH, ER	7 days	□
Vula 2020[16]	Single root canal maxillary anterior teeth	30#	NaCLO/EDTA	AH, ER	7 days	□

Note: AH: AH Plus; GF: GuttaFlow; ER: Resilon/Epiphany; NaCLO: sodium hypochlorite solution; EDTA: ethylenediaminetetraacetic acid solution; Glyde: Glan Gel root canal lubricant; H_2O_2 : hydrogen peroxide solution; □Vacancy incidence after root canal filling = (number of sections in the group with vacant sections ÷ total number of sections in the group (ii) microscopic observation of the dye penetration length; (iii) spectrophotometric quantification of dye penetration

Risk of bias assessment

Table 4 displays the findings of the risk of bias evaluation for the included studies, where a 'yes' item indicates that it is discussed in the article and a 'no' item indicates that it is not mentioned in the article.

Table 4
Evaluation of the risk of bias in the included studies

Study	Sample size calculation	Teeth randomization	Complete results data	Imaging studies	Operated by the same doctor	Manufacturer's notes	Blinding of the examiner	Statistical analysis	risk of bias
Anantula 2011[7]	N	Y	Y	N	N	Y	N	Y	Medium
Fang 2012[8]	N	Y	Y	Y	N	N	N	Y	Medium
Fathia 2012[9]	N	Y	Y	N	N	N	N	Y	High
Kqiku 2010[10]	N	N	Y	N	N	N	N	Y	High
Kqiku 2011[11]	N	Y	Y	N	N	N	N	Y	High
Lambor 2012[12]	N	Y	Y	N	N	Y	N	Y	High
Patil 2016[13]	Y	Y	Y	N	N	Y	N	Y	Medium
Punia 2011[14]	N	Y	Y	N	N	Y	N	Y	Medium
Sultana 2016[15]	Y	Y	Y	N	N	N	N	Y	Medium
Vula 2020[16]	N	N	Y	N	N	Y	N	Y	High
Note: Y (Yes) indicates that the details was discribed in the article									
N (No) indicates that the details was not found in the article									

Meta-analysis of the included literature

The findings of a meta-analysis of the available literature on the influence of various root canal fillers on apical closure were shown in Table 5. The model of random effects The findings of the meta-analysis revealed that there were statistically significant differences in apical microleakage between the RE group and the AH group [SMD = 1.45, 95% CI (1.20, 1.69), $p < 0.00001$] and the GF group [SMD= 1.37, 95% CI (0.80, 1.95), $p < 0.00001$]. A random effects model meta-analysis revealed no statistically significant difference in apical microleakage between the GF and AH groups [SMD = 0.09, 95% CI (−0.21, 0.40), P = 0.55].

Table 5
Effect of different root canal sealers on apical microleakage

Group	I^2	SMD (95% CI)	P-value
AH vs GF	51%	0.09 [−0.21, 0.40]	0.55
AH vs RE	58%	1.45 [1.20, 1.69]	< 0.00001
GF vs RE	51%	1.37 [0.80, 1.95]	< 0.00001

Discussion

The long-term effectiveness of root canal therapy is dependent on thorough root canal disinfection and sterilisation, followed by the root canal system being sealed by filling it with material to insulate it from external stimuli. Apical sealing of high quality is essential for effective root canal therapy [17]. Because of their low toxicity and hypoallergenicity, adhesive tips are widely used in clinical practice; however, they lack the adhesion to the dentin wall to fill irregular areas such as the apical zone [18] and must be used in conjunction with a fluid root canal sealer, making an ideal root canal sealer essential for reducing apical microleakage. The gold standard for assessing root canal sealing systems is AH Plus root canal sealer. In this study, AH Plus, GuttaFlow, and Resilon/Epiphany were utilized in this study to investigate the influence of different root canal filling materials on apical sealing. The results demonstrated that the Resilon/Epiphany filling system outperformed AH Plus and GuttaFlow for apical sealing in the short term (≤ 1 week). This might be owing to Resilon and Epiphany's excellent coupling, which interacts with the dentin wall to generate a thin mixed Resilon-Epiphany-dentin layer. Simultaneously, Epiphany sealers have minimal shrinkage and may stick to and enter the dentin tubules into the root canal wall, giving excellent sealing capabilities and successfully minimizing microleakage [19]. However, some researchers [20] discovered no significant difference in the long-term apical seal between AH Plus and Resilon/Epiphany after 30 days, and some studies [15] even claimed that Resilon/Epiphany had a poorer long-term seal than AH Plus. Failure to adequately remove the dentin staining layer to expose the dentin tubules may impair Resilon/Epiphany bonding. Resilon/Epiphany is a resin-based root canal filling substance, and the material's polymerisation shrinkage influences long-term apical closure.

The GuttaFlow root canal filling system is a particulate adhesive (Diameter 0.9 μ m) that sticks effectively to the dentin wall and expands by roughly 0.2% of its volume after curing, completing root canal filling and producing a good apical seal [21]. However, there was no significant difference in the apical sealing effect of GuttaFlow and AH Plus in this[10] Meta research, which may be due to differences in the manner the experiment was done, according to a review of the relevant literature. Root canal lumen closure [14]. Furthermore, because GuttaFlow does not allow for lateral and vertical root canal filling pressurisation, voids are more prone to emerge once the canal is filled. These two considerations might explain the disparity in AH Plus and GuttaFlow apical closure outcomes.

The research presented in this publication differ greatly, and I believe this is due to the methodological execution of the tests on isolated teeth, such as sample selection, root canal preparation procedures, irrigation solution, and other aspects. To begin, the samples used for the study comprised a variety of tooth placements, such as anterior teeth and premolars, and while the root canal morphology was all single canal, the root canal morphology could not be similar, which had an effect on root canal closure. Second, the capacity of root canal preparation procedures to cut the canal wall varies, and root canal preparation with an excessive file size beyond the working length or an apical width larger than 1 mm may produce complications. Secondly, root canal preparation procedures range in their capacity to cut the canal wall, and excessive file size beyond the working length, or an apical width more than 1 mm, may cause damage to the apical foramen and is a risk factor for apical microleakage. Because an overly broad apical zone may result in impaired sealing of the root tip by the filling material and alter the final trial results, root canal preparation should not be over-prepared and should be confined to the working length of the root canal [22]. The existence of a staining layer can impair the root canal filling material's adherence to the dentin wall. The removal of the stained layer using root canal washing solutions such as EDTA and NaCLO is favorable for root canal therapy success [23]. However, it has been hypothesized [24] that when NaClO rinses are used for root canal irrigation, the fluid left on the root canal wall may have a detrimental effect on the binding between the filling material and the dentin, hence compromising the seal between the two. According to other investigations [25], the NaClO solution has essentially little influence on the binding between the sealer and the root canal wall. As a result, the influence of the washing solution on the sealing effect of the root canal filling material is not yet obvious.

Many techniques exist for identifying microleakage, including clear tooth staining to determine dye leakage length, spectrophotometry to determine dye filtration content, and fluid filtration to determine bubble displacement and other values [26]. Different testing procedures are measured differently, and each has its own set of benefits and drawbacks, therefore they can also produce some mistake in the experimental results. For example, while the dye penetration approach is simple and straightforward, most studies only see microleakage in two dimensions from longitudinal or transverse sections of the root, and data gathering is up to the experimenter's discretion[27]. The oral environment is diverse and varied, and apical microleakage is affected by temperature, flora, and other variables. The emphasis of research in analyzing root canal sealants is how to effectively perform microleakage detection, which is advantageous to improving the study's dependability.

This study had some limitations: it used a small quantity of literature, the implementer was single-blind, the specific random allocation technique was not specified, and the study's outcomes were restricted. Second, the study included literature with differing characteristics, such as preparation process and filling method, which might have influenced the Meta-analysis outcomes. To decrease the likelihood of experimental bias, future randomised controlled trials of isolated teeth must determine sample size, be randomised and blinded, and care for any confounding variables.

Conclusions

In conclusion, In a short period of time (≤ 1 week), the apical microleakage value of the Resilon/Epiphany filling system was lower than that of the AH Plus and GuttaFlow. As a result, the apical sealing effect of the Resilon/Epiphany filling system is thought to be superior than that of ah plus and GuttaFlow in the short term.

Abbreviations

CI
Confidence interval
EDTA
Ethylene diamine tetraacetic acid
NaClO
Sodium hypochlorite
SD
Standard deviation
SMD
Standardized mean difference
VRF
Vertical root fracture

Declarations

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Availability of data and materials

All data generated or analyzed during this study are included within the article.

Authors' contributions

YJP and LZL conceived the study, and conducted the literature search. LKH screened the results. YJC and XG performed the data extraction. YJP, LZL and LKH contributed to the statistical analyses. YJP drafted the manuscript. LZL and LKH contributed to the revision of the paper.

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Ethics approval and consent to participate

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

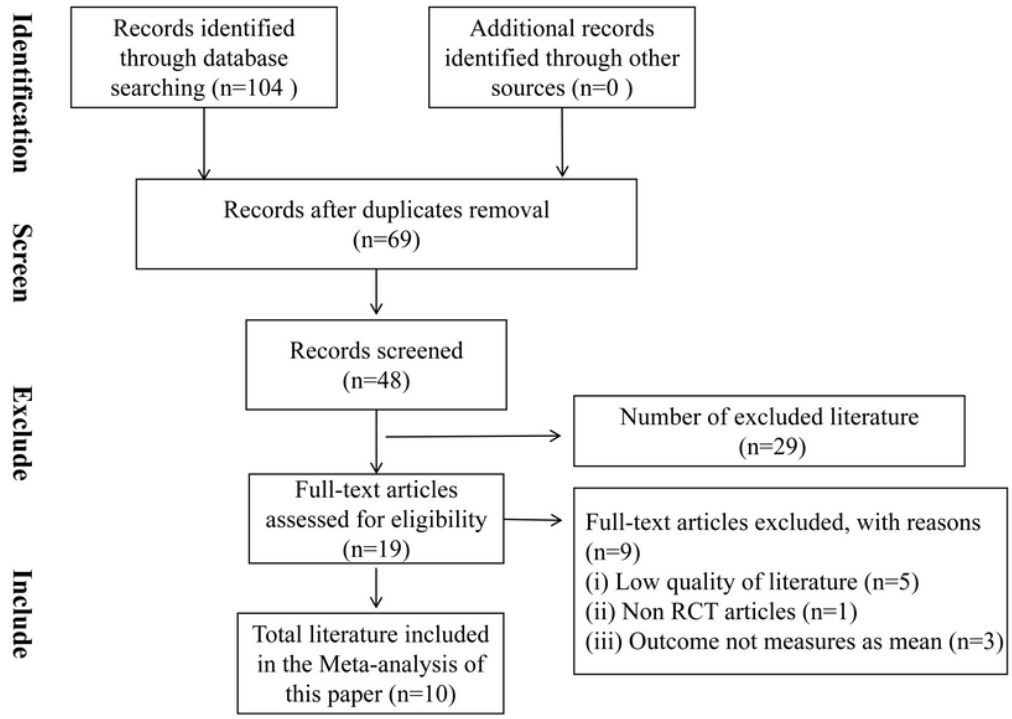

Figure 1

Literature screening process and results