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SYSTEMATIC REVIEW

Do Bulk-Fill Resin Composites Present More Susceptibility to Marginal Degradation in Different Clinical Scenarios? A Systematic Review and Meta-Analysis

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ABSTRACT

Objective: To compare the marginal degradation (susceptibility to marginal adaptation and marginal discoloration) of composite restorations placed in class II and V cavities using conventional and bulk-fill resin composites. **Material and Methods:** This study was approved by PROSPERO database (#42020201596). PubMed, Scopus, Embase, Web of Science, Lilacs, Cochrane, Open Grey, Clinical Trials, and Rebec databases were searched by three independent investigators using MeSH terms, supplementary concepts, synonyms, and free keywords, based on the PICOS strategy (P, population: restoration in permanent teeth; I, intervention: bulk-fill resin composite; C, comparison: conventional resin composite; O, outcome: marginal discoloration and adaptation; and S, study design: randomized and non-randomized clinical trials). The risk of bias was evaluated according to the Cochrane Collaboration's tool, the meta-analyses by RevMan software, the certainty of evidence by the Grading of Recommendations Assessment, Development, and Evaluation, and the leave-one-out sensitivity test. The prevalence of successful events and the total number of restorations were used to calculate the risk difference at a confidence interval of 95%, according to a fixed-effect model. The heterogeneity was evaluated using the I^2 index. **Results:** 16 from 10,780 studies were selected and included for qualitative and quantitative analysis. Two studies were considered as high risk of bias, one showing some concerns, and 13 as low risk of bias. Four meta-analyses evaluated the marginal adaptation and marginal discoloration in class II and V cavities, with a non-significant heterogeneity (I^2 = 0%, $p>0.05$). The certainty of evidence was considered high, except for two subgroups of each outcome. **Conclusion:** There is evidence that composite restorations using conventional and bulk-fill resin composites present similar clinical performance related to marginal degradation.

Keywords: Systematic Review; Meta-Analysis; Composite Resins.

Introduction

The application of adhesive materials over the years in operative dentistry practice, instead of metallic and retentive restorative techniques with unnecessarily large dimensions and overly invasive, became the direct restorative technique of choice in several clinical approaches in dentistry, both in anterior and posterior teeth [1]. Therefore, resin composite presents a successful clinical performance, reestablishing dental functionality and aesthetic, through a minimally invasive dentistry approach [2].

The polymerization reaction of resin-based materials involves the breaking of carbon-carbon double bonds, transforming monomers molecules in a polymer network [3]; however, this process may produce several consequences due to the restorative technique developed, the amount of resin composite used, the size and nature of the monomers, the resin elastic modulus, the type and photopolymerization technique, and the configuration of the cavity (C-factor) [4-6]. All of these factors will generate an amount of internal stress, which is directly related to shrinkage linear and volumetric, and stress on the adhesive layer [5,7,8]. Therefore, the greater the stress-induced, the greater is the susceptibility to occur inadequate adaptation, marginal leakage, marginal discoloration, secondary caries, postoperative sensitivity, enamel cracks, and cuspal deformation [8-11].

For this reason, the incremental restorative technique is recommended to be performed when conventional resin composite is used [5]. On the other hand, thinking about solving these issues, researchers and commercial manufacturers developed a new resin-based formula, named bulk-fill resin composite, whose main features are that it can be inserted in a bulk increment (up to 4mm in thickness) and light-cured for less time [12,13]. These formula modifications are related to resin matrix changes, inorganic particle alterations (amount, shape and surface treatment), and a photoinitiator with a different wavelength and less intense staining compared to camphoroquinone [12,14].

However, both conventional and bulk-fill resin composites may, over the years, show marginal staining or marginal gaps caused by an inadequate technique of resin composite insertion or insufficient light-curing time. Depending on their intensity, they can interfere in the esthetic performance of adhesive restorations, as well as being mistakenly compared to the initial carious lesion, or even characterized as a marginal degradation process by cariogenic challenge [15]. Marginal integrity is subjectively measured by established clinical criteria (i.e., US Public Health Service – USPHS and World Dental Federation - FDI) through visual criteria of clinical features, thus being able to determine a compromise of the hybrid layer, which may be superficial or penetrate deeply into the bond interface [15,16]. Therefore, both clinical parameters need to be considered with caution and correctly evaluated to ensure clinical longevity or diagnose a secondary caries lesion earlier.

In the scientific literature, several systematic reviews with meta-analysis evaluated both resin composite in relation to chemical and mechanical properties [17], clinical performance [17-20], polymerization efficiency [21], and marginal integrity in class II cavities [22]. However, a specific methodological delineation, eliminating all methodological biases with the objective of better understanding marginal discoloration and gap occurrence in different clinical scenarios correlating both resin-based materials in permanent teeth by randomized or non-randomized controlled clinical trials, is required. Thus, this systematic review and meta-analysis aims to answer the question: "Do bulk-fill resin composites present more susceptibility to marginal degradation in different clinical scenarios?". The null hypotheses were: there would be no difference in 1) the marginal discoloration and 2) marginal adaptation susceptibility of adhesive restorations using conventional or bulk-fill resin composites placed in class II or V cavities.

Material and Methods

Study Protocol and Registration

This study was registered in the International Prospective Register of Systematic Reviews (PROSPERO) database under the protocol CRD 42020201596, and its reporting followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [23].

Search Strategy, Databases, and Eligibility Criteria

The elements of the PICOS strategy were defined based on the main question of this systematic review and is described as follows:

- Population (P): adult patients submitted to a restorative procedure in their permanent teeth;
- Intervention (I): restorations using bulk-fill resin composite;
- Comparison (C): restorations using conventional resin composite;
- Outcome (O): marginal discoloration and adaptation according to clinical evaluation parameters of composite restorations, considering different follow-up periods;
- Study design (S): randomized clinical trials and non-randomized.

An electronic search was carried out during the week of May 8, 2021 in the following databases: PubMed, Scopus, Embase, Web of Science, Lilacs by Virtual Health Library (VHL), Cochrane Library, Open Grey, Clinical Trials, and Rebec. The MeSH terms, supplementary concepts, synonyms, and free keywords used for the search strategy, based on PICOS strategy, are presented in Table 1. Besides, a handmade search was also performed with the objective of finding relevant articles that had not been retrieved in the electronic databases mentioned. No restriction of language, date, country, or any other filters were applied.

Therefore, the inclusion criteria for the studies searched based on PICOS strategy were: randomized or non-randomized clinical trials evaluating adhesive restorations in conventional and bulk-fill resin composite, following clinical criteria such as marginal discoloration and adaptation; and the exclusion criteria were: *in vitro*, *in situ* or animal studies; narrative, integrative or systematic reviews; case reports.

Table 1. Electronic databases searched and strategies used (up to May 8th 2021).

PubMed (n=1,802)	#1 ((((((((((Tooth[MeSH Terms]) OR (Tooth[Title/Abstract])) OR (Dentition, permanent[MeSH Terms])) OR (Dentition, permanent[Title/Abstract])) OR (Dental restoration, permanent[MeSH Terms])) OR (Dental restoration, permanent[Title/Abstract])) OR (Teeth[Title/Abstract])) OR (Permanent dentition[Title/Abstract])) OR (Adult dentition[Title/Abstract])) OR (Restorations, Permanent dental[Title/Abstract])) OR (Permanent tooth[Title/Abstract])) OR (Permanent teeth[Title/Abstract])) OR (Dental[Title/Abstract]); #2 ((((((((((((((Composite Resins[MeSH Terms]) OR (Composite Resins[Title/Abstract])) OR (Resins, Composite[Title/Abstract])) OR (Composite resin[Title/Abstract])) OR (Resin composite restoration*[Title/Abstract])) OR (Conventional resin composite[Title/Abstract])) OR (Composite restorative materials[Title/Abstract])) OR (Resin composit*[Title/Abstract])) OR (Resin-based composite*[Title/Abstract])) OR (Dental composite*[Title/Abstract])) OR (Direct composite resin*[Title/Abstract])) OR (Bulk fill composite[Title/Abstract])) OR (Bulk fill resin composite[Title/Abstract])) OR (Bulk fill[Title/Abstract])) OR (Bulkfill[Title/Abstract])) OR (Bulk-fill[Title/Abstract]); #3 ((((((((((Clinical Trials, Randomized[Title/Abstract]) OR (Controlled Clinical Trials, Randomized[Title/Abstract])) OR (Controlled Clinical Trials, Non-Randomized[Title/Abstract])) OR (Clinical evaluation[Title/Abstract])) OR (Clinical study[Title/Abstract])) OR (Trials, randomized clinical[Title/Abstract])) OR (Nonrandomized[Title/Abstract])) OR (Non-randomized[Title/Abstract])) OR (Clinical Trial*[Title/Abstract])) OR (Randomized controlled trial *[Title/Abstract])) OR (Non-

	randomized controlled trial*[Title/Abstract]) OR (clinical performance[Title/Abstract]); #1 AND #2 AND #3
Web of Science (n=3,798)	#1 TS: (Tooth) OR TS: (Dentition, permanent) OR TS: (Dental restoration, permanent) OR TS: (Teeth) OR TS: (Permanent dentition) OR TS: (Adult dentition) OR TS: (Restorations, Permanent dental) OR TS: (Permanent tooth) OR TS: (Permanent teeth) OR TS: (Dental); #2 TS: (Composite Resins) OR TS: (Resins, Composite) OR TS: (Composite resin) OR TS: (Resin composite restoration*) OR TS: (Conventional resin composite) OR TS: (Composite restorative materials) OR TS: (Resin composit*) OR TS: (Resin-based composite*) OR TS: (Dental composite*) OR TS: (Direct composite resin*) OR TS: (Bulk fill composite) OR TS: (Bulk fill resin composite) OR TS: (Bulk fill) OR TS: (Bulkfill) OR TS: (Bulk-fill); #3 TS: (Clinical Trials, Randomized) OR TS: (Controlled Clinical Trials, Randomized) OR TS: (Controlled Clinical Trials, Non-Randomized) OR TS: (Clinical evaluation) OR TS: (Clinical study) OR TS: (Trials, randomized clinical) OR TS: (Nonrandomized) OR TS: (Non-randomized) OR TS: (Clinical Trial*) OR TS: (Randomized controlled trial*) OR TS: (Non-randomized controlled trial*); #1 AND #2 AND #3
Cochrane Library (n=1,607)	#1 MeSH descriptor: [Tooth] explode all trees #2 (Teeth):ti,ab,kw #3 MeSH descriptor: [Dentition, Permanent] explode all trees #4 (Permanent dentition):ti,ab,kw OR (Adult dentition):ti,ab,kw #5 MeSH descriptor: [Dental Restoration, Permanent] explode all trees #6 (Restorations, Permanent dental):ti,ab,kw #7 (Permanent tooth):ti,ab,kw OR (Permanent teeth):ti,ab,kw OR (Dental):ti,ab,kw #8 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 #9 MeSH descriptor: [Composite Resins] explode all trees #10 (Resins, Composite):ti,ab,kw #11 (Composite resin):ti,ab,kw OR (Resin composite restoration*):ti,ab,kw OR (Conventional resin composite):ti,ab,kw OR (Composite restorative materials):ti,ab,kw OR (Resin composit*):ti,ab,kw #12 (Resin-based composite*):ti,ab,kw OR (Dental composite*):ti,ab,kw OR (Direct composite resin*):ti,ab,kw OR (Bulk fill composite):ti,ab,kw OR (Bulk fill resin composite):ti,ab,kw #13 (Bulk fill):ti,ab,kw OR (Bulkfill):ti,ab,kw OR (Bulk-fill):ti,ab,kw #14 #9 OR #10 OR #11 OR #12 OR #13 #15 (Clinical Trials, Randomized):ti,ab,kw OR (Controlled Clinical Trials, Randomized):ti,ab,kw OR (Controlled Clinical Trials, Non-Randomized):ti,ab,kw #16 (Clinical evaluation):ti,ab,kw OR (Clinical study):ti,ab,kw OR (Trials, randomized clinical):ti,ab,kw OR (Nonrandomized):ti,ab,kw OR (Non-randomized):ti,ab,kw #17 (Clinical Trial*):ti,ab,kw OR (Randomized controlled trial *):ti,ab,kw OR (Non-randomized controlled trial*):ti,ab,kw #18 #15 OR #16 OR #17 #19 #8 AND #14 AND #18
Lilacs (n=563)	#1 tw:((mh:(tooth)) OR (mh:(dentition, permanent)) OR (mh:(dental restoration, permanent)) OR (tw:(teeth)) OR (tw:(permanent dentition)) OR (tw:(adult dentition)) OR (tw:(restorations, permanent dental)) OR (tw:(permanent tooth)) OR (tw:(permanent teeth)) OR (tw:(dental)) OR (tw:(tooth)) OR (tw:(dentition, permanent)) OR (tw:(dental restoration, permanent))); #2 tw:((mh:(composite resins)) OR (tw:(resins, composite)) OR (tw:(composite resin)) OR (tw:(resin composite restoration*)) OR (tw:(conventional resin composite)) OR (tw:(composite restorative materials)) OR (tw:(resin composit*)) OR (tw:(resin-based composite*)) OR (tw:(dental composite*)) OR (tw:(direct composite resin*)) OR (tw:(bulk fill composite)) OR (tw:(bulk fill resin composite)) OR (tw:(bulk fill)) OR (tw:(bulkfill)) OR (tw:(bulk-fill)) OR (tw:(composite resins))); #3 tw:((tw:(clinical trials, randomized)) OR (tw:(controlled clinical trials, randomized)) OR (tw:(controlled clinical trials, non-randomized)) OR (tw:(clinical evaluation)) OR (tw:(clinical study)) OR (tw:(trials, randomized clinical)) OR (tw:(nonrandomized)) OR (tw:(non-randomized)) OR (tw:(clinical trial*)) OR (tw:(randomized controlled trial*)) OR (tw:(non-randomized controlled trial*))); #1 AND #2 AND #3
Scopus (n=2,337)	#1 (TITLE-ABS-KEY (tooth) OR TITLE-ABS-KEY (dentition, AND permanent) OR TITLE-ABS-KEY (dental AND restoration, AND permanent) OR TITLE-ABS-KEY (

	teeth) OR TITLE-ABS-KEY (permanent AND dentition) OR TITLE-ABS-KEY (adult AND dentition) OR TITLE-ABS-KEY (restorations, AND permanent AND dental) OR TITLE-ABS-KEY (permanent AND tooth) OR TITLE-ABS-KEY (permanent AND teeth) OR TITLE-ABS-KEY (dental)) #2 (TITLE-ABS-KEY (composite AND resins) OR TITLE-ABS-KEY (resins, AND composite) OR TITLE-ABS-KEY (composite AND resin) OR TITLE-ABS-KEY (resin AND composite AND restoration*) OR TITLE-ABS-KEY (conventional AND resin AND composite) OR TITLE-ABS-KEY (composite AND restorative AND materials) OR TITLE-ABS-KEY (resin AND composit*) OR TITLE-ABS-KEY (resin-based AND composite*) OR TITLE-ABS-KEY (dental AND composite*) OR TITLE-ABS-KEY (direct AND composite AND resin*) OR TITLE-ABS-KEY (bulk AND fill AND composite) OR TITLE-ABS-KEY (bulk AND fill AND resin AND composite) OR TITLE-ABS-KEY (bulk AND fill) OR TITLE-ABS-KEY (bulkfill) OR TITLE-ABS-KEY (bulk-fill)) #3 (TITLE-ABS-KEY (clinical AND trials, AND randomized) OR TITLE-ABS-KEY (controlled AND clinical AND trials, AND randomized) OR TITLE-ABS-KEY (controlled AND clinical AND trials, AND non-randomized) OR TITLE-ABS-KEY (clinical AND evaluation) OR TITLE-ABS-KEY (clinical AND study) OR TITLE-ABS-KEY (trials, AND randomized AND clinical) OR TITLE-ABS-KEY (nonrandomized) OR TITLE-ABS-KEY (non-randomized) OR TITLE-ABS-KEY (clinical AND trial*) OR TITLE-ABS-KEY (randomized AND controlled AND trial*) OR TITLE-ABS-KEY (non-randomized AND controlled AND trial*)) #1 AND #2 AND #3
Embase (n=673)	#1 tooth:ti,ab,kw OR 'dentition, permanent':ti,ab,kw OR 'dental restoration, permanent':ti,ab,kw OR teeth:ti,ab,kw OR 'permanent dentition':ti,ab,kw OR 'adult dentition':ti,ab,kw OR 'restorations, permanent dental':ti,ab,kw OR 'permanent tooth':ti,ab,kw OR 'permanent teeth':ti,ab,kw OR dental:ti,ab,kw; #2 'composite resins':ti,ab,kw OR 'resins, composite':ti,ab,kw OR 'composite resin':ti,ab,kw OR 'resin composite restoration*':ti,ab,kw OR 'conventional resin composite':ti,ab,kw OR 'composite restorative materials':ti,ab,kw OR 'resin composit*':ti,ab,kw OR 'resin-based composite*':ti,ab,kw OR 'dental composite*':ti,ab,kw OR 'direct composite resin*':ti,ab,kw OR 'bulk fill composite':ti,ab,kw OR 'bulk fill resin composite':ti,ab,kw OR bulkfill:ti,ab,kw OR 'bulk fill':ti,ab,kw; #3 'clinical trials, randomized':ti,ab,kw OR 'controlled clinical trials, randomized':ti,ab,kw OR 'controlled clinical trials, non-randomized':ti,ab,kw OR 'clinical evaluation':ti,ab,kw OR 'clinical study':ti,ab,kw OR 'trials, randomized clinical':ti,ab,kw OR nonrandomized:ti,ab,kw OR 'non randomized':ti,ab,kw OR 'clinical trial*':ti,ab,kw OR 'randomized controlled trial*':ti,ab,kw OR 'non-randomized controlled trial*':ti,ab,kw; #1 AND #2 AND #3
Clinical Trials (n=7)	Composite resin OR bulk fill
REBEC (n=0)	Composite resin OR bulk fill
OpenGrey (n=0)	Dental restoration, permanent AND (Bulk fill OR Composite resin)

Study Selection and Data Extraction Process

Firstly, all studies were transferred to an electronic database (Mendeley software, Elsevier, London, UK) and three independent reviewers (M.H.S., L.R.S. and L.N.S.A.) excluded all duplicates and performed an initial screening considering the title and abstract. After that, the remaining studies that could potentially be included in the systematic review were fully read to determine their eligibility. A fourth reviewer (R.B.E.L. or H.S.M.) was consulted in case of disagreement between the three main investigators. After the definition of the eligible studies, the same three investigators (M.H.S., L.R.S., and L.N.S.A.) performed independently the collection of fundamental data, such as author name, year and location; study design, number and age range of the participants; number of the restoration and the corresponding classification; type and number of the resin composites evaluated (conventional and bulk-fill); the classification used to evaluate the marginal discoloration and adaptation; the follow-up periods evaluated (in months and percentage of the recalls); dichotomous data of success and failure of marginal discoloration and adaptation between conventional and bulk-fill resin

composites; and the statistical analyses performed. Finally, a table with the extracted data was made with the information collected by the investigators.

In the case of a study that presented missing data, the investigators contacted the corresponding author or the first author by email to obtain the necessary information. If no response was obtained, two other attempts of contact by email were carried out in order to decide whether the study should be excluded from the systematic review.

Risk of Bias in Individual Studies

The three independent reviewers (M.H.S., L.R.S., and L.N.S.A.) evaluated the risk of bias of all eligible studies using the Cochrane Collaboration's tool for randomized controlled clinical trials (RoB version 2) [24]. The assessment criteria were divided into six domains: 1) random process; 2) effect of assignment of intervention; 3) effect of adhering to intervention; 4) missing outcome data; 5) measurement of the outcome; and 6) selection of the reported results. All key domains were classified as low, high risk of bias and some concerns for each study, and in case of disagreement, a fourth reviewer (R.B.E.L.) was consulted. For a study to be considered low risk of bias, all of its key domains had to be classified as low. If there is one domain showing some concerns, the study was considered as some concern. However, if there are two domains showing some concerns domains or at least one high risk of bias, this would led to the overall classification of the article as high-risk of bias.

Meta-analyses and Sensitivity Test

Marginal discoloration and adaptation data of composite restorations placed in different clinical situations using conventional and bulk-fill resin composites were dichotomized as success and failure according to the criteria used by each selected study and analyzed using the Revman 5.3 Software (Review Manager v. 5, The Cochrane Collaboration, Copenhagen, Denmark). The prevalence of success events and the total number of restorations for each group (conventional or bulk-fill resin composites) were used to calculate the risk difference at a confidence interval of 95%. Fixed-effects models were applied, and heterogeneity was tested using the I^2 index.

Leave-one-out sensitivity analysis was performed for each outcome (marginal discoloration and adaptation) and each clinical situation (class II and V) analyzed by the meta-analyses with the objective to observe the effect of each study on the overall effect size. For this analysis, the Revman software was used.

Certainty of Evidence Assessment

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used to evaluate the quality of evidence (certainty in the estimates of effect) [25]. Randomized controlled clinical trials are considered as high evidence initially, decreasing the evidence to moderate, low, or very low evidence according to serious or very serious issues related to risk of bias, inconsistency, indirectness, imprecision, and publication bias. Besides, this quality may be upgraded if the magnitude of effect was large or very large or if the effect of all plausible confounding factors were reduced or had suggested a false effect. Therefore, the quality of evidence may vary from very low to high. GRADEs were performed for success of marginal discoloration and marginal adaptation in class II and V restorations.

Results

Study Selection

A total of 10,780 studies were exported after the search strategy application in the searched databases, according to the PRISMA guidelines [23]. All studies were analyzed, and 3,583 duplicates were detected and removed; after that, 7,164 studies were excluded after title and abstract screening, remaining 33 studies, from which 19 studies were excluded due to: eight studies performed in primary dentitions; four studies did not evaluate marginal degradation; four studies used bulk-fill resin composite as an incremental technique; one study did not present the full text available; one study performed the restoration using conventional and bulk-fill resin composites in the same cavity; and one study did not evaluate a comparison group (Figure 1). The excluded studies are listed in Table 2. After manual search and screening, two studies were added, totalizing 16 studies for qualitative [2,12,16,26-38], and 14 for quantitative analysis [2,12,16,26,28,29,31-38].

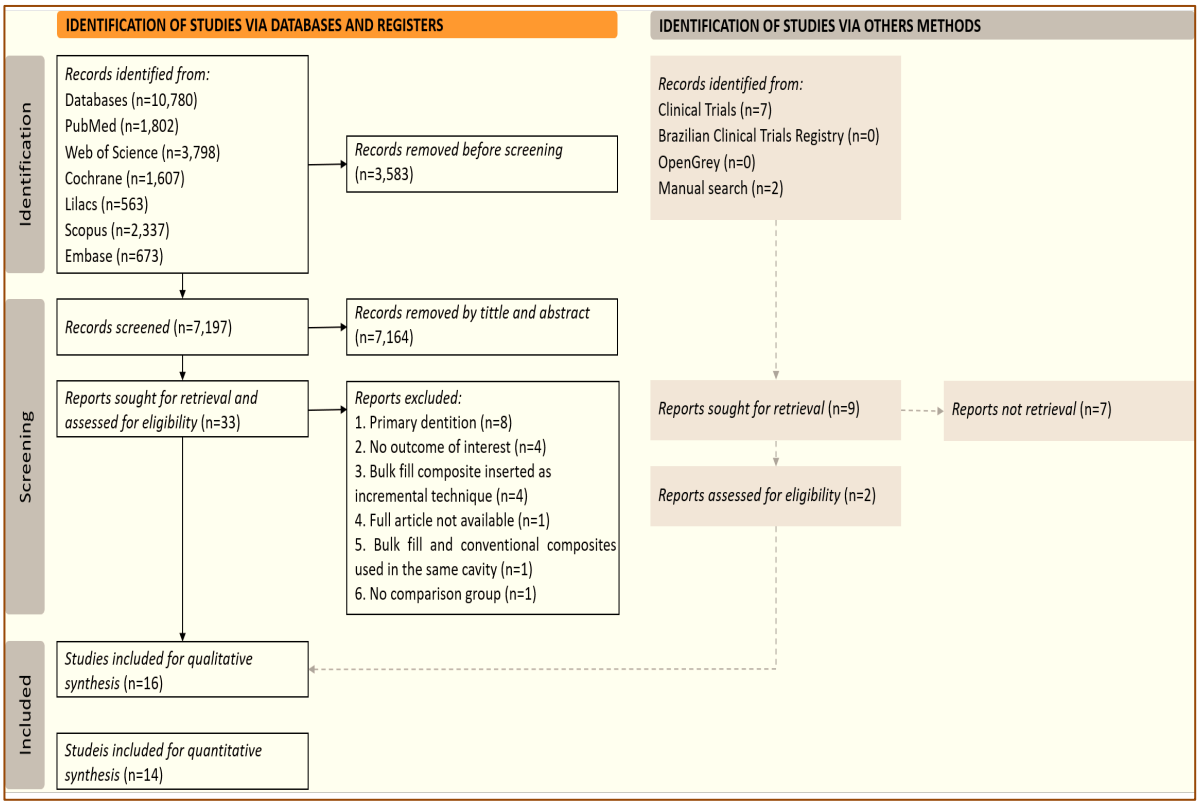

Figure 1. Flowchart of the searched, eligible, and studies included in this systematic review and meta-analysis.

Characteristics of the Included Studies

The essential information of all 16 selected studies of this systematic review is presented as supplementary material. The studies were developed in Brazil, Chile, Germany, Saudi Arabia, Syria and Turkey, published between 2010 and 2020, performed with 16 to 77 participants per study, totalizing 1,751 restorations with 668 patients, and ranging from 12 to 80 years old.

Five studies performed the restorations in class I and II [16,28,30,35,36], seven studies in class II [2,12,26,29,32,34,38], three in class V [31,33,37], and one in class I [27]. All studies reported marginal discoloration and adaptation according to the USPHS and/or FDI assessment, with a follow-up period ranging from 6- to 120-months.

Table 2. References of excluded studies in each reason.

Main Reason for Exclusion	Reference
Studies performed in primary dentitions	▪ Oter B, Deniz K, Cehreli SB. Preliminary data on clinical performance of bulk-fill restorations in primary molars. Niger J Clin Pract 2018; 21:1484-91.
	▪ Akman H, Tosun G. Clinical evaluation of bulk-fill resins and glass ionomer restorative materials: A 1-year follow-up randomized clinical trial in children. Niger J Clin Pract 2020; 23:489-7.
	▪ Ehlers V, Gran K, Callaway A, Azrak B, Ernst CP. One-year clinical performance of flowable bulk-fill composite vs conventional compomer restorations in primary molars. J Adhes Dent 2019; 21:247-54.
	▪ Olegario IC, Hesse D, Bonecker M, Imparato JCP, Braga MM, Mendes FM, Raggio DP. Effectiveness of conventional treatment using bulk fill composite resin versus atraumatic restorative treatments in primary and permanent dentition: a pragmatic randomized clinical trial. BMC Oral Health 2016;17(1):34.
	▪ Casagrande L, Dalpian DM, Ardenghi TM, Zanatta FB, Balbinot CEA, Godoy-García F, de Araujo FB. Randomized clinical trial of adhesive restorations in primary molars. 18-months results. Am J Dent 2013; 26(6):351-5.
	▪ Mosharrafian S, Heidari A, Rahbar P. Microleakage of two bulk fill and one conventional composite in class II restorations of primary posterior teeth. J Dent 2017;14:123-31.
	▪ Abo-Hamar SE, El-Desouky SS, Abu Hamila NA. Two-year clinical performance in primary teeth of nano-filled versus conventional resin-modified glass-ionomer restorations. Quintessence Int 2015; 46:381-8.
	▪ Caceda JH. The use of resin-based composite restorations in pulpotomized primary molars. J Dent Child 2007; 74:147-50.
Studies did not evaluate marginal degradation	▪ Atabek D, Aktas N, Sakaryali D, Bani M. Two-year clinical performance of sonic-resin placement system in posterior restorations. Quintessence Int 2017; 48:743-51.
	▪ van Dijken JW, Pallesen U. Randomized 3-year clinical evaluation of class I and II posterior resin restorations placed with a bulk-fill resin composite and a one-step self-etching adhesive. J Adhes Dent 2015; 17:81-8.
	▪ Tardem C. Clinical time and postoperative sensitivity after use of bulk-fill (syringe and capsule) vs. incremental filling composites: a randomized clinical trial. Braz Oral Res 2019; 33:e089.
	▪ Afifi S, Haridy M, Farid MR. Evaluation of post-operative sensitivity of bulk fill resin composite versus nano resin composite: a randomized controlled clinical study. Open Access Maced J Med Sci 2019; 26:2335-42.
Studies used bulk-fill resin composite as incremental technique	▪ Çelik Ç, Arhun N, Yamanel K. Clinical evaluation of resin-based composites in posterior restorations: a 3-year study. Med Princ Pract 2014; 23:453-9.
	▪ Manhart J, Chen HY, Hickel R. Three-year results of a randomized controlled clinical trial of the posterior composite quixfil in class I and II cavities. Clin Oral Investig 2009; 13:301-7.
	▪ Manhart J, Chen HY, Neuerer P, Thiele L, Jaensch B, Hickel R. Clinical performance of the posterior composite quixfil after 3, 6 and 18 months in class 1 and 2 cavities. Quintessence Int 2008; 39:757-65.
	▪ Loguercio AD, Rezende M, Gutierresz MF, Costa TF, Armas-Veja A. Randomized 36-month follow-up of posterior bulk-filled resin composite restorations. J Dent 2019; 85:93-102.
Study did not present the full text available	▪ Dogan D, Ercan E, Hamidi MM, Aylikçi BU, Colak H. One-year clinical evaluation of quixfil and gradia direct composite restorative materials in posterior teeth. J Mich Dent Assoc 2013; 95:36-41.
Study performed the restoration using conventional and bulk-fill resin composites in the same cavity	▪ Frascino S, Fagundes TC, Silva U, Rahal V, Barboza A, Santos PH, Briso A. Randomized prospective clinical trial of class II restorations using low-shrinkage flowable resin composite. Oper Dent 2020; 45:19-29.
Study did not evaluate a comparison group	▪ Cetin AR, Unlu N. One-year clinical evaluation of direct nanofilled and indirect composite restorations in posterior teeth. Dent Mater J 2009; 28:620-6.

Risk of Bias Assessment

The risk of bias in selected studies is presented in Figure 2. All 16 studies presented a low risk of bias for effect of assignment and adhering to intervention and missing outcome data domains; however, one study did not report information related to the methods of randomization [26], three studies did not report information related to patient blinding, operator and/or evaluator [26,27,35], and one study did not report results for marginal discoloration [27]. For these reasons, these three studies were considered showing some concerns for randomization process, measurement of the outcome and selection of the reported result domains, respectively. Therefore, thirteen studies were considered to have a low risk of bias [2,12,16,28-34,36-38], one study with some concerns risk of bias [35] and two studies with a high risk of bias [26,27].

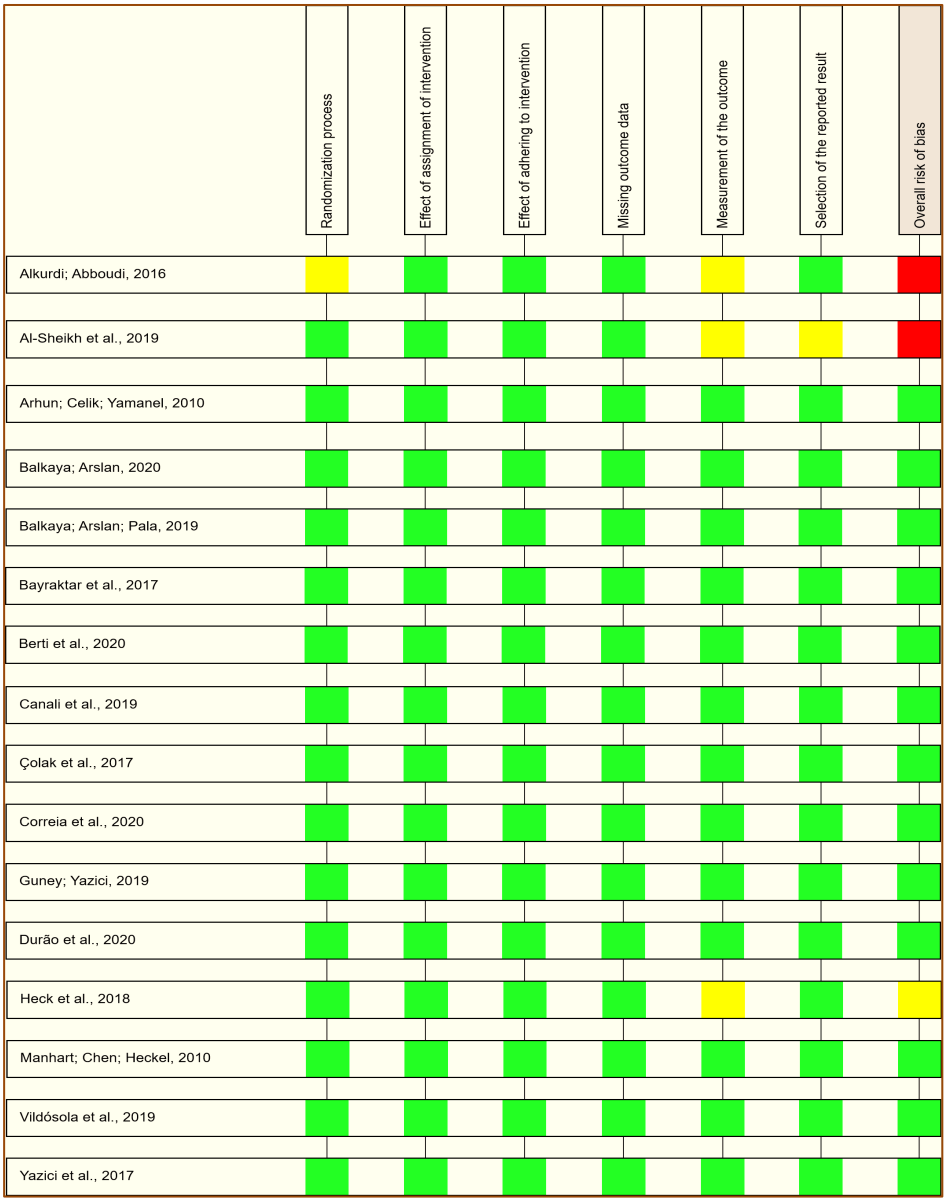

Figure 2. Risk of bias assessment for the studies included: (green) low; (yellow) under some concerns; or (red) high risk of bias.

Meta-Analysis Assessment and Sensitivity Test

The meta-analyses evaluated all selected studies that presented available data for marginal discoloration and marginal adaptation according to USPHS classification, with low, high risk of bias or some

concerns. For this reason, four separate meta-analyses were performed for 1) success of marginal discoloration in class II restorations (at 6-, 12-, 18-, and 24-months); 2) success of marginal discoloration in class V restorations (at 6- and 12-months); 3) success of marginal adaptation in class II restorations (at 6-, 12-, 18-, and 24-months); and 4) success of marginal adaptation in class V restorations (at 6- and 12-months). Considering that each study evaluated the marginal discoloration and adaptation in different follow-up periods, beyond of different clinical situations, a different number of studies were included in each meta-analysis.

For the first and third meta-analyses (Figures 3 and 5), five studies were included for 6-months of follow-up [2,12,32,34,38], six for 12-months [12,26,29,32,34,38], two for 18-months [34,38], and three for 24-months [9,34,38]. For the second and fourth meta-analyses (Figures 4 and 6), three studies were included for 6-months of follow-up [31,33,37], and two for and 12-months [31,33].

The overall heterogeneity was considered low for all meta-analyses ($I^2 = 0\%$) and the p-value of all subgroups of each meta-analysis was no significant ($p>0.05$), as well as for overall. Leave-one-out sensitivity test (Table 3) indicated that the results obtained from meta-analyses are robust and that no study evaluated influenced the overall effect size.

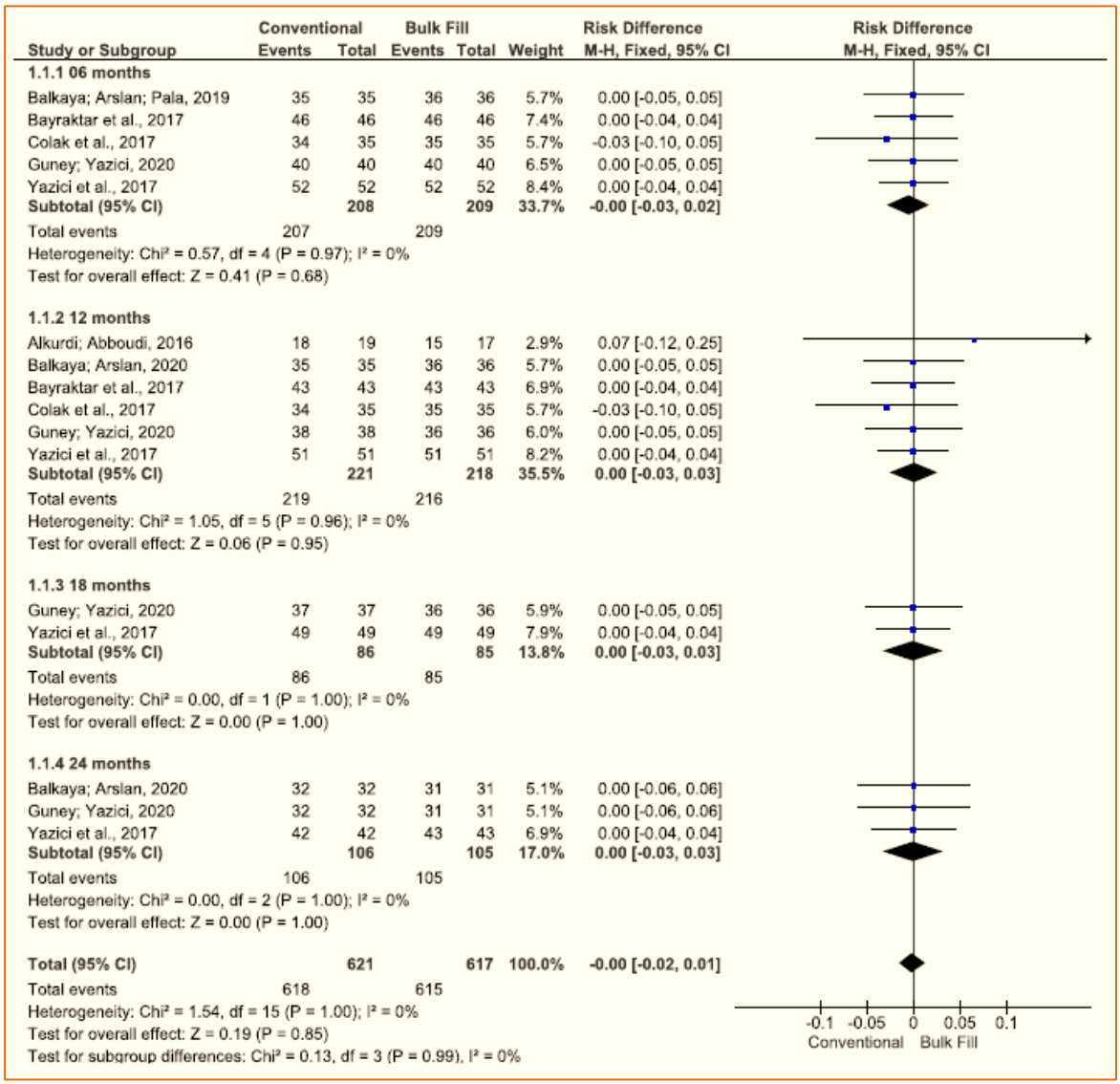

Figure 3. Forest plot of marginal discoloration of conventional and bulk-fill resin composites in class II cavities according to success and failure rates.

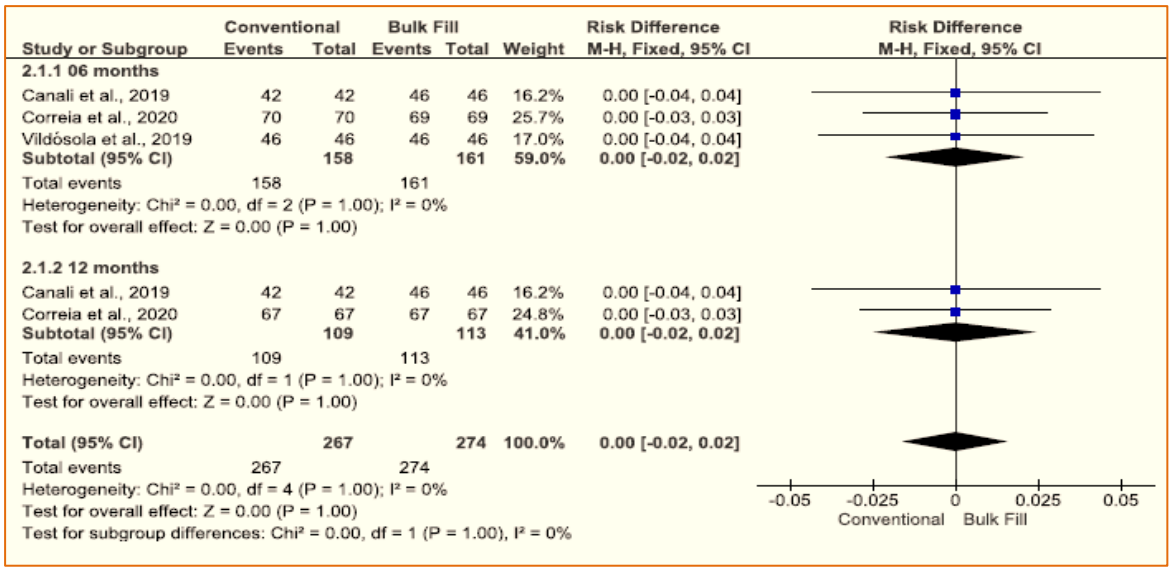

Figure 4. Forest plot of marginal discoloration of conventional and bulk-fill resin composites in class V cavities according to success and failure rates.

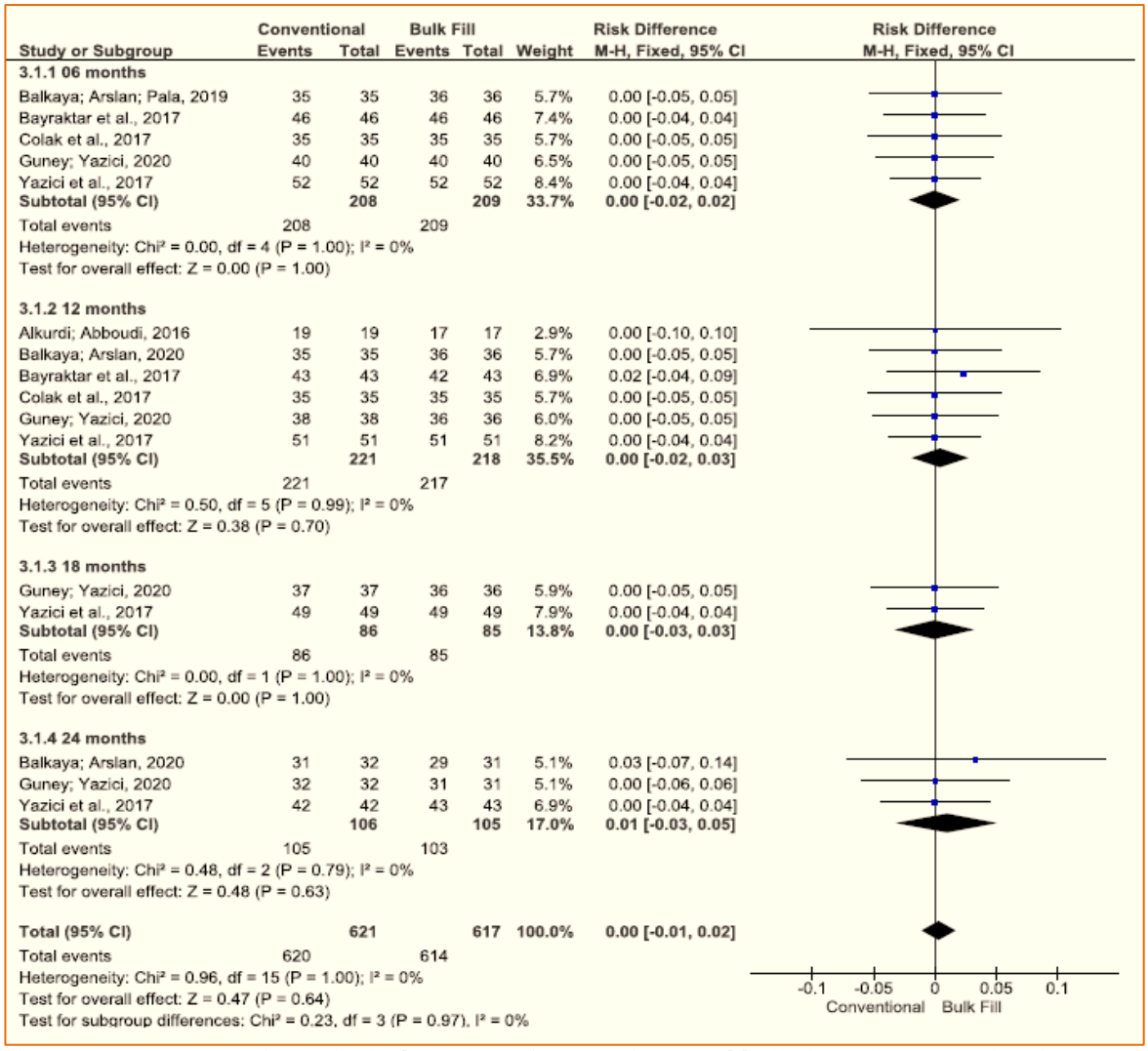

Figure 5. Forest plot of marginal adaptation of conventional and bulk-fill resin composites in class II cavities according to success and failure rates.

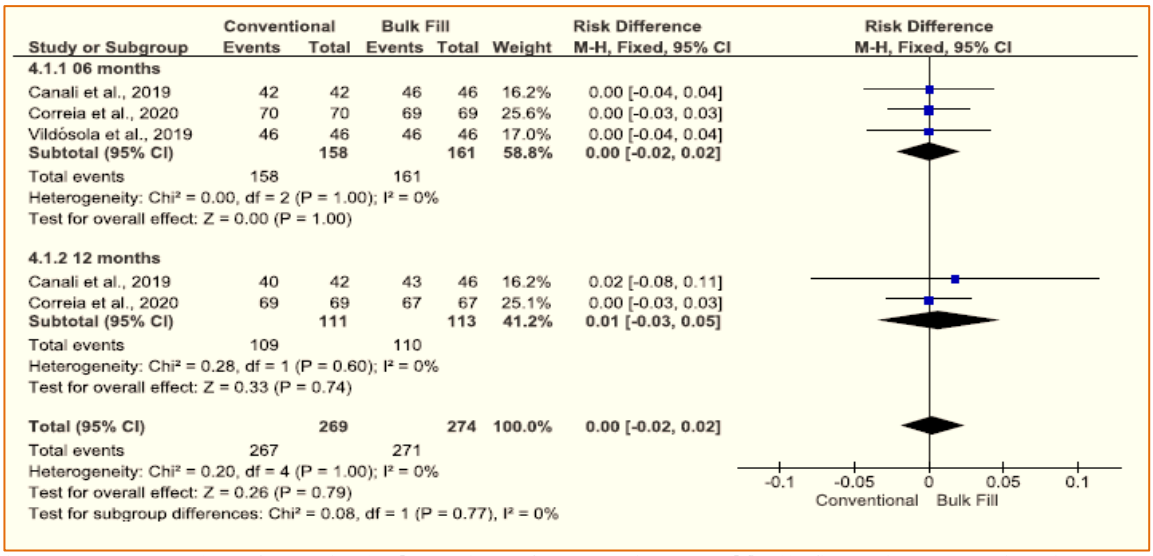

Figure 6. Forest plot of marginal adaptation of conventional and bulk-fill resin composites in class V cavities according to success and failure rates.

Table 3. Sensitivity test (leave-one-out) for all meta-analysis performed.

Marginal Discoloration in Class II Cavities	Difference in Means	Lower Limit	Upper Limit	Z-Value	I²	p-value
6 Months						
Balkaya et al. [2]	0.00	-0.02	0.01	0.19	0%	0.85
Bayraktar et al. [12]	0.00	-0.02	0.01	0.19	0%	0.85
Çolak et al. [32]	0.00	-0.01	0.01	0.04	0%	0.97
Guney; Yazici [34]	0.00	-0.02	0.01	0.19	0%	0.85
Yazici et al. [38]	0.00	-0.02	0.01	0.19	0%	0.85
12 Months						
Alkurdi; Abboudi [26]	0.00	-0.02	0.01	0.49	0%	0.62
Balkaya; Arslan [29]	0.00	-0.02	0.01	0.19	0%	0.85
Bayraktar et al. [21]	0.00	-0.02	0.01	0.19	0%	0.85
Çolak et al. [32]	0.00	-0.01	0.01	0.04	0%	0.97
Guney; Yazici [34]	0.00	-0.02	0.01	0.19	0%	0.85
Yazici et al. [38]	0.00	-0.02	0.01	0.19	0%	0.85
18 Months						
Guney; Yazici [34]	0.00	-0.02	0.01	0.19	0%	0.85
Yazici et al. [38]	0.00	-0.02	0.01	0.19	0%	0.85
24 Months						
Balkaya; Arslan [29]	0.00	-0.02	0.01	0.19	0%	0.85
Guney; Yazici [34]	0.00	-0.02	0.01	0.19	0%	0.85
Yazici et al [38]	0.00	-0.02	0.01	0.19	0%	0.85
Overall	0.00	-0.02	0.01	0.19	0%	0.85
Marginal Discoloration in Class V Cavities	**Difference in Means**	**Lower Limit**	**Upper Limit**	**Z-Value**	**I²**	**p-value**
6 Months						
Canali et al. [31]	0.00	-0.02	0.02	0.00	0%	1.00
Correia et al. [33]	0.00	-0.02	0.02	0.00	0%	1.00
Vildósola et al. [37]	0.00	-0.02	0.02	0.00	0%	1.00
12 Months						
Canali et al. [31]	0.00	-0.02	0.02	0.00	0%	1.00
Correia et al. [33]	0.00	-0.02	0.02	0.00	0%	1.00
Overall	0.00	-0.02	0.02	0.00	0%	1.00
Marginal Adaptation in Class II Cavities	**Difference in Means**	**Lower Limit**	**Upper Limit**	**Z-Value**	**I²**	**p-value**
6 Months						
Balkaya et al. [2]	0.00	-0.01	0.02	0.49	0%	0.63
Bayraktar et al. [12]	0.00	-0.01	0.02	0.49	0%	0.63

Çolak et al. [32]	0.00	-0.01	0.02	0.49	0%	0.63
Guney; Yazici [34]	0.00	-0.01	0.02	0.49	0%	0.63
Yazici et al. [38]	0.00	-0.01	0.02	0.49	0%	0.63
12 Months						
Alkurdi; Abboudi [26]	0.00	-0.01	0.02	0.49	0%	0.63
Balkaya; Arslan [29]	0.00	-0.01	0.02	0.49	0%	0.63
Bayraktar et al. [12]	0.00	-0.01	0.02	0.26	0%	0.80
Çolak et al. [32]	0.00	-0.01	0.02	0.49	0%	0.63
Guney; Yazici [34]	0.00	-0.01	0.02	0.49	0%	0.63
Yazici et al. [38]	0.00	-0.01	0.02	0.49	0%	0.63
18 Months						
Guney; Yazici [34]	0.00	-0.01	0.02	0.49	0%	0.63
Yazici et al. [38]	0.00	-0.01	0.02	0.49	0%	0.63
24 Months						
Balkaya; Arslan [29]	0.00	-0.01	0.01	0.25	0%	0.80
Guney; Yazici [34]	0.00	-0.01	0.02	0.49	0%	0.63
Yazici et al. [38]	0.00	-0.01	0.02	0.49	0%	0.63
Overall	0.00	-0.01	0.02	0.47	0%	0.64
Marginal Adaptation in Class V Cavities	**Difference in Means**	**Lower Limit**	**Upper Limit**	**Z-Value**	**I^2**	**p-value**
6 Months						
Canali et al. [31]	0.00	-0.02	0.03	0.28	0%	0.78
Correia et al. [33]	0.00	-0.02	0.03	0.28	0%	0.78
Vildósola et al. [37]	0.00	-0.02	0.03	0.28	0%	0.78
12 Months						
Canali et al. [31]	0.00	-0.02	0.02	0.00	0%	1.00
Correia et al. [33]	0.00	-0.02	0.03	0.28	0%	0.78
Overall	0.00	-0.02	0.02	0.26	0%	0.79

I^2: Overall Heterogeneity.

Assessment of the Quality of Evidence

Table 4 presents the GRADE assessment for all randomized controlled clinical trials submitted to quantitative analysis. The quality of evidence observed was high certainty of evidence for all follow-up periods of each clinical situation from marginal discoloration and adaptation, with a very strong association of at least 881 events per 1,000; except for 12-months in class II that were considered as low certainty of evidence for both parameters. The quality of evidence was downgraded according to the risk of bias in the studies included, related to the unclear methods of randomization and blinding by the patient, dentist, and/or evaluator, as well as for the very few events reported.

Table 4. The quality of evidence assessment according to GRADE.

Outcomes			Number of Participants		Effect		Certainty
Parameter	Clinical situation	Follow-up periods	Conventional resin composite	Bulk-fill resin composite	Relative (95% CI)	Absolute (95% CI)	
Marginal Discoloration	Class II	6 months	207/208	209/209	RR 0.00 (-0.02 to 0.02)	995 per 1.000 (from 1.000 fewer to 980 fewer)	⊕⊕⊕⊕ HIGH[a]
		12 months	219/221	216/218	RR 0.00 (-0.02 to 0.02)	991 per 1.000 (from 1.000 fewer to 971 fewer)	⊕⊕◯◯ LOW[a,b,c]
		18 months	86/86	85/85	RR 0.00 (-0.03 to 0.03)	1.000 per 1.000 (from 1.000 fewer to 970 fewer)	⊕⊕⊕⊕ HIGH[a]
		24 months	106/106	105/105	RR 0.00 (-0.03 to 0.03)	1.000 per 1.000 (from 1.000 fewer to 970 fewer)	⊕⊕⊕⊕ HIGH[a]
	Class V	6 months	158/158	161/161	RR 0.00	1.000 per 1.000	⊕⊕⊕⊕

					(-0.02 to 0.02)	(from 1.000 fewer to 980 fewer)	HIGH[a]
		12 months	109/109	113/113	RR 0.00 (-0.02 to 0.02)	1.000 per 1.000 (from 1.000 fewer to 980 fewer)	⊕⊕⊕⊕ HIGH[a]
Marginal Adaptation	Class II	6 months	208/208	209/209	RR 0.00 (-0.02 to 0.02)	1.000 per 1.000 (from 1.000 fewer to 980 fewer)	⊕⊕⊕⊕ HIGH[a]
		12 months	221/221	217/218	RR 0.00 (-0.02 to 0.02)	995 per 1.000 (from 1.000 fewer to 976 fewer)	⊕⊕◯◯ LOW[a,b,c]
		18 months	86/86	85/85	RR 0.00 (-0.03 to 0.03)	1.000 per 1.000 (from 1.000 fewer to 970 fewer)	⊕⊕⊕⊕ HIGH[a]
		24 months	105/106	103/105	RR 0.00 (-0.03 to 0.04)	981 fewer per 1.000 (from 1.000 fewer to 942 fewer)	⊕⊕⊕⊕ HIGH[a]
	Class V	6 months	158/158	161/161	RR 0.00 (-0.02 to 0.02)	1.000 per 1.000 (from 1.000 fewer to 980 fewer)	⊕⊕⊕⊕ HIGH[a]
		12 months	96/109	106/113	RR 0.00 (-0.03 to 0.03)	881 per 1.000 (from 966 fewer to 910 fewer)	⊕⊕⊕⊕ HIGH[a]

[a]Total number of events lower than 300; [b]Unclear methods of randomization; [c]Unclear blind methodology by the patient, dentist and/or evaluator; RR: Risk Ratio; CI: Confidence Interval; SMD: Standard Mean Difference.

Discussion

Alterations in the basic composition of resin composites are the differential of the bulk-fill composites, which are related to a modified methacrylate monomer with prepolymerized particles, inducing a low shrinkage stress, as well as changes in the photoinitiator systems with alternative ones instead of camphorquinone, i.e., Ivocerin (dibenzoyl germanium derivative) and TPO (mono-alkyl phosphine oxide) photoinitiators [16]. As a consequence, this material may be inserted in bulk increments up to 4mm, as recommended by each manufacturer, and light-cured in short periods of time [12,13]. However, the insertion of a bulk and thick increment in a large posterior cavity could be a challenge for the operator, which should compromise the adequate adaptation of the resin composites and favor the marginal degradation of the restoration [39]. Thinking of that, the hypotheses of this systematic review and meta-analyses were that there would be no difference in the 1. marginal discoloration and 2. marginal adaptation susceptibility of adhesive restorations using conventional or bulk-fill resin composites placed in class II or V cavities. Therefore, comparing the hypotheses with the systematic review and meta-analyses results (Figures 3 to 6), both hypotheses could be upheld.

The marginal degradation starts with the occurrence of marginal discoloration, which could be associated to several factors, such as poor etching surface preparation; inadequate adhesive technique; salivary contamination; or insufficient finishing and polishing technique, which could compromise the hybrid layer interface with water sorption and promoting hydrolysis of the bond compounds [15]. This mechanism of action of marginal degradation begins with the esthetic commitment, like surface areas of orange or black stains along of the bond interface that progress to deep stains in the hybrid layer; and this progression needs to be clinically evaluated with caution due to the establishment of a secondary caries lesion [15].

As a consequence of continuous degradation of the hybrid layer, the marginal adaptation could be compromised by the excessive occlusal forces promoting stress concentration at the margin of the restoration and inducing microscopic cracks with potential for propagation along of the marginal interface, characterizing

a fracture of the restoration and/or dental structure, as well as inadequate insertion and adaptation of the resin composite by the operator [15]. This clinical occurrence is also likely to be confused or correlated with the presence of secondary caries lesions [15]. Another factor related to gap formation along the hybrid layer is the polymerization shrinkage stress promoted by all resin-based materials, whether it is conventional or bulk-fill [8,39]. The marginal adaptation will be compromised when the adhesion between resin composite and enamel or dentin is insufficient to support the resin-based shrinkage stress [39].

Regarding the clinical evaluation according to USPHS, described by van Dijken [40], marginal discoloration is scored in: zero or Alfa (no margin discoloration evident), one or Bravo (discoloration at the margin, not penetrating in pulpal direction), and two or Charlie (discoloration at margin, penetrating in pulpal direction); and marginal adaptation is scored in: zero or Alfa (continuous restoration with an anatomical form), one or Bravo (no crevice is visible into the explorer catches), two or Charlie (enamel exposure with crevice at margin), three or Delta (dentin or base exposure with obvious crevice at margin), and four (fracture or absent of the restoration). This classification was used by most of the included studies (as presented in the supplementary material), due to this, all meta-analyses were performed with studies based on USPHS criteria.

On the other hand, this clinical method of evaluation is considered as limited sensitivity and does not correspond to a true clinical success [20,30]. Therefore, an alternative classification is also scientifically accepted, such as the FDI, which was used by three of the studies included [16,30,37]. However, due to differences in methodologies and different clinical scenarios, the results of FDI criteria could not be used in the meta-analyses. The FDI criteria classify the restoration in five scores: 1 (clinically excellent), 2 (clinically good), 3 (clinically sufficient/satisfactory), 4 (clinically unsatisfactory), and 5 (clinically poor) for both marginal discoloration and marginal adaptation [37].

The selected studies for this systematic review were based on recent randomized controlled clinical trials, since 2010, which accompanied the emergence and development of this material, as observed in Arhun et al. [28], and Manhart et al. [36], studies that performed the bulk-fill technique, as well as the development of a new technology named SDR™ (stress decreasing resin) firstly described as a reduction of shrinkage stress [41]. For this reason, follow-up periods were observed until 48 months for the majority and one study in particular that evaluated after 10 years of follow-up [35].

During the assessment of the risk of bias of the included studies, all domains were considered key domains, which were used for qualifying the certainty of evidence of this systematic review, according to the GRADE assessment. The unclear information related to random process and blinding of the participants, operator and/or evaluator, as well as the absence of the results for the clinical parameters of interest were taken into consideration for two subgroups that were downgraded to low certainty of evidence (Table 4). These domains are essential to ensure adequate sample allocations without bias.

Based on the meta-analyses, the behavior of both resin composites is similar related to marginal discoloration and adaptation in class II and V restorations, between 6 and 24 months of follow-up period, according to the included studies in this systematic review with high certainty of evidence and robust findings by leave-one-out sensitivity test. We believed that this promising and clinical acceptable behavior is directly related to a calibrated and experienced operator/dentist [2,29], and the high quality of restorative materials used, as demonstrated in Table 5 for all resin composites evaluated. Only one study [35] of all included studies, evaluated the resin-based restoration with a follow-up of 120 months (or 10 years) in class I and II, which after this period of time could begin to perceive a marginal degradation; however, no significant differences were observed between the resin composites used. Therefore, longitudinal clinical trials are essential to observe some influence of the restorative technique and the restorative materials applied.

Table 5. Conventional and bulk-fill resin composites under investigation.

Conventional Resin Composite (Manufacturer)	Composition	Viscosity	Bulk-fill Resin Composite (Manufacturer)	Composition	Viscosity
Charisma Smart Composite (Kulzer GmbH, Hanau, Germany)	Bis-GMA, Barium Aluminum Fluoride glass, Silicon Dioxide	Regular	Filtek Bulk Fill Posterior Restorative (3M, St. Paul, MN, USA)	Silane Treated Ceramic, Aromatic Urethane Dimethacrylate, YbF3, UDMA, Silane Treated Silica, DDDMA, Silane Treated Zirconia, Water, EDMAB, Benzotrialzol, Titanium Dioxide, Pentanedioic acid, 2,2-dimethyl-4-methylene-, reaction products with glycidyl methacrylate	Regular
Clearfil Photo Posterior (Kuraray Noritake, Hattersheim am Main, Germany)	UTMA, Silanated silica filler, Silanated barium glass filler, Silanated colloidal silica, dl-Camphorquinone, Catalysts, Accelerators, Pigments	Regular	Tetric EvoCeram Bulk-Fill (Ivoclar Vivadent AG, Schaan, Liechtenstein, Germany)	Bis-GMA, UDMA, YbF3, Bis-EMA	Regular
Filtek Supreme Ultra Universal (3M, St. Paul, MN, USA)	Silane Treated Ceramic, Bis-GMA, Bis-EMA-6, UDMA, Silane Treated Silica, PEGDMA, Silane Treated Zirconia, TEGDMA	Regular	Filtek Bulk Fill Flowable (3M, St. Paul, MN, USA)	Silane Treated Ceramic, UDMA, Substituted Dimethacrylate, YbF3, Bis-GMA, Bis-EMA-6, TEGDMA	Flow
Tetric EvoCeram (Ivoclar Vivadent, Schaan, Liechtenstein)	UDMA, Bis-GMA, YbF3, EBPADMA	Regular	QuiXfill (Dentsply DeTrey GmbH, Konstanz, Germany)	Isopropylidenediphenol, ethoxylated and 2- methylprop-2-enoic acid, UDMA, Butanedioic acid, 1,4-bis ester 2,3 dicarboxylic acid, 2,2′-ethylenedioxydiethyl dimetharcylate, propylidynetrimethyl trimethacrylate, 2,6-di-tert-butyl-p-cresol	Regular
Filtek Z350 XT (3M, St. Paul, MN, USA)	Silane Treated Ceramic, Bis-GMA, Bis-EMA-6, UDMA, Silane Treated Silica, PEGDMA, Silane Treated Zirconia, TEGDMA	Regular	Tetric N-Ceram Bulk Fill (Ivoclar Vivadent AG, Schaan, Liechtenstein, Germany)	Bis-GMA, UDMA, YbF3, Bis-EMA	Regular
Filtek Z250 XT (3M, St. Paul, MN, USA)	Bis-GMA, Bis-EMA-6, UDMA, TEGDMA, Silane Treated Ceramic, Silane Treated Silica	Regular	SureFil SDR Flow (Dentsply Caulk, Milford, DE, USA)	TEGDMA, Barium and strontium alumino-fluoro-silicate glass, UDMA, dimethacrylate	Flow
Filtek Ultimate (3M, St. Paul, MN, USA)	Silane Treated Ceramic, Bis-GMA, Bis-EMA-6, UDMA, Silane Treated Silica, PEGDMA, Silane Treated Zirconia, TEGDMA	Regular	SonicFill (Kerr, Orange, CA, USA)	Glass, oxide, chemicals, Silicon dioxide, 2,2'-ethylenedioxydiethyl dimethacrylate, (1-methylethylidene) bis(4,1-phenyleneoxy-2,1-ethanediyloxy-2,1-ethanediyl) bismethacrylate	Flowable, sound activated, sculptable
Grandio (Voco GmbH, Cuxhaven, Germany)	Bis-GMA, TEGDMA, UDMA	Regular			
Ceram.X mono (Dentsply DeTrey GmbH, Konstanz Germany)	Dimethacrylate resin, Methacrylate modified polysiloxane, Methacrylate functionalized silicon dioxide nanofillers, Barium-aluminum-borosilicate glass	Regular			
EverX Posterior (GC Co, Milford, DE, USA)	2,2'-ethylenedioxydiethyl dimethacrylate, diphenyl(2,4,6-trimethylbenzoyl) phosphine oxide, Bis-GMA, TEGDMA	Regular			
G-aenial Posterior (GC Co, Leuven, Bélgica)	UDMA, YbF3, 2-(2H-benzotriazol-2-yl)-p-creso, Esterification products of 4,4'-isopropylidenediphenol, ethoxylated and 2-methylprop-2-enoic acid	Regular			

Bis-GMA, Bisphenol A Diglycidyl Ether Dimethacrylate; UTMA, Urethane tetramethacrylate; Bis-EMA-6, Bisphenol A Polyethylene Glycol Diether Dimethacrylate; UDMA, Urethane Dimethacrylate; PEGDMA, Polyethylene Glycol Dimethacrylate; TEGDMA, Triethylene Glycol Dimethacrylate; YbF3, Ytterbium Fluoride; EBPADMA, ethyoxylated bisphenol A dimethacrylate; EDMAB, Ethyl 4-Dimethyl Aminobenzoate; DDDMA, 1,12-Dodecanediol dimethacrylate.

This systematic review and meta-analysis could observe that both resin-based materials present promising clinical performance with low marginal degradation over the years; however, different clinical situations demonstrated a limitation of this study, making it difficult for results comparison. Additionally, a highly experienced operator that certainly interferes with the great quality and control of the adhesive restoration is being a challenge for the occurrence of failure.

Conclusion

Based on the results of this systematic review and meta-analysis, there is a high certainty of evidence that there is no significant difference regarding the susceptibility of marginal discoloration or marginal adaptation between conventional or bulk-fill resin composite restorations in class II or V cavities.

Authors' Contributions

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RBEL	https://orcid.org/0000-0002-8224-6578	Conceptualization, Methodology, Investigation, Data Curation, Writing - Original Draft, Writing - Review and Editing, Supervision and Project Administration.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

Financial Support

None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

References

[1] Ferracane JL. Resin composite--state of the art. Dent Mater 2011; 27(1):29-38. https://doi.org/10.1016/j.dental.2010.10.020

[2] Balkaya H, Arslan S, Pala K. A randomized, prospective clinical study evaluating effectiveness of a bulk-fill composite resin, a conventional composite resin and a reinforced glass ionomer in Class II cavities: one-year results. J Appl Oral Sci 2019; 7:e20180678. https://doi.org/10.1590/1678-7757-2018-0678

[3] Leprince JG, Palin WM, Hadis MA, Devaux J, Leloup G. Progress in dimethacrylate-based dental composite technology and curing efficiency. Dent Mater 2013; 29(2):139-56. https://doi.org/10.1016/j.dental.2012.11.005

[4] Yoshikawa T, Sano H, Burrow MF, Tagami J, Pashley DH. Effects of dentin depth and cavity configuration on bond strength. J Dent Res 1999; 78(4):898-905. https://doi.org/10.1177/00220345990780041001

[5] Ferracane JL, Hilton TJ. Polymerization stress--is it clinically meaningful?. Dent Mater 2016; 32(1):1-10. https://doi.org/10.1016/j.dental.2015.06.020

[6] Rueggeberg FA, Giannini M, Arrais CAG, Price RBT. Light curing in dentistry and clinical implications: a literature review. Braz Oral Res 2017; 31(suppl 1):e61. https://doi.org/10.1590/1807-3107bor-2017.vol31.0061

[7] Lins R, Vinagre A, Alberto N, Domingues MF, Messias A, Martins LR, et al. Polymerization shrinkage evaluation of restorative resin-based composites using fiber bragg grating sensors. Polymers 2019; 11(5):859. https://doi.org/10.3390/polym11050859

[8] Lins RBE, Aristilde S, Osório JH, Cordeiro CMB, Yanikian CRF, Bicalho AA, et al. Biomechanical behaviour of bulk-fill resin composites in class II restorations. J Mech Behav Biomed Mater 2019; 98:255-61. https://doi.org/10.1016/j.jmbbm.2019.06.032

[9] Bicalho AA, Valdívia AD, Barreto BC, Tantbirojn D, Versluis A, Soares CJ. Incremental filling technique and composite material--part II: shrinkage and shrinkage stresses. Oper Dent 2014; 39(2):e83-92. https://doi.org/10.2341/12-442-L

[10] Tardem C, Albuquerque EG, Lopes LS, Marins SS, Calazans FS, Poubel LA, et al. Clinical time and postoperative sensitivity after use of bulk-fill (syringe and capsule) vs. incremental filling composites: a randomized clinical trial. Braz Oral Res 2019; 16:e089. https://doi.org/10.1590/1807-3107bor-2019.vol33.0089

[11] Vinagre A, Ramos J, Alves S, Messias A, Alberto N, Nogueira R. Cuspal displacement induced by bulk fill resin composite polymerization: biomechanical evaluation using fiber bragg grating sensors. Int J Biom 2016; 2016:7134283. https://doi.org/10.1155/2016/7134283

[12] Bayraktar Y, Ercan E, Hamidi MM, Çolak H. One-year clinical evaluation of different types of bulk-fill composites. J Investig Clin Dent 2017; 8(2). https://doi.org/10.1111/jicd.12210

[13] Zorzin J, Maier E, Harre S, Fey T, Belli R, Lohbauer U, et al. Bulk-fill resin composites: polymerization properties and extended light curing. Dent. Mater 2015; 31(3):293-301. https://doi.org/10.1016/j.dental.2014.12.010

[14] Gan JK, Yap AU, Cheong JW, Arista N, Tan C. Bulk-fill composites: effectiveness of cure with poly- and monowave curing lights and modes. Oper Dent 2018; 43(2):136-43. https://doi.org/10.2341/16-304-L

[15] Dennison JB, Sarrett DC. Prediction and diagnosis of clinical outcomes affecting restoration margins. Journal of Oral Rehabilitation 2012; 39(4):301-18. https://doi.org/10.1111/j.1365-2842.2011.02267.x

[16] Durão MA, Andrade AKM, Santos MDCMDS, Montes MAJR, Monteiro GQM. Clinical performance of bulk-fill resin composite restorations using the United States Public Health Service and Federation Dentaire Internationale criteria: a 12-month randomized clinical trial. Eur J Dent 2021; 15(2):179-92. https://doi.org/10.1055/s-0040-1718639

[17] Boaro LCC, Lopes DP, de Souza ASC, Nakano EL, Perez MDA, Pfeifer CS, et al. Clinical performance and chemical-physical properties of bulk fill composites resin -a systematic review and meta-analysis. Dent Mater 2019; 35:e249-e264. https://doi.org/10.1016/j.dental.2019.07.007

[18] Arbildo-Vega HI, Lapinska B, Panda S, Lamas-Lara C, Khan AS, Lukomska-Szymanska M. Clinical effectiveness of bulk-fill and conventional resin composite restorations: systematic review and meta-analysis. Polymers 2020; 12(8):1786. https://doi.org/10.3390/polym12081786

[19] Kruly PC, Giannini M, Pascotto RC, Tokubo LM, Suga USG, Marques ACR, et al. Meta-analysis of the clinical behavior of posterior direct resin restorations: Low polymerization shrinkage resin in comparison to methacrylate composite resin. Plos One 2018; 13(2):e0191942. https://doi.org/10.1371/journal.pone.0191942

[20] Veloso SRM, Lemos CAA, de Moraes SLD, do Egito Vasconcelos BC, Pellizzer EP, de Melo Monteiro GQ. Clinical performance of bulk-fill and conventional resin composite restorations in posterior teeth: a systematic review and meta-analysis. Clin Oral Investig 2019; 23(1):221-33. https://doi.org/10.1007/s00784-018-2429-7

[21] Reis AF, Vestphal M, Amaral RCD, Rodrigues JA, Roulet JF, Roscoe MG. Efficiency of polymerization of bulk-fill composite resins: a systematic review. Braz Oral Res 2017; 31(Suppl 1):e59. https://doi.org/10.1590/1807-3107bor-2017.vol31.0059

[22] Gerula-Szymańska A, Kaczor K, Lewusz-Butkiewicz K, Nowicka A. Marginal integrity of flowable and packable bulk fill materials used for class II restorations - A systematic review and meta-analysis of in vitro studies. Dent Mater J 2020; 39(3):335-44. https://doi.org/10.4012/dmj.2018-180

[23] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an apdated guideline for reporting systematic reviews. BMJ 2021; 372:n71. https://doi.org/10.1136/bmj.n71

[24] Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ 2019; 366:l4898. https://doi.org/10.1136/bmj.l4898

[25] Ryan R, Hill S. How to GRADE the quality of the evidence. Cochrane consumers and communication group; 2016. 2019.

[26] Alkurdi RM, Abboud SA. Clinical evaluation of class II composite: Resin restorations placed by two different bulk-fill techniques. J Orofac Sci 2016; 8(1):34-9. https://doi.org/10.4103/0975-8844.181926

[27] Al-Sheikh R. Effects of different application techniques on nanohybrid composite restorations clinical success. Open Dent J 2019; 13(1):228-35. https://doi.org/10.2174/1874210601913010228

[28] Arhun N, Celik C, Yamanel K. Clinical evaluation of resin-based composites in posterior restorations: two-year results. Oper Dent 2010; 35(4):397-404. https://doi.org/10.2341/09-345-C

[29] Balkaya H, Arslan S. A Two-year clinical comparison of three different restorative materials in class ii cavities. Oper Dent 2020; 45(1):e32-e42. https://doi.org/10.2341/19-078-C

[30] Berti LS, Turssi CP, Amaral FL, Basting RT, Junqueira JLC, Panzarella FK, et al. Clinical and radiographic evaluation of high viscosity bulk-fill resin composite restorations. Am J Dent 2020; 33(4):213-7.

[31] Canali GD, Ignácio SA, Rached RN, Souza EM. One-year clinical evaluation of bulk-fill flowable vs. regular nanofilled composite in non-carious cervical lesions. Clin Oral Investig 2019; 23(2):889-97. https://doi.org/10.1007/s00784-018-2509-8

[32] Çolak H, Tokay U, Uzgur R, Hamidi MM, Ercan E. A prospective, randomized, double-blind clinical trial of one nano-hybrid and one high-viscosity bulk-fill composite restorative systems in class II cavities: 12 months results. Niger J Clin Pract 2017; 20(7):822-31. https://doi.org/10.4103/1119-3077.212449

[33] Correia A, Jurema A, Andrade MR, Borges A, Bresciani E, Caneppele T. Clinical evaluation of noncarious cervical lesions of different extensions restored with bulk-fill or conventional resin composite: preliminary results of a randomized clinical trial. Oper Dent 2020; 45(1):e11-e20. https://doi.org/10.2341/18-256-C

[34] Guney T, Yazici AR. 24-month clinical evaluation of different bulk-fill restorative resins in class ii restorations. Oper Dent 2020; 45(2):123-33. https://doi.org/10.2341/18-144-C

[35] Heck K, Manhart J, Hickel R, Diegritz C. Clinical evaluation of the bulk fill composite QuiXfil in molar class I and II cavities: 10-year results of a RCT. Dent Mater 2018; 34(6):e138-e147. https://doi.org/10.1016/j.dental.2018.03.023

[36] Manhart J, Chen HY, Hickel R. Clinical evaluation of the posterior composite Quixfil in class I and II cavities: 4-year follow-up of a randomized controlled trial. J Adhes Dent 2010; 12(3):237-43. https://doi.org/10.3290/j.jad.a17551

[37] Vildósola P, Nakouzi J, Rodriguez S, Reyes A, Reyes J, Conejeros C. Six month follow-up of two Bulk-fill composites in non-carious cervical lesions: double blind randomized clinical trial. J Oral Res 2019; 8(3):210-9. https://doi.org/10.17126/joralres.2019.032

[38] Yazici AR, Antonson SA, Kutuk ZB, Ergin E. Thirty-six-month clinical comparison of bulk fill and nanofill composite restorations. Oper Dent 2017; 42(5):478-85. https://doi.org/10.2341/16-220-C

[39] Campos EA, Ardu S, Lefever D, Jassé FF, Bortolotto T, Krejci I. Marginal adaptation of class II cavities restored with bulk-fill composites. J Dent 2014; 42(5):575-81. https://doi.org/10.1016/j.jdent.2014.02.007

[40] van Dijken JW. A clinical evaluation of anterior conventional, microfiller, and hybrid composite resin fillings. A 6-year follow-up study. Acta Odontol Scand 1986; 44(6):357-67. https://doi.org/10.3109/00016358609094346

[41] Roggendorf MJ, Krämer N, Appelt A, Naumann M, Frankenberger R. Marginal quality of flowable 4-mm base vs. conventionally layered resin composite. J Dent 2011; 39(10):643-7. https://doi.org/10.1016/j.jdent.2011.07.004