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Review Article

Hydrophobic or hydrophilic fissure sealants: A systematic review and meta-analysis

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ABSTRACT

Objectives: The objective of the study was to evaluate caries development and retention rate of resin-based hydrophilic and hydrophobic fissure sealants based on the randomized clinical trials in which the investigators have studied this subject.
Materials and Methods: A literature screen was conducted in some databases, including PubMed, Scopus, Embase, ISI Web of Science, and Cochrane Library, to select randomized clinical trials that compared the caries development/retention rate of resin-based hydrophilic and hydrophobic fissure sealants until March 2025. The risk of bias of the included studies was assessed using version 2 of the Cochrane risk-of-bias tool for randomized trials (RoB 2), and the meta-analysis was performed using a random-effect model. The quality of evidence was assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach.
Results: A total of 20,945 articles were initially retrieved for screening, and fourteen studies were identified as eligible for inclusion in the quantitative analysis. The RoB assessment showed a high risk of bias in 5 studies, some concerns in 5, and low risk in 4. Caries development was reported in 11 studies, and retention rate in 14. The meta-analysis results showed a statistically significant difference for caries development (odds ratio [OR]: 0.490, 95% confidence interval [CI]: 0.277–0.867; $P = 0.014$), whereas the retention rate (OR: 0.859, 95% CI: 0.596–1.237; $P = 0.414$) indicated no statistically significant differences. The quality of evidence for both outcomes was rated as very low according to the GRADE system.
Conclusion: It could be concluded that hydrophilic and hydrophobic resin-based fissure sealants are approximately equal in caries development and retention rate, with very low quality of evidence.
Clinical Relevance: In clinical practice, resin-based hydrophilic fissure sealants could be applied on susceptible tooth surfaces; in case of difficult isolation, with an almost equal clinical success for hydrophobic fissure sealants.

Key Words: Hydrophilic, hydrophobic, meta-analysis, pit- and-fissure sealants, systematic review

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INTRODUCTION

In the oral cavity, the processes of demineralization and remineralization of tooth structure are ongoing processes. As a result of the metabolic activity of cariogenic bacteria in the dental plaque, organic acids, mainly lactic acid, are produced that could dissolve the mineral content of enamel. On the other hand, the

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host's defense mechanisms produce a supersaturated concentration of calcium and phosphate ions in saliva, thereby arresting the demineralization process and resubstituting the lost mineral components in the tooth structure.[1]

The presence of fermentable carbohydrates, bacterial activity, and time and tooth susceptibility can lead to an imbalance. Therefore, the demineralization overcomes the remineralization process and subsurface carious lesion development.[2]

Preventive approaches have focused on the aforementioned factors to prevent the initiation of caries development and to arrest it in the case of incipient caries. The use of fluoride products and fissure sealants on exposed tooth surfaces are examples of these preventive efforts.[3]

Fissure sealants were first introduced in the 1960s.[4] Since then, they have been used as barriers and protective layers against cariogenic bacteria, mostly on occlusal tooth surfaces and generally on any susceptible tooth surface.[5]

Susceptible pits and fissures of newly erupted teeth in children with a high risk of caries development could mostly benefit from applying fissure sealants.[6-8] It was even shown that noncavitated dentinal occlusal caries can be successfully sealed and arrested based on the "seal and heal" concept.[9]

The major adhesive mechanism of this preventive approach is the micromechanical adhesion,[10] and the most investigated criterion to determine the success of fissure sealants is their retention.[11,12] In case of a partial or complete loss of sealant material, the tooth surface might be more susceptible to caries development, because there would be a zone of plaque retention, which is an appropriate environment for cariogenic activity.[13]

As deeper penetration between enamel rods as well as a good adhesion of sealant to the tooth structure make it less prone to loss, some researches have focused on different methods of achieving a better adhesion using different adhesive systems under fissure sealants, different surface treatment methods before acid etching (i.e. air abrasion, bur enameloplasty, and laser treatment), and innovating moisture-tolerant or hydrophilic fissure sealants.[5,14]

Isolation of the tooth against saliva has been considered the key factor of a successful clinical procedure of fissure sealant placement, as well as its long-term clinical efficacy, historically.[15] However, it is not easy to achieve, especially in children and in erupting teeth. Conventional hydrophobic fissure sealants are moisture-sensitive, so they require a dry enamel surface during placement.[16] Although developing moisture-friendly fissure sealants could be considered an effort to overcome the challenge of moisture control based on *in vitro* studies, clinical studies have shown no similar results.

The first commercially available hydrophilic resin-based fissure sealant was presented in 2002. Accordingly, the claim was related to its ability to adhere to tooth structure in the presence of moisture.[14] It is composed of di-tri-acrylate and multifunctional monomers that can provide a hydrophilic–hydrophobic balance and contain no Bis-GMA, which is present in conventional fissure sealants. Moreover, its filler particles are activated under wet conditions, so leaving the enamel surface slightly wet after washing the etchant material is optimal during the clinical procedure, in contrast to hydrophobic ones.[17] It is even claimed that the sealant bonds to surfaces that are slightly moist from saliva; however, it is best to avoid bacterial contamination.[18]

Another commercially available hydrophilic fissure sealant material that was introduced with its thixotropic, fluoride-releasing properties and resistance to water absorption and degradation was first presented in 2013.[19]

Review of the literature represented *in vitro* and *in vivo* studies on different properties of moisture-tolerant fissure sealants.

One experimental study showed that the mean micro tensile bond strength of a hydrophilic sealant remains unchanged in most of the contaminated environments.[20] Another *in vitro* study on primary molars showed that hydrophilic pit and fissure sealants have higher tolerance to saliva contamination with less micro leakage; however, in terms of penetration ability, hydrophobic sealants were found to be superior to them.[21]

Although some clinical trials have been conducted to compare caries development and retention rates of conventional hydrophobic and recent hydrophilic sealants, they have reported different and sometimes contradictory results.

On the other hand, one clinical study concluded that a moisture-tolerant resin-based sealant, due to its lesser technique sensitivity, could be successfully used as a pit and fissure sealant.[22] However, another study showed that the retention of a hydrophobic sealant was superior to two hydrophilic sealants.[23]

This systematic review and meta-analysis were designed to compare hydrophilic and hydrophobic fissure sealants, caries development, and retention rate based on the randomized clinical trials, in which the investigators have studied this subject.

MATERIALS AND METHODS

Protocol and registration

This systematic review and meta-analysis were performed in terms of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) checklist.[24]

Eligibility criteria

The PICO method was used to assess the inclusion and exclusion criteria. The randomized clinical trials with the population of permanent molars, applying a hydrophobic resin-based fissure sealant in one group and a hydrophilic resin-based fissure sealant in another group, and reporting retention rate and/or caries development as outcomes were included in this study. *In vitro*, nonrandomized, and clinical studies with a follow-up duration of <1 year were excluded. Table 1 presents the search strategy using PICOS analysis.

Information sources

To include all the studies performed on caries development and retention rate of hydrophobic and hydrophilic fissure sealants, the following databases were searched until March 2025: PubMed, Scopus, Embase, ISI Web of Science, and Cochrane Library for published articles without time and language limitations. In addition, a hand search was conducted in reference lists of the included studies. The studies obtained from all databases were imported into an EndNote library (EndNote X9, Clarivate Analytics).

Study selection

After removing duplicates, the titles and abstracts of the imported studies were separately reviewed by two authors to find eligible studies for this systematic review in terms of the eligibility criteria. If an abstract did not provide enough information, the full text was further reviewed. All the eligible studies were included after all reviewers' consensus.

Data collection process

Available information was extracted from the included studies by two reviewers. Accuracy and completeness of the gathered data were also assessed by a second investigator. Afterward, descriptive information was gathered as follows: authors, year, country, sample size, tooth sample, type of fissure sealants, study design, isolation method, outcome variable, *P* value, and follow-up duration. Unclear or missing data were requested from corresponding authors via email; in case of no reply, a second email was sent.

Risk of bias assessment

The quality of all the included studies was assessed using version 2 of the Cochrane risk-of-bias tool for the randomized trials (RoB 2) provided by Cochrane's collaboration.[25] The overall assessment of RoB for the randomized clinical trials was performed based on five domains of RoB 2, which are biases arising from "randomization process," "deviations intended interventions," "missing outcome data," "measurement of the outcome," and "selection of the reported result." Following the evaluation of each key domain, the assessment of the overall RoB for each study was done as follows: "low" RoB if all domains were low RoB, "some concern" if at least one domain was judged to have some concern, and "high" RoB if at least one domain had high RoB or multiple domains were judged to have some concerns in a way that substantially lowered confidence was achieved in the result [Table 2].

Table 1: Search strategy using participants, intervention, comparisons, outcomes, study design analysis

	Definition	Main search terms for Pubmed (controlled vocabulary and free text terms)
Participants	All teeth with fissure sealant treatment	(("Pit and Fissure Sealants"[Mesh]) OR (Fissure Sealants, Pit) OR (Sealants, Dental) OR (Dental Sealants) OR (Sealants, Tooth) OR (Tooth Sealants) OR (Fissure Sealant))
Intervention	Hydrophilic resin-based fissure sealant	[Search results manually screened to include randomised clinical trials with a resin-based fissure sealant.]
Comparisons	Regular resin-based fissure sealant	[Search results manually screened to include randomised clinical trials with a resin-based fissure sealant.]
Outcomes	Caries development Retention rate	-
Study design	All included	[Search results manually screened to include randomised controlled clinical trials.]

Synthesis of results

The meta-analysis outcome was used to compare caries development, retention rate of hydrophilic resin-based fissure sealants, and regular resin-based fissure sealants. The odds ratio (OR) and risk difference with 95% confidence intervals (CIs) were used as the main effect size.

Because of the considerable heterogeneity among the included studies in relation to methods and materials, the random-effect model was used to pool the data. In addition, the Cochrane Q test was used to assess the heterogeneity, and the significance level was set at $P = 0.05$. Furthermore, the I^2 index was used to quantify the degree of heterogeneity. In our primary meta-analysis, we included all eligible studies regardless of RoB. However, a pre-specified sensitivity analysis excluded studies with high RoB to assess their influence on pooled effect estimates. Comprehensive meta-analysis software (Version 2, Biostat) was used for statistical analyses.

Risk of bias across studies (grading)

The quality of evidence of each outcome in the meta-analysis was evaluated using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system.[26] The following criteria were included for assessment of the quality of evidence for each outcome across studies: study design: study limitations (RoB); inconsistency of results; indirectness of evidence; imprecision; and other considerations. In the GRADE approach to quality of evidence, randomized trials without important limitations provide high-quality evidence. RoB was determined by using the RoB 2 tool. Indirectness of evidence was judged as: not serious if the evidence directly compared the interventions, population, or outcomes; serious if the findings did not apply to the population; and very serious if an indirect comparison was made. Inconsistency was judged based on the heterogeneity (I^2) of each outcome, and the following rule of thumb was used to rank it: low – 40%; moderate – 40%–60%; substantial – 50%–90%; and considerable_75%–100%. Imprecision was judged based on the crossing of the 95% CI of the pooled outcome to the no-effect line and the extent of the 95% CI of the pooled outcome. The GRADE system results in four grades in rating the quality of evidence: (1) high, (2) moderate, (3) low, and (4) very low. The certainty of evidence for primary outcomes was evaluated using the GRADE framework. All studies included in the primary meta-analysis (irrespective of RoB) were considered in the GRADE assessment. We downgraded evidence for risk of bias if >25% of the weight in the analysis came from high-RoB studies or if methodological limitations suggested bias could alter the effect magnitude.

RESULTS

Study selection

The process of including studies is illustrated in the PRISMA flow diagram in Figure 1. The results of our search were able to retrieve 20945 articles, which were obtained from five different databases as follows: ScienceDirect (n = 3962), PubMed (n = 4985), Cochrane (n = 1021), Scopus (n = 6633), and Embase (n = 4344). The search was conducted in March 2025. After the removal of the duplicate results, only 8903 articles remained. Only 25 articles met the inclusion criteria for this systematic review after the titles and summaries of all these articles were assessed for suitability. After full-text reading, all 14 articles were found to be suitable for inclusion in the qualitative synthesis. Only 6 articles' data could be pooled in the meta-analysis after they were assessed for quality.

Study characteristics

A summary of the 14 included studies is presented in Table 3. This systematic review and meta-analysis included 14 randomized clinical trials with a total of 2063 primary samples (1098 samples performed in the hydrophilic group and 965 samples in the hydrophobic resin-based fissure sealant group). Among these, 11 studies utilized a split-mouth design, whereas the remaining 2 were parallel RCTs and 1 was full factorial.

Of them, one study compared two hydrophilic resin-based fissure sealants with one hydrophobic resin-based fissure sealant, and one study compared two hydrophobic resin-based fissure sealants with one hydrophilic resin-based fissure sealant. Thus, from this study, two sets of data were finally imported to the meta-analysis.[23,27]

In addition, the studies conducted by Beresescu *et al*.,[28] Ghadge *et al*.,[29] and Bhat *et al*.[22] involved the use of bonding agents in one or both intervention groups and the studies conducted by Bhatia *et al*.,[30] Ratnaditya *et al*.,[31] Mohanraj *et al*.,[23] Topal and Kirzioglu,[32] and Bhat *et al*.[22] were categorized as having a high overall risk of bias on the RoB

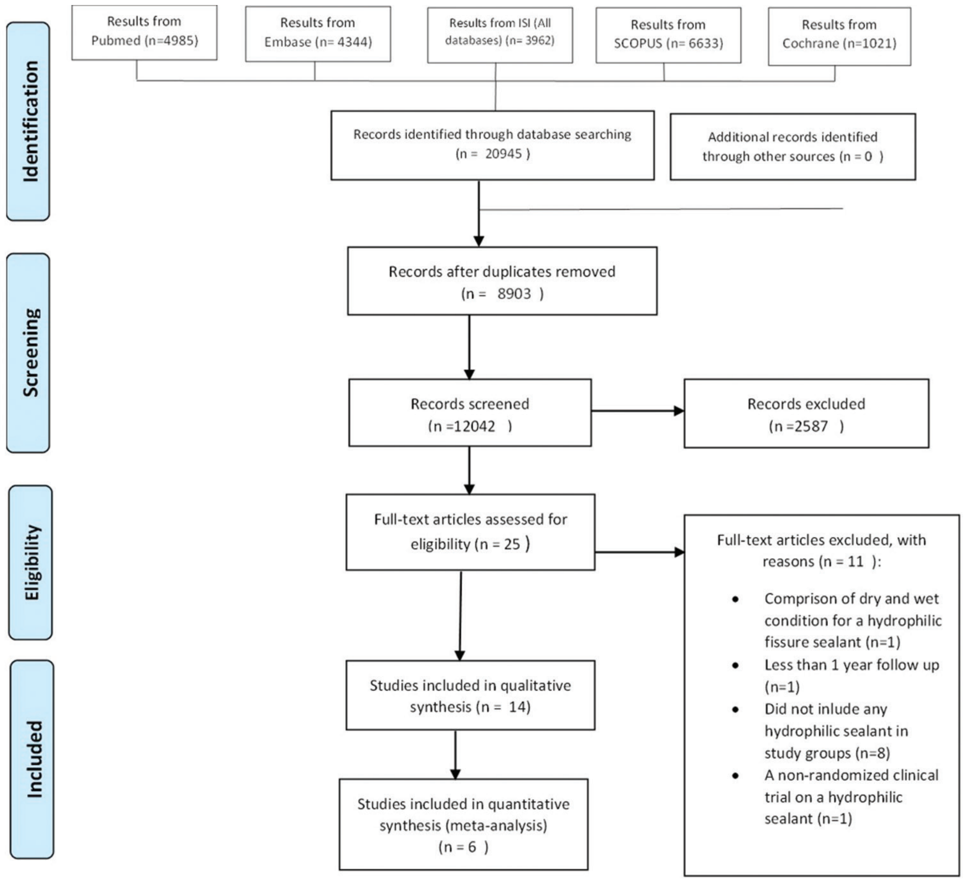

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-analyses flowchart diagram of included studies based on search strategy.

assessment were excluded from the meta-analysis to avoid introducing methodological heterogeneity.

Regarding the type of hydrophilic sealant, 12 studies[17,22,23,27,28,30-36] utilized Embrace® WetBond (Pulpdent, Watertown, MA, USA), 2 studies[29,37] used UltraSeal XT® hydro (Ultradent Products, USA), and 1 study[23] used Champ (Centrix, USA). In contrast, the use of hydrophobic sealants showed greater variation. Specifically, 4 studies[27,28,34,36] utilized Helioseal® (Ivoclar Vivadent AG, Schaan, Liechtenstein), 2 studies[30,31] used Delton FS (Dentsply International, York, PA, USA), 4 studies[22,23,27,33] used Clinpro™ (3M ESPE, St. Paul, MN, USA), 2 studies[17,37] used Helioseal-F (Ivoclar Vivadent AG, Schaan, Liechtenstein), 1 study[32] used Fissurit F® (VOCO, Cuxhaven, Germany), 1 study[29] used Conseal F, and 1 study[34] used a sealant containing amorphous calcium phosphate (Aegis™).

The follow-up periods in the included studies ranged from 12 to 24 months: 12 studies[17,22,23,27-31,34-37] had a 12-month follow-up, 3 studies[28,32,33] had an 18-month follow-up, and 3 studies[27,28,31] had a 24-month follow-up.

All studies used cotton rolls for isolation, except for two studies[23,29] that utilized a rubber dam.

Risk of bias within studies

Among the studies assessed, five – conducted by Schlueter, Khatri, Reić, Alharthy, and Ghadge – were found to have a low risk of bias, indicating a high level of methodological rigor.[27,29,35-37] These studies adhered closely to key quality criteria, particularly in areas such as randomization, blinding, and comprehensive outcome reporting. Another four studies, authored by Askarizadeh, Khatri, Gyati, and Beresescu, were rated as having some concerns in at least one domain.[17,28,33,34] These concerns were primarily related to insufficient detail regarding the randomization process or evidence of selective outcome reporting. Conversely, five studies – by Bhatia, Ratnaditya, Mohanraj, Topal, and Bhat – were categorized as having a high overall risk of bias, largely due to multiple methodological domain.[22,23,30-32] Common issues included unclear or inadequate randomization

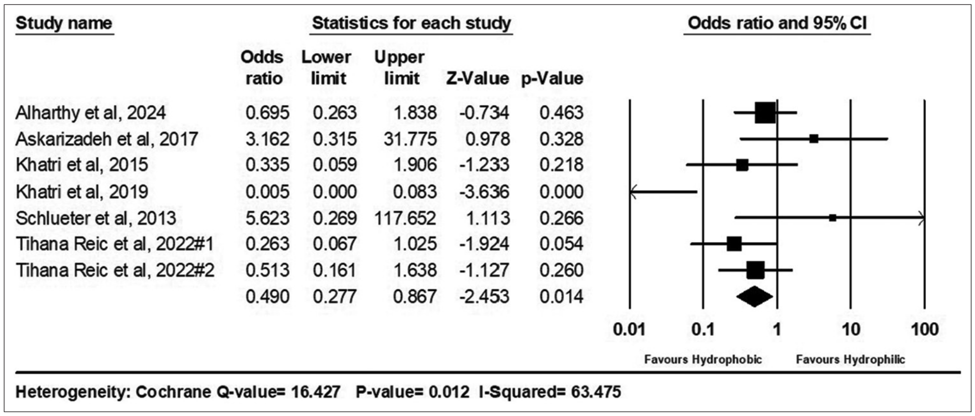

Figure 2: Forest plot comparing caries development of resin-based hydrophilic with hydrophobic fissure sealants.

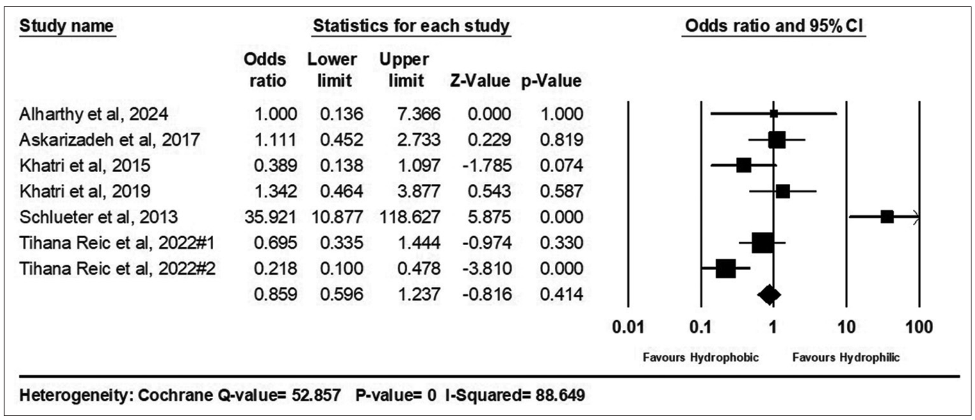

Figure 3: Forest plot comparing retention rate of resin-based hydrophilic with hydrophobic fissure sealants.

Table 2: Risk of bias assessment for randomized controlled trials based on Cochrane risk of bias 2

Author, year	Randomization process	Deviations from intended interventions	Measurement of the outcome	Missing outcome data	Selection of the reported result	Overall RoB assessment
Bhatia *et al*., 2012[30]	Some concerns	Low	Low	High	Some concerns	High
Bhat *et al*., 2013[22]	Some concerns	Low	Low	High	Low	High
Schlueter *et al*., 2013[36]	Some concerns	Low	Low	Low	Low	Low
Khatri *et al*., 2015[35]	Low	Low	Low	Low	Low	Low
Ratnaditya *et al*., 2015[31]	High	Low	Low	High	Some concerns	High
Askarizadeh *et al*., 2017[17]	Some concerns	Low	Low	Low	Low	Some concerns
Khatri *et al*., 2019[34]	Some concerns	Low	Low	Low	Low	Some concerns
Mohanraj *et al*., 2019[23]	Some concerns	Low	High	Low	Low	High
Topal and Kirzioglu, 2019[32]	Some concerns	Low	Low	High	Low	High
Beresescu *et al*., 2022[28]	Some concerns	Low	Low	Low	Low	Some concerns
Reić *et al*., 2022[27]	Low	Low	Low	Low	Low	Low
Gyati *et al*., 2023[33]	Some concerns	Low	Some concerns	Some concerns	Low	Some concerns
Alharthy *et al*., 2024[37]	Low	Low	Low	Low	Low	Low
Ghadge *et al*., 2024[29]	Low	Low	Low	Low	Low	Low

RoB: Risk of bias

procedures, significant amounts of missing outcome data, and indications of selective reporting. Notably, the study by Ratnaditya *et al*.[31] exhibited a high risk of bias in both the randomization process and handling of missing data, which raises substantial concerns regarding the reliability of its findings. Similarly, Topal *et al*.[32] reported a considerable loss to follow-up, with 293 out of 683 teeth unaccounted for, which could have introduced bias into the study's findings and contributed to its high-risk rating

Synthesis of results

As mentioned earlier, due to the considerable heterogeneity among the included studies, a random-effects model was used to pool the data; moreover, studies with a high risk of bias and those that included bonding agents were excluded from the meta-analysis, resulting in the inclusion of six studies with a 12-month follow-up.

The meta-analysis on caries development revealed a statistically significant difference (OR: 0.490, 95% CI: 0.277–0.867; P = 0.014) [Figure 2]. Furthermore, the results of meta-analysis on retention rate indicated no significant difference (OR: 0.859; 95% CI: 0.596–1.237; P = 0.414) [Figure 3].

As shown in Figures 2 and 3, there was no difference between the use of resin-based hydrophilic or hydrophobic fissure sealants regarding caries development and retention rate.

Risk of bias across studies (grading)

Table 4 presents the summary of findings for grading the quality of evidence for the outcomes of caries development and retention rate. The quality of evidence for both outcomes was downgraded to very low due to considerable risk of bias within 50% or more of studies, high heterogeneity across included studies, and serious imprecision because of 95% CI crossing the clinical decision threshold.

DISCUSSION

To the best of our knowledge, this is the first systematic review and meta-analysis pooling the clinical evidence available in the literature comparing two types of resin-based fissure sealants. As an effort to increase the quality of this systematic review and meta-analysis, only those randomized clinical trials with at least 12 months of follow-up duration were included in the study. The main sealant materials used by the investigators in the studies were hydrophobic and hydrophilic resin-based fissure sealants.

It is clear that the effectiveness of fissure sealants, as caries preventive agents, is markedly related to the proper bonding of the material to the tooth surface as well as to its complete retention to the tooth. As it is obvious from the included studies, researchers have achieved various results when comparing caries development and retention rate of resin-based hydrophobic and hydrophilic fissure sealants. Thus, this systematic review and meta-analysis aimed to evaluate the ability of these two types of fissure sealants to prevent the occurrence of caries and their retention in those clinical studies, in which the investigators used resin-based hydrophobic fissure sealants compared with resin-based hydrophilic fissure sealants.

The results of this meta-analysis show that despite variation in the achieved results among the included clinical trials, there is no statistically significant difference concerning both caries development and retention rate of the considered types of fissure sealants overall. Among the included studies for quantitative analyses, 11 studies reporting caries development and 14 studies reporting retention rate, concluded that there is no statistically significant difference between the compared materials.

Totally, the studies suggested that sealant loss may occur because of inadequate sealing of all the pits and fissures, inadequate etching, rinsing, drying, insufficient curing time, position of tooth in the mouth, state of tooth eruption, tooth morphology, caries risk, oral hygiene habits, skill of the operator, placement technique, and the patient's age.[23,38,39]

High technical sensitivity is a matter of consideration when using hydrophobic resin-based fissure sealants. Therefore, isolation is a key feature in any clinical procedure. In a study, Eidelman *et al*. reported a similar retention rate for using a rubber dam or cotton roll during the application of fissure sealant.[40]

In the study by Schlueter *et al*., who presented significantly superior retention rate of Helioseal, it was proposed that for applying Embrace Wetbond in terms of the manufacturers' recommendations, it is difficult to achieve moisture control using the material on surfaces that are wet enough so that no etching pattern is visible, but dry enough so that water is not visible in the fissures. In a clinical practice, this problem may arise due to the reason that, by drying the fissure with the air syringe, the etching pattern becomes visible, and on the other hand, leaving the etched surface humid may cause pooling or drops of water in the fissures.[36] Therefore, it is highly recommended to remove the excess moisture from the tooth surface with a dry cotton pellet.

If using adhesive resin under sealant material is not considered in clinical procedures in community programs or due to procedural limitations in uncooperative patients, and if dentin is exposed

Table 3: Summary of included studies

Author, year	Country	Final sample size	Tooth sample	Type of fissure sealants	Study design	Isolation	Outcome variable	*P*	Follow-up duration
Askarizadeh *et al*., 2017[17]	Iran	40 teeth with Hydrophilic and 40 with Hydrophobic	Permanent maxillary and mandibular first molars	Embrace Wetbond Helioseal-F	Split-mouth	Cotton roll and saliva ejector	Retention Marginal adaptation Color match Smoothness of surface Caries recurrence	>0.05 for all variables	12 months
Bhat *et al*., 2013[22]	India	76 teeth with hydrophilic and 76 teeth with hydrophobic	Permanent maxillary and mandibular first molars	Embrace Wetbond Clinpro	Full factorial	Cotton rolls and a saliva ejector	Retention rate and development of caries	0.2	12 months
Bhatia *et al*., 2012[30]	India	34 teeth with hydrophilic and 34 teeth with hydrophobic	Permanent maxillary and mandibular first molars	Embrace Wetbond Delton FS+	Split-mouth	Cotton rolls and suction	Retention rate	0.73	12 months
Khatri *et al*., 2015[35]	India	32 teeth with hydrophilic and 32 teeth with hydrophobic	Permanent mandibular first molars	Embrace Wetbond Helioseal	Split-mouth	Cotton roll and high volume suction	Retention rate Caries score	0.03 (Embrace) 0.48	12 months
Khatri *et al*., 2019[34]	India	34 (32) teeth with hydrophilic and 34 (32) teeth with hydrophobic	Permanent mandibular first molars	Embrace Wetbond Aegis	Split-mouth	Cotton rolls and high-volume suction	Retention rate Caries score	0.8 0.02 (Aegis)	12 months
Mohanraj *et al*., 2019[23]	India	200 (no mentioned drop outs) teeth with a hydrophilic and 200 (no mentioned drop outs) teeth with another hydrophilic and 200 (no mentioned drop outs) teeth with hydrophobic	Permanent maxillary and mandibular first molars	Embrace Wetbond Champ Clinpro	Parallel	Rubber dam and a saliva ejector	Retention Caries development	<0.05 (for clinpro vs. champ and clinpro vs. embrace) (clinpro) <0.05 for most comparisons in partial and total loss (clinpro)	12 months
Ratnaditya *et al*., 2015[31]	India	106 (106) teeth with hydrophilic and 106 (106) teeth with hydrophobic	Permanent maxillary and mandibular first molars	Embrace Wetbond Delton FS+	Split-mouth	Cotton rolls and a saliva ejector	Retention rate	0.00 (Embrace)	12 months 24 months
Schlueter *et al*., 2013[36]	Germany	55 teeth with hydrophilic and 55 teeth with hydrophobic	Permanent maxillary and mandibular first molars	Embrace Wetbond Helioseal	Split-mouth	cotton rolls	Retention rate Caries incidence	≤0.001 (Helioseal) >0.05	12 months
Topal and Kirzioglu, 2019[32]	Turkey	58 teeth with hydrophilic 60 teeth with hydrophobic	Permanent maxillary and mandibular first molars at stage 4 of eruption	Embrace Wetbond Fissurit F	Parallel	Cotton rolls and saliva suction	Retention rate Caries development	>0.05>0.05	18 months

Contd...

Table 3: Contd...

Author, year	Country	Final sample size	Tooth sample	Type of fissure sealants	Study design	Isolation	Outcome variable	*P*	Follow-up duration
Gyati *et al.*, 2023[33]	India	40 teeth with hydrophilic and 40 teeth with hydrophobic	Permanent maxillary and mandibular first molars	Embrace WetBond Clinpro	Split-mouth	Cotton roll and saliva ejector	Sealant retention marginal integrity caries incidence	0.968 0.882 0.270	18 months
Beresescu *et al.*, 2022[28]	Romania	56 teeth with hydrophilic and 56 teeth with hydrophobic	Permanent maxillary and mandibular first molars	Embrace WetBond Helioseal	Split-mouth	Cotton roll and saliva ejector	Retention Caries development	0.561 0.594 0.804 1.00 1.00 0.716	12 18 24 months
Reić *et al.*, 2022[27]	Croatia	58 teeth with hydrophilic and 65 teeth with hydrophobic and 58 teeth with hydrophobic	Permanent maxillary and mandibular first and second molars	Embrace WetBond Helioseal Clinpro	Split-mouth	Cotton rolls and saliva ejectors	Retention Presence of occlusal caries	<0.001 <0.001 0.193 0.126	12 24 months
Alharthy *et al.*, 2024[37]	Saudi Arabia	49 teeth with hydrophilic and 49 teeth with hydrophobic	Permanent maxillary and mandibular first molars	UltraSeal Helioseal-F	Split-mouth	Cotton rolls and saliva ejectors	Retention Caries	0.706 0.448	12 months
Ghadge *et al.*, 2024[29]	India	60 teeth with hydrophilic and 60 teeth with hydrophobic	Maxillary and mandibular first permanent molars	UltraSeal Conseal F	Split-mouth	Rubber dam	Retention Marginal adaptation Marginal discoloration	0.001 0.023 0.004	12 months

Table 4: Summary of findings of grading of recommendations assessment, development, and evaluation for the outcomes caries development and retention rate

Quality assessment							Number of patients		Effect; Relative (95% CI)	Quality	Importance
Number of studies	Design	RoB	Inconsistency	Indirectness	Imprecision	Other considerations	Hydrophilic fissure sealant	Hydrophobic fissure sealant			
Retention rate (follow-up mean 12 months; assessed with: Complete retention)											
10	Randomised trials	Serious[a]	Serious[b]	No serious indirectness	Serious[c]	None	850	747	OR 1.235 (0.566–2.694)	⊕OOO very low	Important
Caries development (follow-up mean 12 months; measured with: Caries development)											
8	Randomised trials	Serious[a]	Serious[a]	No serious indirectness	Serious[c]	None	742	607	OR 0.809 higher (0.345–1.896 higher)	⊕OOO very low	Important

[a]Downgraded by 1 level due to high risk of bias of some studies; [b]Downgraded by 1 level due to high heterogeneity (I^2 of >60); [c]Downgraded by 1 level due to wide confidence interval that crosses no-effect line). RoB: Risk of bias; OR: Odds ratio; CI: Confidence interval

based on fissure morphology, the moisture-tolerant sealant may present its full potential better. Cardoso *et al*. explained that dentin is hydrophilic, and its moisture after preparation is somewhat uniform. As the sealant matrix substitutes hydrophilic groups, the amphiphilicity of the material increases its ability to bond to dentin.[41] Although hydrophilic monomers of Embrace, which were the major ones compared to hydrophilic sealant in the included studies, allow the formation of bonds in the presence of water, they can also lead to higher water sorption and degradation. It is believed that compounds containing bis-GMA have lower solubility compared to those compounds without it or containing UDMA.[42] In contrast, Strassler *et al*. in their study reported similar wear, water sorption, solubility, and retention of Helioseal and Embrace.[12] Therefore, Ratnaditya *et al*., based on their results, concluded that in case of a difficult isolation, Embrace is recommended as a sealing material.[31] In a clinical study, Eskandarian *et al*. concluded that using Smartseal and loc hydrophilic fissure sealant can reduce technical sensitivities arising from saliva contamination of etched enamel during performing treatment procedures. In their comparison group, they used a saliva-contaminated microbrush to wet the etched enamel surface. After 12-month follow-ups, they reported statistically similar clinical success under dry and wet conditions.[16]

Another aspect of the studies on fissure sealant materials is that, based on evidence, bis-GMA-containing compounds like resin-based hydrophobic fissure sealants are not polymerized totally, and free monomers could be detected in the saliva. Bisphenol A and aromatic compounds react with biological molecules and bind to estrogen receptors.[43]

Given the methodological heterogeneity, a random-effects model was justified over a fixed-effect model to ensure accurate pooled estimates. Although most of the included studies were designed as split-mouth randomized clinical trials, some studies did not follow this setting of clinical research. Therefore, reducing the diversity of future clinical research methods may allow a fixed-effect data analysis that could consequently result in the clarification of the differences between the two types of fissure sealants in clinical success.

To perform this systematic review and meta-analysis, all steps, including literature screening, data extraction, and synthesis, assessment of risk of bias and quality of evidence, were based on the PRISMA checklist. In addition, version 2 of the Cochrane risk-of-bias tool for the randomized trials (RoB 2) provided by Cochrane's collaboration and the GRADE approach were used to assess risk of bias within and across studies, respectively.

Generally, clinicians should consider the discussed advantages and disadvantages of these two types of sealant materials and use them in individualized clinical situations.

The greatest limitation of this study was the lack of high-quality RCTs. In addition, due to the high heterogeneity between studies, the quality of evidence was ranked very low. Owing to the variance in study design and the studied patient pools, the forest plots of the assessed outcome showed high inconsistency and low precision. For future studies, more variables such as marginal integrity, color change, and longer follow-up duration can be included.

CONCLUSION

Based on the results of this systematic review and meta-analysis, it could be concluded that resin-based hydrophilic fissure sealants can be used when ideal isolation is not feasible, with approximately equal caries development and retention rate to resin-based hydrophobic fissure sealants, with very low quality of evidence. However, more well-designed randomized clinical trials are needed for more conclusive analyses.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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