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Efficacy of Different Tooth Lining Materials on Marginal Seal of Composite Restorations Extended upto Root Surface of the Tooth- Systematic Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Systematic Review

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ABSTRACT

Introduction: Microleakage is a major concern in composite restorations, especially with margins located on dentin or cementum of the tooth. This study aimed to review the available literature investigating in vitro the efficacy of different tooth lining materials on the marginal seal of composite restorations extended below the Cemento-Enamel Junction (CEJ) of the tooth.
Materials and Methods: Different combinations of the review terms were used to electronically search PubMed, Google Scholar, Cochrane Library, and Ebscohost databases for the last fifteen years. The records were initially screened for relevancy based on title and abstract. Articles that seemed to meet the criteria for inclusion were selected for full-text assessment. Studies deemed eligible were in vitro studies conducted on human teeth with cavities extending below the CEJ and restored using different tooth lining materials under the composite restorations.Every included study was evaluated using the Cochrane risk of bias assessment tool.

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Results: The initial search identified 619 publications. After removing duplicated records, the remaining 421 records are screened at the level of titles and abstracts to meet our inclusion criteria. 62 records were designated for full-text methodological assessment, and 15 studies were found eligible for qualitative synthesis. The sealing ability of different tooth lining materials under composite restorations was investigated in the chosen studies, with varying outcomes. Microleakage in the tooth restorations was determined by examining the extent of dye penetration under a microscope.

Conclusion: Despite the reports of less dye penetration with specific tooth liners in some in-vitro studies, there is no consistent evidence supporting that such tooth liners could reduce microleakage in composite restorations of the tooth.

Keywords: Composite restorations; cemento-enamel junction; microleakage; marginal adaptation, tooth liners.

1. INTRODUCTION

Resin composite represents the widely utilized material for direct anterior and posterior restorations. The major limitation of this material is polymerization shrinkage, which may result in gap formation at the tooth restoration interface [1]. Such gaps can result in the passage of salivary fluid and microorganisms, resulting in micro-leakage, which could be considered a major concern influencing the clinical longevity of composite resin restorations [2]. Microleakage is not a significant problem in restorations with all their margins in enamel, as enamel is a reliable substrate for bonding. However, it is difficult to achieve a complete seal if the restoration margins are on dentin or cementum [3]. Microleakage is one of the most common issues with posterior composite restorations, particularly at gingival margins placed apically to the CEJ, as in deep Class II cavities [4]. Different materials and techniques have been suggested to minimize the effect of polymerization shrinkage and gap formation, especially with restorations, where the gingival margin extends to the cementum. Among these methods, oblique incremental layering using lining materials such as flowable composite or Resin Modified Glass Ionomer Cement (RMGIC).The use of oblique incremental layering may reduce the effects of the C-factor. Increments linking fewer surfaces are regarded as having a reduced "C-factor,"which in turn leads to a reduction in polymerization stress and associated problems. Lowering the C-factor may lower the internal stresses within the placed restoration [5]. The use of tooth lining materials as a first gingival increment has been widely investigated in laboratory studies. Lining materials are usually placed as a first gingival increment in either the open or closed sandwich technique. The materials that have been tested and reported in the literature are light or dual-cured flowable composite, compomer, RMGIC, self-etch adhesive resins, and bulk-fill flowable resins. The idea behind using flowable resin liners under composite restoration has been considered as it may act as a flexible intermediate layer, relieving polymerization shrinkage stresses of the restoration [6]. Adaptation of a highly viscous composite with the cavity wall is more difficult. Therefore, the flowable composite application as a liner under the packable composite enhances adaptation and reduces microleakage [7].

Different studies have reported abeneficial effect of placing flowable composite [7-9] or flowable compomer [10] liners, which was represented by reducing the microleakage scores at tooth restoration interface in cavities with margins below CEJ. On the other hand, with the same cavities designs, the flowable resin liners showed positive leakage scores when used as a gingival increment with the centripetal opened sandwich technique [11].

Another lining material that has been investigated is RMGIC as a liner in the open or closed sandwich technique. The idea was to benefit from the sealing capability of glass ionomer when chemically bonded to dentin or cementum. As a liner, it has improved the composite restorations' sealing ability in many in-vitro tests with either deep gingival preparations in open [12] or closed [13,14] sandwich technique;or with gingival margins located above CEJ [15,16].

The use of either flowable composite or RMGIC liners has been reported to enhance composite restoration's marginal integrity [17] and provide less microleakage when placed under composite restorations with margins above the CEJ [18] or under composite restoration with

marginsondentin [19]. Majety et al in 2011 reported better sealing ability of flowable composite compared to RMGIC [20] in margins on enamel, while in Padram et al. (2018) study, RMGIC showed better results than flowable resins with margins at CEJ [13].

In contrast, some studies have reported that the use of flowable resin composite as a gingival liner has no influence on microleakage in composite restorations with margins placed on cementum/ dentin [12,13,21,22] and should be avoided when the margins are located below the CEJ [23]. Furthermore, some studies reported a negative effect of using liners as the first increment under composite restorations. Oliveira LC et al. in 2010 [24] reported that using a flowable composite or GMGI as a liner under composite resin restorations increases the polymerization shrinkage stresses at the adhesive interface leading to a possible adhesive failure. Other studies showed no influence of either flowable resins or RMGIC on microleakage indifferent in vitro studies with gingival margins located below CEJ [25-27].

One additional material tested in vitro as a gingival liner is bulk-fill flowable resins with different outcomes.In one study, microleakage testing of these materials under composite restoration showed significantly higher microleakage scores at dentin-restoration interface [28]; others showed no effect of using these new generations of flowable bulk-fill materials if compared to conventional flowable composite [29]. However, Segal P. et al. in 2018 [30] reported that bulk-fill flowable resin base provided a better marginal seal in class II restorations with gingival margins above the CEJ, and the author did not recommend this material for preparations with gingival margins located below the CEJ.

Moreover, Self-adhesive resin materials have been investigatedas a gingival liner under composite restorations. Mishra P. et al. in 2018 [31] and DoozandehM. et al.in2017 [32] reported an improved sealing abilityusing these materials as a gingival increment under packable or nanohybrid composite restorations, respectively.

1.1 Aim of the Study

To review the available data investigating the efficacy of different tooth gingival lining materials in improving the marginal seal of composite restorations extending apically to the CEJ.

1.2 Review Question

What effect do different tooth gingival lining materials have on composite restorations that extend to the root surface's marginal seal (i.e., least microleakage)?

2. MATERIALS AND METHODS

2.1 Search Strategy

Relevant electronic databases were searched using different combinations of specific keywords for in-vitro randomized trials:Pub Med,Ebscohost, Cochrane database, and Google Scholar.The search strategy included in vitro studies within the last 15 years, using terms and keywords derived from the review question to find all possible relevant studies investigating microleakage and sealing ability of different materials in restorations extending to the root surface. A manual search was also performed for studies cited in the reference list of review articles.

2.2 Study Records and Selection Process

Records were managed through EndNote citation manager software (Clarivate Analytics, Philadelphia, Pennsylvania, USA). Duplicate records were removed, and all records were assigned a number identifying the study. The guidelines developed and recommended by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) were employed in the present systematic review. Identified studies were assessed for relevancy based on titles and abstractsand inclusion/exclusion criteria**.** The PICO inclusion criteria for the current review are presented in Fig. 1.

2.3 Inclusion Criteria

- Randomized controlled trials involving extracted human teeth.
- In the last fifteen years.
- Cavities with gingival margins at / or below the CEJ.

2.4 Exclusion Criteria

- Case reports and systematic reviews.
- Studies on non-human teeth.
- Non-English language.
- Review articles (the reference lists of review articles were searched to find out more studies that might be included in the assessment).

The full texts of the relevant studies were reviewed and methodologically assessed for risk of bias using the Cochrane Collaboration 's" risk of bias" assessment tool. Then each study was categorized into high risk of bias, unclear risk of bias, or low risk of bias. A data extraction standardized form was formulated to comparethe following summary of each study: sample size, study design, intervention, materials used, measuring tools, and outcomes.

3. RESULTS

The search process of the electronic databases identified 619 records. The Endnote citation management system automatically removed 198 duplicated records to produce 421 studies. These studies were screened on the level of title and abstract for relevancy to our PICO inclusion criteria, and 359 were non-relevant and excluded from the next assessment step Fig. 1.

A full-text qualitative assessment was conducted for the remaining 62 studies using the Cochrane Risk of Bias assessment tool, and 13 studies were considered in the current study. Two records were added after a manual search from reference lists of review articles. The PRISMA Flow Diagram for study selection and reasons for exclusion is shown in Fig. 2.
The fifteen studies included for the final qualitative analysis were in-vitro design and aimed to evaluate the influence of different lining materials on composite restorations' sealing ability. Different liners, restorative materials, and testing methods used in the final list of the included records are presented in Fig. 3.

In all of the investigations that were considered, dye penetration and observation under the microscope were used to determine leakage. The thickness of the lining materials was not revealed in most of the studies. The study features are shown in Table 1.

When reviewing the findings of the included studies, variations were found in the reported outcomes regarding different liners' ability to improve the seal of composite restorations. All studies showed that none of the materials could eliminate microleakage at the dentine or cementum margin.Although some studies reported improved sealing ability when using a gingival liner, other studies failed to show any positive effect on these lining materials. Of the fifteen studies, nine reported that using a liner positively reduced microleakage (six for flowable resins liners and three for RMGIC), while the remaining six failed to find any improved sealing effect under composite restorations. In the three studies where RMGIC showed reduced leakage scores, flowable resins failed to improve gingival sealing. The findings of the studies included in the current review are presented in Table 2.

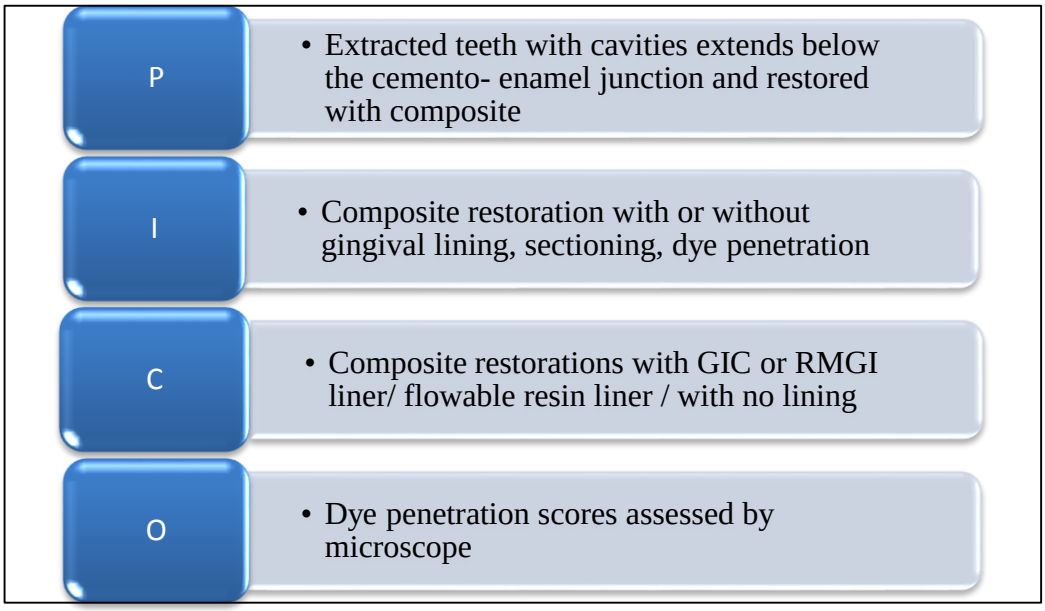

Fig. 1. PICO inclusion criteria for the current review

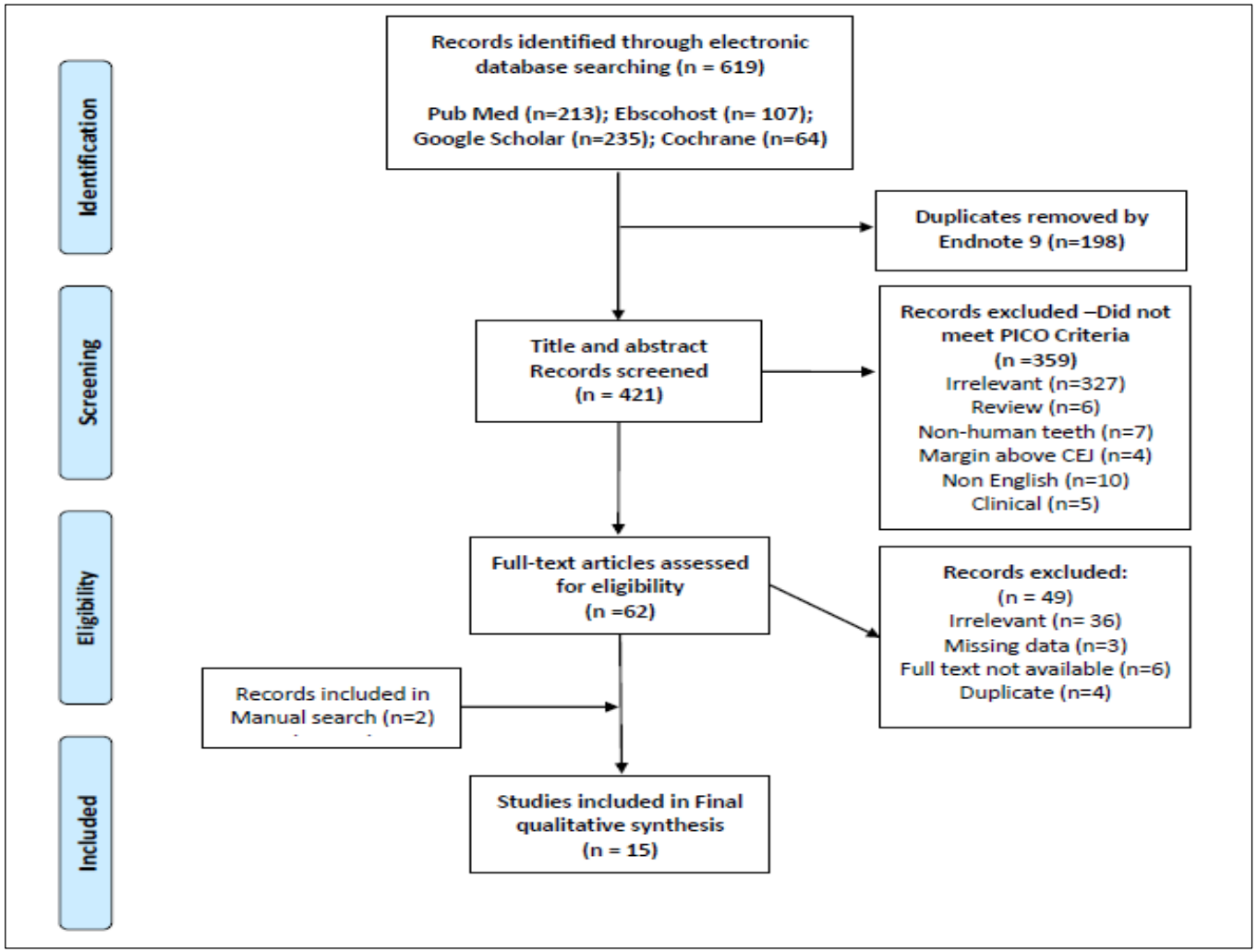

Fig. 2. PRISMA flow chart for the management of the collected records (screening and selecting of the studies

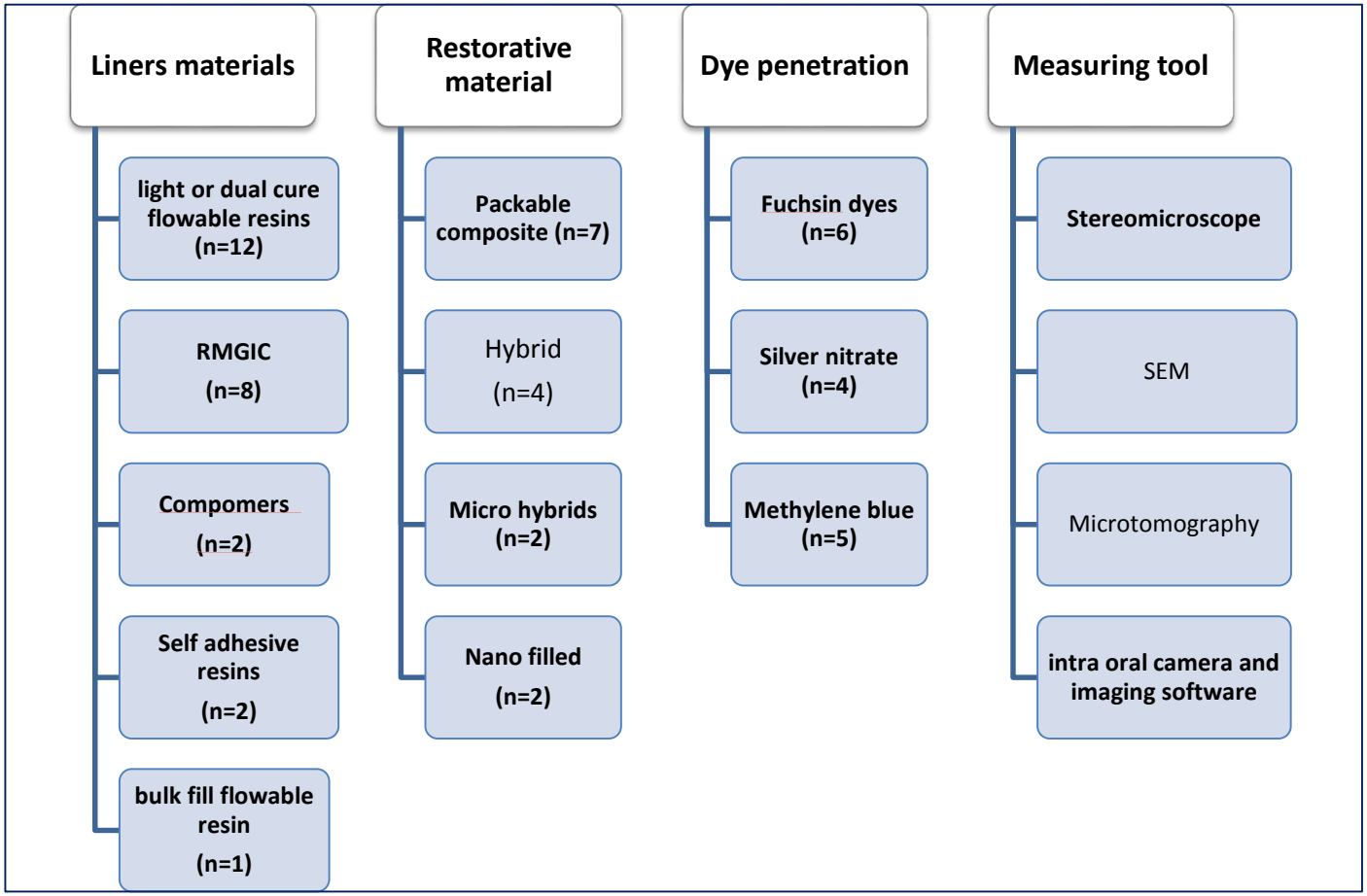

Fig. 3. Difference lining/ restorative materials categories and testing methods used in the included records for the qualitative assessment

Table 1. Summary of the *in-vitro* studies included in the qualitative synthesis

Author (yr.)	Sample (no. of extracted teeth)	Tooth preparation design	Lining Material	Filling material	dye	Measuring tool
Arora R. et al. [19]	60	Proximal below CEJ	RMGIC ; Flowable	Packable composite	fuchsine	stereomicroscope
Arslan S. et al. [29]	72	144 class V below CEJ	SDR, Flowable	Hybrid composite	fuchsine	stereomicroscope
Fabianelli A. et al. [11]	30	Proximal below CEJ	Flowable	Hybrid composite	Methylene blue	Scanning Electron Microscope
Gyanani H. et al. [27]	40	Proximal below CEJ	RMGIC; Flowable	Hybrid Composite	Methylene blue	Stereomicroscope
Kasraeri S. et al. [12]	48	Proximal below CEJ	RMGIC; flowable	Packable composite	Methylene blue	Stereomicroscope
Mishra P. et al. [31]	60	Proximal below and above CEJ	Self-adhesive flowable resin	packable	fuchsine	Stereomicroscope
Moazzami SM. et al. [25]	50	Proximal below CEJ	RMGIC; Compomer; Flowable	packable	fuchsine	Stereomicroscope
Pedram P. et al. [13]	36	Proximal at CEJ	RMGIC; Flowable	Universal composite	Silver nitrate	Stereomicroscope
Radhika M. et al. [9]	60	Proximal at CEJ	Flowable	Microhybrid, packable	Silver nitrate	Stereomicroscope
Risk HM. et al. [10]	40	Class V below CEJ	Flowable; compomer; RMGIC	Packable composite	Methylene blue	Stereomicroscope
Sadeghi M. & Lynch CD. [8]	72	Proximal below CEJ	Flowable; compomer	Nanofilled; packable	fuchsine	Stereomicroscope
Zavattini A. et al. [23]	30	Proximal below CEJ	Flowable	Universal composite	Silver nitrate	Microtomography
Sawani S. et al. [26]	53	Proximal below CEJ	Flowabel; RMGIC	Nano-composite	fuchsin	Stereomicroscope
Koubi S. et al. [14]	50	Proximal below CEJ	RMGIC; Dual cure resin	Hybrid composite	Silver nitrate	Light microscope
Ziskind et al. [22]	20	Proximal below CEJ	Flowable	Packable	Methylene blue	

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4. DISCUSSION

The benefit of the gingival liner for reducing polymerization contraction stress is still somewhat controversial[21]. In the present review, we tried to review the available literature on the evidence of using gingival liners on microleakage under composite restorations. We included in vitro studies where leakage testing was performed on human teeth with cavity margins at or below the CEJ. Studies with a gingival margin located above CEJ and studies that utilized

bovine teeth were excluded. This is because bonding to dentine and cementum is significantly more difficult and unpredictable than bonding to enamel[3]. We restricted our search to the last fifteen years as a time limit since there is continuous improvement in resin materials and bonding systems formulations in the recent decade. The amount to which dye penetrates in the restoration-tooth interface observed under the microscopein different magnifications was the measurement used to indicate microleakage scores in all studies. One limitation of this method in which dye penetration is measured after making longitudinal sections is that only the sectioned part of the restored cavity could be examined. The observed section may not necessarily be the best representative of the total leakage distribution [33].

When reviewing the results of the included studies, it was found that there are wide variations in the reports regarding the ability of different liners under composite restorations to improve the seal of tooth restoration interphase. The results of this review revealed that some improvement in sealing ability could be achieved when using low viscosity resin or RMGIC liners under composite restorations extending at or

Table 2. Outcomes of the studies included in the this systematic review

2.1 Studies reported a positive effect of flowable resinsliners		
Authors (yr.)	**Lining materials**	**Outcomes**
Sadeghi M. & Lynch CD. [8]	Flowable; Compomer	Flowable composite and compomer liners resulted in a significant reduction of the microleakage
Mishra P. et al. [31]	Self-adhesive flowable resin	Self-adhesive flowable resin liner could provide better sealing
Fabianelli A. et al. [11]	Flowable	Flowable resin in open sandwich technique provided better marginal adaptation
Radhika M. et al. [9]	Flowable	Flowable composite as the first increment is recommended in deep class II cavities.
Risk HM. et al. [10]	Flowable; Compomer; RMGIC	Flowable compomer lining material can significantly reduce microleakage , flowable composite and RMGI has no effect
2.2 Studies reported a positive effect of both flowable composite and RMGIC liners		
Arora R. et al. [19]	RMGIC ; Flowable	Flowable composite and RMGIC liners beneath the packable composite significantly reduces the microleakage
2.3 Studies reported a positive effect of RMGIC liner		
Pedram P. et al. [13]	RMGIC; Flowable	RMGI as a cavity liner under composite restorations showed the least microleakage. Flowable composite had no influence on the marginal sealing.
Koubi S. et al. [14]	RMGIC; Dual cure resin	RMGIC provided the best sealing in open-sandwich technique, dual cure flowable resin has no effect
Kasraei S. et al. [12]	RMGIC; Flowable	RMGI as a liner in closed-sandwich technique to decrease microleakage, flowable composite liner has no effect
2.4 Studies reported no effect of using liner under composite restorations		
Gyanani H. et al. [27]	RMGIC; Flowable	No significant effect of both materials
Moazzami SM. et al. [25]	RMGIC; Compomer; Flowable	No lining material could reduce gingival microleakage
Arslan S. et al [29]	SDR, Flowable	Micro-leakage is not affected by the application of either conventional or new-generation flowable composite resin
Zavattini A. et al. [23]	Flowable	Flowable composite should be avoided at the dentin/cementum margin.
Sawani S. et al. (2014)26	Flowabel; RMGIC	Liners in opened sandwich technique did not provide any better sealing effect over Centripetal build up layering
Ziskind et al. [22]	Flowable	The use of flowable composite resin as intermediate material does not reduce microleakage.

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below the CEJ. Still, these findings are not consistent among different studies. This inconsistency in the different outcomes could be due to the following factors:

- **The Type of Composite Material:** Restorative material itself may affect the reported outcomes of such in vitro leakage investigations.In a study by Narayanan et al. [34], nanocomposite resulted in the least microleakage in class II cavities extending to the cementum compared to hybrid and packable composites. Nanocomposites are characterized by nanoparticles that increase filler loading, with the consequences of reducing polymerization shrinkage and increased mechanical properties [18].
- **Different Etching and Bonding Strategies:** The adhesive system is considered an important factor for bonding quality at the tooth restoration interface. Etching and bonding strategy has been reported as an important factor that may influence the marginal seal of the composite restoration.
- **Type of Liners Investigated:** different liners -restorative materials combinations were used in the included studies. Light cured flowable resins, and RMGIC were the most commonly tested liners. Composites have a relatively high modulus of elasticity, and applying an intermediate layer of the flowable composite liner may provide better adaptation [7]. Self-adhesive flowable resin and compomer liners have been investigated and found to provide better sealing when placed gingival if compared to light-cured flowable composite [10,31]. Furthermore,other studies reported better sealing with RMGIC linerswhen compared with flowable resins [12-14].
- **Restoration Placement Technique:** the thickness of applied lining material was not revealed in most of the studies. Restorative material was placed either centripetal incremental, oblique incremental, or bulk-fill techniques. A group of composite restoration with no liner was presented as a control in all included studies. The oblique incremental layering technique has been suggested to reduce shrinkage stresses in composite restorations[5]. Centripetal placement technique with flowable composite as a gingival liner in the open sandwich technique has been reported to reduce leakage [11].
- **Variation in the Light Cure Machine and Curing Mode:** The cured in soft-start or pulse curing mode. Dual cure resin was tested as a gingival increment to overcome the incomplete curing of the material at the deep gingival margin. The use of dual or self-cure flowable resin as a gingival increment did not show an improved sealing ability compared to light-cured flowable resins or RMGIC liners [14,25].
- **Different Methodological Processing:** The studies' methodologies that evaluated gingival liners' effect on microleakage are very different. Thermo cycling and cyclic loading were not done in all studies.
- **Measuring Outcomes:** The subjective way of evaluating leakage scores and the absence of any quantitative assessment methods may explain the different outcomes in leakage studies.

5. CONCLUSION

Cannot find lining materials or technique can eliminate microleakage at the gingival margin. Despite the findings of some in vitro studies of improved sealing ability using specific liners, there is no consistent evidence that supports the use of liners under composite restorations to reduce microleakage in restorations with gingival margins at or below the CEJ.

CONSENT

It is not applicable.

ETHICAL APPROVAL

The current review was registeredon the REU research center,andInstitutional review board approval (SRS/2020/7/213/216) was obtained.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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