Pesquisa Brasileira em Odontopediatria e Clínica Integrada 2024; 24:e230120
https://doi.org/10.1590/pboci.2024.083
ISSN 1519-0501 / eISSN 1983-4632

SYSTEMATIC REVIEW

Clinical Longevity of Sonicated and Unsonicated Composite Resin Restorations in Posterior Permanent Teeth: A Systematic Review and Meta-Analysis

Lorrane Salvador de Mello[1], Fabiola Fontes Galdino[2], Jayzon Stephan Brooks[1], Tatiana Kelly da Silva Fidalgo[2], Kátia Rodrigues Reis[1]

[1]Department of Prosthodontics and Dental Materials, School of Dentistry, Federal University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil.
[2]Department of Preventive and Community Dentistry, School of Dentistry, State University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil.

Corresponding author: Tatiana Kelly da Silva Fidalgo **E-mail:** tatianaksfidalgo@gmail.com

Academic Editor: Lucianne Cople Maia de Faria

Received: June 22, 2023 / **Review:** January 08, 2024 / **Accepted:** January 26, 2024

How to cite: Mello LS, Galdino FF, Brooks JS, Fidalgo TKS, Reis KR. Clinical longevity of sonicated and unsonicated composite resin restorations in posterior permanent teeth: A systematic review and meta-analysis. Pesqui Bras Odontopediatria Clín Integr. 2024; 24:e230120. https://doi.org/10.1590/pboci.2024.083

ABSTRACT

Objective: To evaluate the clinical longevity of Class I and II composite resin restorations with and without using sonic energy through a systematic literature review and meta-analysis. **Material and Methods:** Five databases were consulted: PubMed, Cochrane Library, Web of Science, Scopus, VHL-LILACS, and BBO and gray literature. The search was carried out in January 2024. The inclusion criteria comprised clinical trials evaluating the success/longevity of composite resin restorations with and without sonic energy. RoB and ROBINS-I assessed the risk of bias. The meta-analysis analyzed the number of restorations with alpha USPHS scores. Heterogeneity was assessed (I^2 index, $p<0.05$). Certain evidence was assessed using the GRADE tool. **Results:** A total of 8,582 studies were identified, including four studies, 2 RCTs, and two controlled clinical trials, with moderate and low risk of bias, respectively. No difference was observed in the longevity ($p>0.05$) for: anatomical shape (CI=1.05 [0.95,1.15]; I^2=0%; p=0.37); color stability (CI=1.02 [0.93,1.13; I^2=0%, p=0.65); marginal adaptation (CI=1.05 [0.95,1.16]; I^2=%; p=0.38); postoperative sensitivity (CI=1.01 [0.93,1.10]; I^2=0%; p=0.80); secondary caries (CI=1.01 [0.93,1.10]; I^2=0%; p=0.80); marginal discoloration (CI=1.05 [0.95,1.16]; I^2=0%; p=0.38), surface texture (CI=1.09 [0.97,1.23]; I^2=19%; p=0.14) and retention (CI=1.00 [1.91,1.10]; I^2=0%; p=1.00). The certainty of the evidence was very low. **Conclusion:** No evidence supports using sonic energy for direct composite resin restorations, regardless of the technique and the restored tooth. More robust and well-conducted studies should be performed.

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

Introduction

Composite resins are dental materials widely used in direct restorations. Due to their color, similar to natural teeth, and their ability to adhere to the dental substrate, they have been the material of first choice in restorative procedures. In addition, they allow for more conservative tooth preparations, preserving the remaining tooth structure [1-3].

The most used method for insertion in the dental cavity is the incremental technique, with increments of up to 2 mm thick. In doing so, minimizing polymerization shrinkage stresses and increasing the degree of depth of the curing light during its conversion is possible. However, *in vitro* studies show that although this technique is used as an alternative to the limitations of polymerization of this material, its insertion in layers can create voids between them, generating a more significant number of adhesive failures and, consequently, greater postoperative sensitivity, microleakage and secondary caries [4,5]. Furthermore, the longer clinical time required for insertion and polymerization of each increment makes the operative technique more sensitive [5]. Seeking to overcome the disadvantages of the conventional technique, new resin-based materials have emerged in the dental market [4]. Single-increment composite resins, known as bulk fill resins, are indicated for dental cavities with a depth of up to 4 mm and can be classified as high or low viscosity, light, or dual polymerization materials [6]. They can fill the dental cavity and serve as a base for another restoration, as with fluid resins [7].

Among the reported advantages of this class of dental materials are decreased polymerization shrinkage, lower cusp deflection, and higher bond strength [7]. Adding photoinitiators other than camphorquinone and increasing translucency, concentration, and particle size present gives a greater depth of polymerization of single-increment resin [8,9]. Despite this, the decrease in the fluidity of this material can reduce its mechanical properties, requiring an additional layer of composite resin on the occlusal surface [10].

In this sense, some strategies to optimize the clinical performance of composite resins have been developed. For example, the oscillatory instruments that work with wave energy can have several applications in dental specialties, seeking. These equipments are divided into sonic and ultrasonic by the physical characteristics of the generation of these waves and by the magnitude of their power [11]. The former uses compressed air energy to produce vibration effects of a maximum of 6000 Hz or 6Khz. In contrast, the ultrasonic ones use electrical energy through a transducer, generating waves above 20,000 Hz [12,13].

Using sonic energy to decrease the viscosity of regular viscosity bulk fill resins was introduced as an alternative to minimize the disadvantages found in fluids. However, the SonicFill (Kerr) system is the only one available in the dental market for clinical use. It consists of a fluid restorative material capable of filling cavities up to 5 mm, unlike other fluid-filling materials [9,10]. According to the manufacturer, a sonic energy system activates this bulk-fill composite through a handpiece that makes up the product. A capsule with the resinous material is attached to the upper end of this piece, which presents a single dose. This energy can be applied at five different levels, decreasing the viscosity of the material by up to 87% [14]. At the end of the activation of the sonic system, the resin returns to its more dense consistency, allowing the sculpting of the appropriate occlusal anatomy. In its composition, 2.5% of Bis-GMA, TEGDMA in 5%, EPDMA, and modifiers can react to sonic energy and change the material's viscosity [15].

Laboratory studies demonstrate that using sonic energy can improve the properties of bulk-fill resins, including their marginal adaptation, mechanical strength, and reduction of polymerization stresses [7,15]. In general, composites in increments shrink by 3%, while SonicFill averages 1.6% [7]. *In vitro* studies are essential for evaluating restorative materials and knowledge of their properties; however, to support their professional use, it is necessary to analyze clinical results for better technical conduct. In the study by Alkurdi and Abboud

[16], failures of the restorative material were reported. In contrast, in other clinical studies, there have been successes in using resin restorations with sonic energy [13,17]. These contradictory results found in some studies are reasons for a systematic review. Therefore, a systematic review and meta-analyses were conducted to summarize the findings of clinical trials comparing the clinical longevity of composite resin restorations (Class I and II) made using sonic energy and incremental or single-increment techniques without the use of sonic energy. This research aims to conduct a systematic review and meta-analysis of the literature involving clinical trials that compare the use of sonic energy in conventional incremental and single-increment techniques without sonic energy in composite resin restorations. Class I and II, with a minimum follow-up time of twelve months, and to evaluate the clinical longevity of composite resin restorations inserted using sonic energy.

Material and Methods

Registration Protocol

This systematic review was registered in the Prospero database under number CRD42020205529 (https://www.crd.york.ac.uk/PROSPERO) and conducted following the recommendations in the guidelines for systematic review and meta-analysis (PRISMA 2020) [18].

Search Strategy

The bibliographic search process of this research was carried out by a researcher (L.S.D.M) guided by two librarians (D.N.R and M.B.G.S) on 2nd January 2024. The search strategy included MeSH terms, "free terms," and "keywords" related to sonic energy, bulk fill, and conventional direct composite resins. The search strategies were adapted according to the requirements of each searched database and are individually described in Table 1, and search alerts were created. Searches that appeared in more than one database were considered only once. The complementary search was performed manually by consulting the selected articles' reference lists to find possible studies not identified by the electronic search strategy. Authors were contacted for information about unpublished or ongoing work. These terms were searched in the Title and Abstract fields without applying filters or year or language restrictions. Five databases were consulted: MEDLINE via PubMed, Cochrane, Library, Web of Science, Scopus, VHL - Latin American and Caribbean Health Sciences Literature (LILACS), the Brazilian Dental Library (BBO), and the gray literature (Table 1).

Table 1. Electronic database and research strategy.

Database	Search Strategy
Pubmed	#1 (((((((Composite Resins[MeSH Terms]) OR (Composite Resin[Title/Abstract])) OR (Bulk-Fill Composite*[Title/Abstract])) OR (Bulk-fill resin*[Title/Abstract])) OR (bulk fill[Title/Abstract])) OR (Bulk-filling[Title/Abstract])) OR (Bulk filled[Title/Abstract])) OR (sonic resin)) AND (Dental Restoration Failure[MeSH Terms]) #2 ((((((Dental Restoration Failure[MeSH Terms]) OR (Dental Restoration Failure[Title/Abstract])) OR (deterioration margins[Title/Abstract])) OR (marginal discrepancies[Title/Abstract])) OR (restoration defect[Title/Abstract])) OR (clinical performance[Title/Abstract])) OR (longevity[Title/Abstract]) #1 AND #2
Scopus	#1 (TITLE-ABS-KEY (composite AND resins) OR TITLE-ABS-KEY (composite AND resin) OR TITLE-ABS-KEY (bulk-fill AND composite) OR TITLE-ABS-KEY (bulk-fill AND composites) OR TITLE-ABS-KEY (bulk-fill AND resin) OR TITLE-ABS-KEY (bulk-fill AND resins) OR TITLE-ABS-KEY (bulk AND fill) OR TITLE-ABS-KEY (bulk-filling) OR TITLE-ABS-KEY (bulk AND filled) OR TITLE-ABS-KEY (sonic AND resin)) #2 (TITLE-ABS-KEY (dental AND restoration AND failure) OR TITLE-ABS-KEY (deterioration AND margins) OR TITLE-ABS-KEY (marginal AND discrepancies) OR TITLE-ABS-KEY (restoration AND defect)) #1 AND #2

Web of Science	#1"Composite Resins" OR "Composite Resin" or "Bulk-Fill Composite" OR "Bulk-Fill Composites" OR "Bulk-fill resin" OR "Bulkfill resins" OR "bulk fill" or "Bulk-filling" OR "Bulk filled" OR "sonic resin" #2 "Dental Restoration Failure" OR "deterioration margins" OR "marginal discrepancies" OR "restoration defect" OR "clinical performance" or longevity #1 AND #2
Cochrane Library	#1 MeSH descriptor: [Composite Resins] explode all trees #2 Composite Resin * OR Bulk-Fill Composite* OR Bulk-fill resin* OR bulk fill OR Bulk-filling OR Bulk filled OR sonic #3 (#1OR#2) #4 MeSH descriptor: [Dental Restoration Failure] explode all trees #5 deterioration margins OR marginal discrepancies OR restoration defect. OR clinical performance OR longevity #6 (#4OR#5) #7 (#3 AND #6)
BVS (Lilacs and BBO)	#1 (mh: "Composite Resins" OR tw: "Composite Resins" OR mh: "Resinas Compostas" OR tw: "resinas compostas" OR tw: "Bulk-Fill Composite" OR tw: "Bulk-Fill Composites" OR tw: "Bulk-fill resin" OR tw: "Bulk-fill resins" OR tw: "bulk fill" OR tw: "Bulk-filling" OR tw: "Bulk filled" OR "sonic resin") #2 (mh: "dental restoration failure" OR tw: "dental restoration failure" OR mh:"Falha de Restauração Dentária" OR tw: "Falha de Restauração Dentária" OR tw:"deterioration margins" OR tw:"marginal discrepancies" OR tw:"discrepância marginal" OR tw:"restoration defect" OR tw: "falha de restauração" OR tw: "clinical performance"OR tw:"performance clínica" OR tw: longevity OR tw: longevidade) #1AND #2
Open Gray	(Composite Resins OR Composite Resin or Bulk-Fill Composite OR Bulk-Fill Composites OR Bulk-fill resin OR Bulkfill resins OR bulk fill or Bulk-filling OR Bulk filled OR sonic resin) AND (Dental Restoration Failure OR deterioration margins OR marginal discrepancies OR restoration defect OR clinical performance or longevity)

Eligibility Criteria

The determination of eligibility criteria, controlled vocabulary of MeSH (Medical Subject Headings) terms, and free terms was performed according to a research strategy based on the acronym PICOS.

- Population (P): Human posterior permanent teeth with Class I or II composite resin restorations.
- Intervention (I): Class I or II restorations in composite resin using sonic energy.
- Comparison (C): Class I or II composite resin restorations performed in conventional incremental and single-increment techniques without sonic energy.
- Outcomes (O): Clinical success and longevity of composite resin restorations using sonic energy during the follow-up period according to clinical evaluation criteria (anatomical shape, color stability, marginal adaptation, postoperative sensitivity, secondary caries, marginal discoloration, surface texture, and retention).
- Study Design (S): Clinical trials with a minimum of 12 months of follow-up.

It included only controlled clinical studies or randomized controlled clinical trials, which compared the clinical success and longevity of Class I and II restorations in single-increment composite resin with the use of sonic energy, Class I, and II restorations done by the incremental technique, and the single-increment technique without the use of sonic energy, with at least twelve months of follow-up. There were no restrictions on language, year of publication, or place of study. Failure rates were assessed based on the Criteria for Clinical Evaluation of Restorative Materials (Modified USPHS). The criteria for clinical evaluation of restorative materials, called USPHS, was used in the study to classify the results. Such criteria involve variables associated with the restoration and the dental element and classify the results as Alpha, Bravo, and Charlie, respectively: totally satisfactory, partially satisfactory, clinically acceptable, and clinically unsatisfactory [19].

Inclusion Criteria

The review included clinical trials, whether randomized or not, that evaluated the Clinical success and longevity of Class I and II restorations (including or not cusps) in bulk-fill composite resin with and without the use of sonic energy and incremental resins, extending to the dentin.

Exclusion Criteria

Case reports, case series, review articles, abstracts, *in vitro* studies, discussions, interviews, editorials or opinions, and studies with less than twelve months of follow-up were excluded. Studies that followed the subjects for a period inferior to 12 months were also excluded.

Selection of Studies and Data Extraction

After the bibliographic search, all references found were exported and stored in reference management software (www.myendnoteweb.com). This tool made it possible to carry out the selection process to identify and exclude duplicate references. Sequentially, articles were selected by reading all titles and abstracts independently by two authors (L.S.D.M and T.K.S.F). When there was disagreement between the authors about the selected articles, a third author (K.R.R.D) analyzed the studies for a consensus on the inclusion or exclusion of the articles, following the pre-defined eligibility criteria. In cases where the information in the abstracts and titles was insufficient, the text was read in full. In the presence of sample overlap in studies, only the study with the most extended follow-up period was considered eligible. The authors were contacted by electronic message in clinical studies with missing or doubtful data.

Data Extraction

Two authors (L.S.D.M and T.K.S.F) independently analyzed the included studies. In case of doubts or disagreements about the information collected from each, a third author with experience in systematic reviews (K.R.R.D) analyzed the issues addressed, and a consensus was reached regarding their resolution. During data extraction, information was collected and entered in Table 2, including study details such as first author name, year and country, follow-up period (in months), mean age of research participants (in a range), dental material used, sample size, tooth type, results and summary of conclusions. In case of the absence of information in any of the studies, the authors were contacted by electronic messages three times.

Assessment of Risk of Bias and Methodological Quality

The methodological quality of the included studies was analyzed using two tools, according to the presence or absence of randomization in the groups. The studies by Atabek et al. [20] and Bayraktar et al. [21] were analyzed using the tool "Risk of bias assessment of randomized controlled trials" Cochrane Handbook 5.0.2 [22] due to the random allocation of patients in the groups. The absence of randomization in the research does not invalidate the analysis of its methodology since the literature presents other analysis options for these studies. ROBINS-I "Risk of bias in non-randomized intervention studies" [23] was the tool used to assess the methodological quality of the other two included clinical trials, as they did not present randomization of the groups involved in the study. Based on the grid of methodological evaluation of Cochrane, it was an alternative found mainly for systematic reviews due to the importance of gathering scientific data from methodologically evaluated studies [23].

Due to the methodological characteristics of the studies, the following domains were considered for the studies by Atabek et al. [20] and Bayraktar et al. [21]: (I) Random sequence generation; II) Allocation

concealment; III) Blinding of participants; IV) Blinding the evaluation of results; V) Incomplete results data and VI) Selective reports and VII) Other sources of bias. For non-randomized studies [16,17], according to the tool used, the following were considered: (I) Confounding bias. (II) Selection bias, (III) Bias of deviation from intended intentions, (IV) Incomplete data, (V) Measurement of results, (VI) Selective reports, (VII) Selection bias of reported results, and (VIII) Other sources of bias.

Operator blinding was not considered since the intervention using sonic energy does not allow hiding the technique used from the operator, as there is a need for specific equipment. To make an overall judgment of individual risk of bias, each included study was judged to have a "high" risk of bias for a negative domain response (red), a "low" risk of bias for a positive domain response (green), and a risk of bias "uncertain" (yellow) when the answer was unclear. When the study was judged as "uncertain," the authors were contacted via email at least three times for further information, and the study could be classified as having a "low" (green) or "high" (red) risk of bias. If this contact was not possible, the articles remained with domains judged as "uncertain" risks of bias.

Quantitative Analysis and Synthesis of Results

Meta-analysis was performed using RevMan software (Review Manager – RevMan - Computer program, Version 5.2. Copenhagen: The Nordic Cochrane Center, The Cochrane Collaboration, 2012). Dichotomous variables were used and included in the software as the number of restorations with alpha scores and total restorations. The fixed effects model and the relative risk were used for the analysis. Heterogeneity was assessed by the I2 index, with significance set at $p<0.05$, where I^2 values of 25%, 50%, and 75% indicated low, medium, and high heterogeneity, respectively [17].

Certainty of Evidence

The evidence of the included studies was evaluated using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) (GRADEpro GDT: GRADEpro Guideline Development Tool Software, McMaster University) [17]. The GRADE tool has five domains that can receive a downgrade in the quality of the evidence in up to two levels [18]. The "risk of bias" domain was evaluated considering the following parameters: (1) failure to develop and apply adequate eligibility criteria to include the population, (2) failure to measure the exposure and outcome, and (3) failure to control the confounding factors [19] adequately. The "inconsistency" domain refers to an unexplained heterogeneity of results among the included studies [20]. The "indirectness" domain is comprised of "(1) differences in the population, (2) differences in the interventions, (3) differences in the measures of results and the indirectness of comparisons [21]. The "imprecision" domain [22] was considered "not serious" if the size of the grouped sample was considerable (at least 300 is the ideal size of information) and if the 95% confidence interval (CI) of the Odds Ratio (OR) does not include considerable benefit or damage (OR of less than 0.75 or above 1.25 as an approximate guide). The "other consideration" domain includes the publication bias, a significant effect, a plausible confusion, and a dose-response gradient [23,24].

Results

Characteristics of the Included Studies

After the bibliographic search and removing duplicates (3,575 records), 5,007 studies were identified. The titles and abstracts were read to select the studies according to the eligibility criteria. A total of 16 articles

were selected for full reading, and four were included in this study. Among the causes of exclusion of the articles chosen initially are overlapping data (n = 1) [16], not related to the main objective (n = 9) [2,15,24-30], incomplete evaluation of the variables (n = 1) [31], and did not present control group (n = 1) [32] (Figure 1). There was no inclusion of new articles after the manual search in the bibliographic references of the included articles.

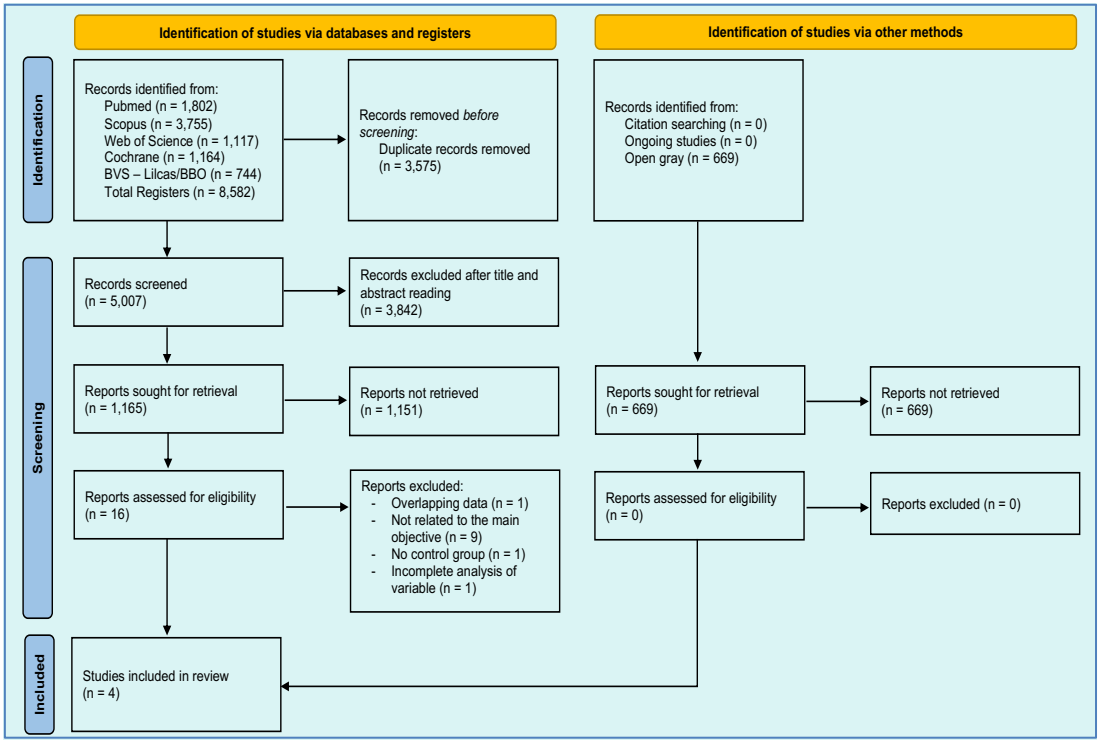

Figure 1. Study selection flowchart.

The characteristics of the four studies selected by qualitative data are listed in the Data Extraction Table (Table 2). Two studies were randomized from the included studies. All studies were developed at universities with follow-up from 12 to 24 months. In a general analysis of the clinical trials, heterogeneity was observed in the patients included in the studies, ranging from twenty to sixty, with heterogeneous ages. One of the studies [13] used the split-mouth method, where each patient received two restorations; in another, there were three different restorations in the same individual [21]. In the third article, research subjects received only one type of restoration (intervention or control) [16], while in another clinical trial, a patient received four different types of restorations [17].

The United States Public Health Service - Modified (USPHS-M) indexes were used in all studies (marginal discoloration, postoperative sensitivity, surface texture, anatomical shape, marginal fit, secondary caries, and color stability and retention). Such criteria involve variables associated with the restoration and the dental element and classify the results as Alpha, Bravo, and Charlie, respectively: totally satisfactory, partially satisfactory, clinically acceptable, and clinically unsatisfactory. It was observed that the use of sonic energy in single-increment composite resin restorations has success rates similar to the incremental technique already established in the literature. In some criteria evaluated (color stability, marginal discoloration, marginal adaptation), the single-increment restorations without sonic energy presented lower values than those of the application of sonic vibration [16,17,21].

Table 2. Characteristics of studies included for qualitative analysis.

Author / Place	Follow-Up Time	Age Group	Treatment (n)	Control (n)	Results			Conclusions
Atabek et al. [20], Turkey	24 months	7-16 years	SonicFill (n=30 Classe I 18=1°molar; 12=2° molar)	Conventional Composite (n=30) [Classe I -18=1°molar; 12=2° molar]	Sonicfill AS: Alpha=100% ST: Alpha=96.67%, Bravo=3.33% MA: Alpha=96.67%, Bravo=3.33% CS: Alpha=96.67%, Bravo=3.33% RT: Alpha=100% POS: Alpha=100% SC: Alpha=100%	Conventional Resin AS: Alpha=100% ST: Alpha=93.34%, Bravo=6.66% MA: Alpha=96.67%, Bravo=3.33% CS: Alpha=100% RT: Alpha=100% POS: Alpha=100% SC: Alpha=100%		No statistical differences were observed between restorations and conventional restorations and with the use of sonic energy in the analyzed parameters. Retention, anatomical shape, and secondary caries criteria were 100% Alpha during the two years of follow-up.
Rashmi et al. [17], India	12 months	18-30 years	SonicFill n=23	Tetric Evoceram Bulk Fill (n=23) Filtek Bulkfill (n=23)	Sonicfill MD: Alpha=95.65%, Bravo=4.35% SC: Alpha=100% ST: Alpha=100% MA: Alpha=91.3% Bravo=8.7% RT: Alpha=100% AS: Alpha=95.65%, Bravo=4.35% POS: Alpha=100% CS: Alpha=95.65%, Bravo=4.35%	Tetric Evoceram MD: Alpha=95.65% Bravo=4.35% SC: Alpha=100% ST: Alpha=100% MA: Alpha=86.96%, Bravo=13.04% RT: Alpha=100% AS: Alpha=100% POS: Alpha=95.65% Bravo=4.35% CS: Alpha=95.65%, Bravo=4.35%	Filtek Bulkfill MD: Alpha=95.65% Bravo=4.35% SC: Alpha=100% ST: Alpha=95.65% Bravo=4.35% MA: Alpha=82.6% Bravo=17.4% RT: Alpha=100% AS: Alpha=100% POS: Alpha=95.65% Bravo=4.35% CS: Alpha=91.3% Bravo=8.7%	A total of 69 restorations were placed on 23 patients (three types of restoration in each). The recall rate was 100% within one year. After one year, the Sonicfill restoration received a Bravo for Anatomical Shape, Color Stability, and Marginal Discoloration. The Marginal Adaptation received two Bravo scores after one year. There was not significant difference between the restorative groups in terms of anatomical shape. Success rate: SF = 91.3% / TEBF = 86.9% / FBP = 82.6% Overall success rate = 86.93%
Alkurdi and Abboud [16], Siria			SonicFill n=20 (n=10 pre-molars)	TetricEvo Ceram n=20 (n= 10 premolars) (n=10 molars) Tetric N-Ceram Bulk Fill n=20 (n= 10 premolars) (n=10 molars)	Tetricevo Ceram MD: Alpha=78.95% Bravo=15.79% Charlie=5.26% SC: Alpha=100% AS: Alpha=78.95% Bravo=21.05% MI: Alpha=89.47% Bravo=10.53% POS: Alpha=100% ST: Alpha=84.21% Bravo=15.79% CS: Alpha=89.47% Bravo=21.05% FC: Alpha=100%	Tetric N-Ceram Bulk Fill MD: Alpha=76.5% Bravo=11.77% Charlie=11.77% SC: Alpha=100% AS: Alpha=82.35% Bravo=17.65% MI: Alpha=76.5% Bravo=23.5% POS: Alpha=100% ST: Alpha=88.23% Bravo=11.77% CS: Alpha=82.35% Bravo=17.65% FC: Alpha=100%	Sonic Fill MD: Alpha=90% Bravo=10% SC: Alpha=100% AS: Alpha=95% Bravo=5% MI: Alpha=95% Bravo=5% POS: Alpha=100% ST: Alpha=95% Bravo=5% CS: Alpha=90% Bravo=10% FC: Alpha=100%	After 12 months: 58 restorations and patients reassessed (recall rate 96%). The overall success rate was 91.3%. Five restorations failed, four in group 2 (Tetric N Ceram Bulk Fill: 2 Marginal discoloration, 2 postoperative sensitivity) and one in group 1 (Tertic Evo Ceram: 1 Marginal discoloration). Success rate: SF= 100%, Tetric Evo Ceram = 94.7% Tetric NCeram = 78.9% (p>0.05).

Bayraktar et al. [21], Turquia	12 months	18-45 years	Sonicfill Class II Restoration n=50 16= upper premolars; 7= lower premolars; 12= upper molars; and 15 = lower molars	Clearfill Photo Posterior Class II Restoration n= 50 19 = upper premolars; 5 = lower premolars; 13= upper molars; 15= lower molars) Filtek Bulkfill Flowable + P60 Class II Restoration n= 50 (20= upper premolars; 5= lower premolars; 14=upper molars; 11= lower molars;) Tetric Evo Ceram Bulk fill Class II Restoration n= 50 (16= upper premolars; 7= lower premolars; 12= upper molars; and 15= lower molars)	Clearfill Photo Posterior AS: Alpha=100% CS: Alpha=100% MD: Alpha=97.67% Bravo=2.33% MA: Alpha=100% SC: Alpha=97.67% Charlie=2.33% RT: Apha=100% POS: Alpha=98% Filtek Bulkfill Flowable + P60 AS: Alpha=93.02% Bravo=0.33% Charlie=4.65% CS: Alpha=97.67 Bravo=2.33%	MD: Alpha=95.35% MA: Alpha=93.02% Bravo=2.33% Charlie 4.65% MA: Alpha=93.02% Bravo=2.33% Charlie 4.65% SC: Alpha=95.35% Charlie=4.65% POS: Alfa=97.67% Charlie=2.33% RT: Alpha=97.67% Charlie=2.33% Tetric Evoceram Bulk Fill AS: Alpha=97.67% Charlie=2.33% CS: Alpha=100%	MD: Alpha=97.67% Bravo=2.33% MA: Alpha=97.67% Charlie=2.33% SC: Alpha=95.35% Charlie=4.65% POS: Alpha=100% RT: Alpha=100% Sonicfill Resin AS: Alpha=100% CS: Alpha=100% MD: Alpha=100% MA: Alpha=100% SC: Alpha=100% POS: Alpha=100% RT: Alpha=100%	After 12 months, 172 restorations were evaluated, and 43 patients were reevaluated (an 86% return rate). SF showed better results than other restorations in terms of anatomical shape and Secondary Caries (100% Alpha), but there was no statistical difference between the four materials (p=0.108 and p=0.522, respectively). Success rate: CPP=97.6% / FBF=95.3% / TBF=95.3% / SF=100% Overall Success Rate: 97%. FBF was considered worse than other group restorations. However, there was no statistically significant difference between the four materials (p>0.05).

AS: Anatomical Shape; ST: Surface Texture; MA: Marginal Adaptation; CS: Color Stability; RT: Retention; POS: Postoperative Sensitivity; SC: Secondary Caries; MD: Marginal Discoloration; MI: Marginal Integrity; FC: Fracture.

The four studies compared the performance of direct restorations in composite resins and included restorations made using sonic energy in one of their analyzed groups. Two performed Class II restorations on premolars and molars [16,21] and compared SonicFill (Kerr) to non-sonicated bulk fill restorations and incremental resins. One compared Class I composite resin restorations with and without using sonic energy in the first and second molars [13]. The fourth study compared sonicated and non-sonicated single-increment Class I type restorations in posterior teeth but did not specify which dental group [17].

As for the materials used, various composite resins were observed in the comparison groups. The percentage of resin loading varied between 65% and 82% by weight. One study used only one resin type to compare with SonicFill [13], while the other three used at least two types in the comparative groups [17,21]. One of the clinical trials used two resins in the same comparison group: a fluid Bulk-fill resin restoration and a single-fill occlusal layer with a resin of regular consistency [21]. Resin restorations using sonic energy showed a high success rate in the studies; however, in two studies [16,21], failures were reported regarding the following variables: anatomical shape, color maintenance, marginal discoloration, marginal adaptation, and surface texture. None of the SonicFill restorations received a Charlie score for the aforementioned variables. It should be noted that in the study by Alkurdi and Abboud [16], the presence of the Charlie score at baseline for postoperative sensitivity in two restorations in Group 2 (Tetric N Ceram Bulk Fill) was observed in the clinical evaluation results table, where a single-increment composite resin was used without the use of sonic energy. In the final evaluation, these two restorations were not counted in the table after twelve months, leading the reader to infer that they were lost over time. However, throughout the text, the author describes this result and explains that although sensitivity was observed at baseline, it did not remain after twelve months in this group. This information is crucial for the analysis of the success rate of the groups involved in the study.

Risks of Bias

Figures 2 and 3 present an assessment of the selected studies' risk of bias. According to the predetermined key domains, two were classified as 'low' risk of bias [16,17] and two as 'uncertain' risk of bias [13,21].

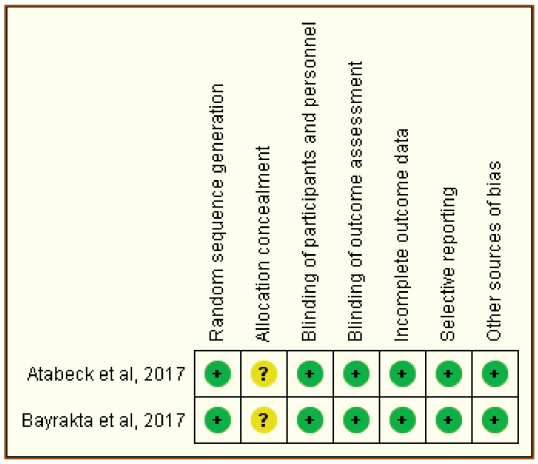

Figure 2. Assessment of methodological quality of randomized trials according to The Cochrane Collaboration tool for risk of bias assessment.

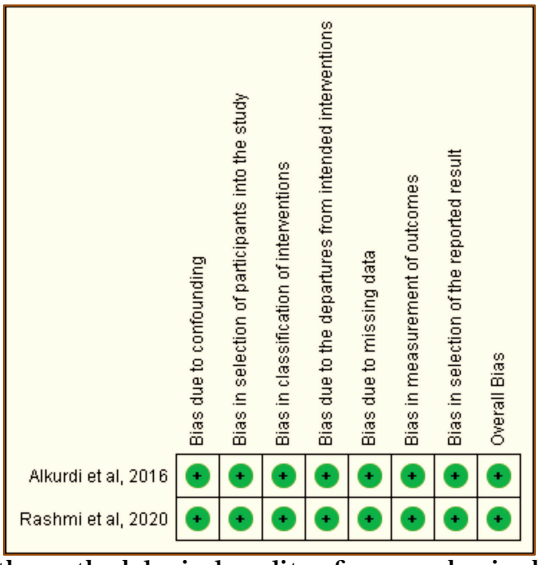

Figure 3. Assessment of the methodological quality of non-randomized studies according to the ROBINS-I tool for risk of bias assessment.

Summary of Results: Meta-Analysis

The selected studies were quantitatively evaluated following the guidance of the Cochrane 5.0.2 manual. No statistically significant difference was observed for the studied results ($p>0.05$). The meta-analysis of the data analyzed in the studies by Alkurdi and Abboud [16], Atabek et al. [20] and Bayraktar et al. [21] was performed considering the success rates of the USPHS criteria analyzed in common.

Figures 4A and 4B show the subgroup analysis of the variable's sensitivity and secondary caries, respectively, where the relative risk was the same for the two criteria CI=1.01 (0.93,1.10). In addition, there was no heterogeneity ($I^2=0\%$) between the results of the two included studies, with a p-value equal to 0.8. The meta-analysis of the color stability subgroup (Figure 4C) obtained a relative risk of 1.02 (0.93,1.13), null heterogeneity ($I^2=0\%$), and p-value of 0.65.

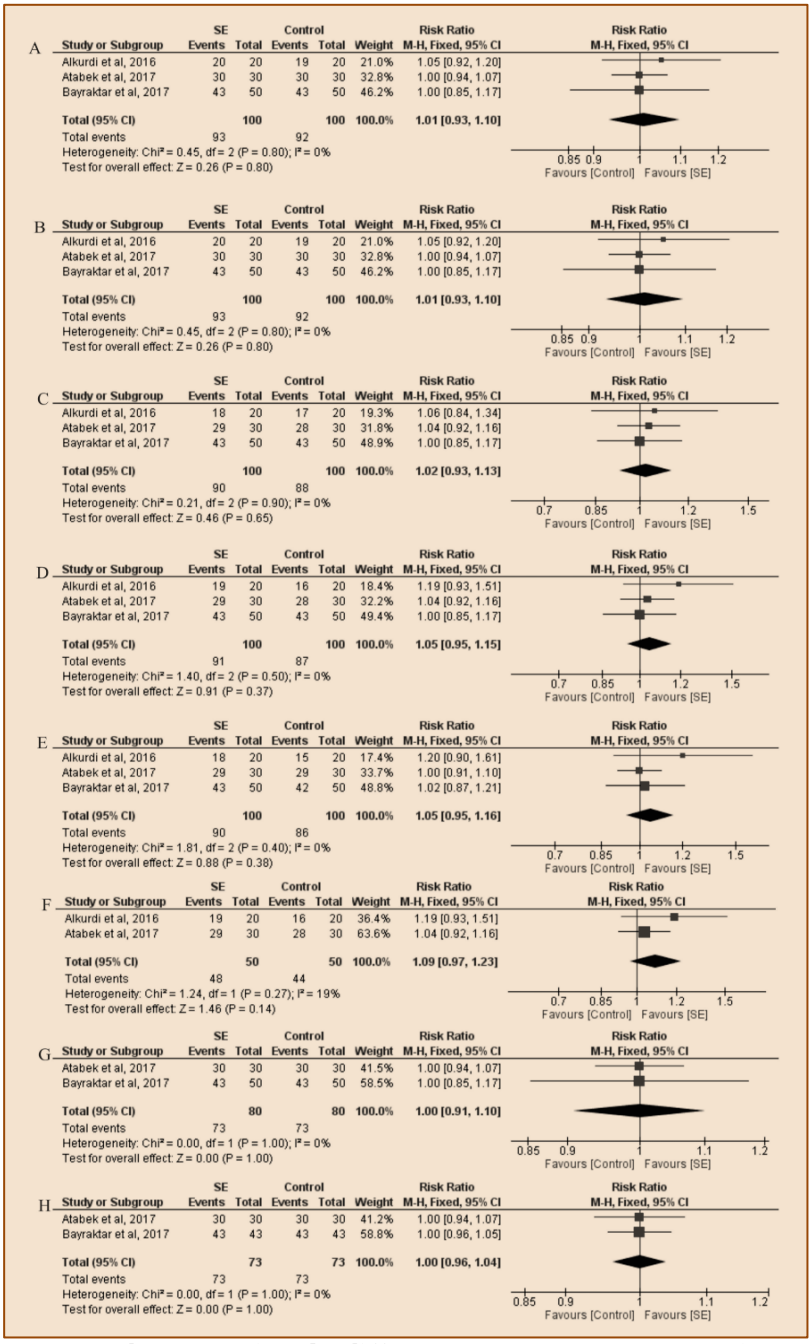

Figure 4. Forest plot demonstrating the different outcomes. A: Postoperative sensitivity; B: Secondary Caries criterion; C: Color stability; D: Anatomical shape; E: Marginal adaptation; F: Marginal discoloration; G: Surface roughness; and H: Retention.

Figures 4D, 4E, and 4F show the statistical analysis of the anatomical shape, marginal adaptation, and marginal discoloration criteria, which presented similar relative risks: 1.05 (0.95,1.15) for the first and 1.05 (0.95,1.16) for both. This evaluation had no heterogeneity (I^2=0%), and the p-values were 0.37, 0.38, and 0.38, respectively. The statistical assessment of the surface texture data (Figure 4G) included the groups of studies by Atabek et al. [20] and Alkurdi and Abboud [16], showing a low heterogeneity (I^2=19%) and a relative risk of 1, 09 (0.97,1.23) with p=0.14. The study results by Bayraktar et al. [21] were not included in the meta-analysis of this last criterion (Figure 4H) as it was not evaluated in this study. Likewise, the meta-analysis of the retention outcome (Figure 4H) did not include the study by Alkurdi and Abboud [16], which presented the following results: relative risk = 1.00 (0.91, 1.10) with p=1.00 and I^2= 0%.

The meta-analysis compiled the studies that evaluated composite resin restorations sonicated with resins made in the incremental technique, statistically comparing an intervention proposal to a standard control group agreed by the dental literature.

Certainty of Evidence

The four included randomized clinical studies were submitted to the GRADE tool, and the certainty of evidence was classified as very low (Table 3). The major concerns were the different types of composite resins used in the risk of bias, the difference in results among included studies in the inconsistence, and the sample number less than 300 in most of the studies in the imprecision.

Table 3. Certain evidence assessments.

		Certainty Assessment					
Nº of Studies	**Study Design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considerations**	**Certainty**
04	Clinical Trials	Serious[a]	Very Serious[b]	Not Serious	Very Serious[c]	All plausible residual confounding would reduce the demonstrated effect	⊕◯◯◯ Very Low

[a]Differents types of composite resins used; [b]Difference in results among included studies; [c]Sample number less than 300 in most of the studies.

Discussion

The application of technology in restorative dental materials has significantly advanced clinical use. An example is the combination of sonic energy during the insertion of the bulk-fill composite resin into the dental cavity. Although laboratory studies show significant results regarding variables such as marginal adaptation, surface roughness, and mechanical strength, it is necessary to monitor the behavior of the material clinically [8,33].

The clinical studies selected for this systematic literature review were carried out in a controlled manner. They compared the results obtained in direct Class I and Class II composite resin restorations using different techniques: the single-increment technique using sonic energy compared to the incremental technique and the single increment without applying this energy during the insertion of the restorative material in the dental cavity. All of them showed positive results regarding the application of sonic energy but assumed the null hypothesis as they observed little statistical difference between the restorative techniques compared.

The tool recommended by the Cochrane Handbook 5.02 was used for randomized studies and ROBINS-I for non-randomized studies to assess the risk of bias in the studies included in this systematic review and meta-analysis. The studies by Atabek et al. [20] and Bayraktar et al. [21] showed a moderate risk of bias, both showing an uncertain response to the dominant allocation secret of the Cochrane tool. Non-randomized studies [16,17] had a low risk of bias.

As observed in the study by da Veiga et al. [13], the RCTS included in this systematic review had difficulty reporting the allocation sequence and its concealment, requiring email contact with the authors [13,21]. Only one response was obtained, in which the author confirmed the randomization in the clinical trial but did not describe the sequence and reported that there was no operator blinding due to the technical infeasibility of the procedure, in addition to not being a split-mouth study. As presented in the article, the evaluators and patients were unaware of the materials used in the operative procedures [21].

The blinding of participants, operators, and evaluators is essential to avoid detection bias in the study and contributes to its power of evidence. However, it is not always feasible to do so [23]. Due to the different techniques between the intervention and control groups, it was not possible to blind the operator.

Only two included studies had patient losses during follow-up, 14% in the study of Bayraktar et al. [21] in Alkurdi and Abboud [16]. Dropout from follow-up and change of address are the main causes of participant loss during clinical studies [16,21]. On the other hand, in this systematic review, patient losses were not found in the study with a longer follow-up period [13].

No divergence was observed regarding the data reporting in the studies, an important domain of methodological quality analysis that assesses the presence of selective results to examine the results' impartiality and to know if they matched the pre-existing protocols [23]. The study by Alkurdi and Abboud [16] presented a table of clinical results showing the presence of two Charlie criteria for postoperative sensitivity in the baseline of composite resin restorations with a single increment and without the use of sonic energy. However, they were not considered in the final analysis (after twelve months) of the table, a factor that could cause a bias if the author did not report the results clearly in the text, which was not the case, thus understanding the rate of success of this group of restorations.

The data obtained from the included studies were analyzed through the criteria for clinical evaluation of restorative materials, which became widely known for being used by the US Public Health Service, then called USPHS [19]. Such criteria involve variables associated with the restoration and the dental element and classify the results as Alpha, Bravo, and Charlie, respectively: totally satisfactory, partially satisfactory, clinically acceptable, and clinically unsatisfactory [19]. Common criteria were included in the meta-analysis, so surface texture and retention were evaluated in only two studies. In contrast, the fracture was not included in the quantitative analysis since only one study assessed this criterion in isolation; therefore, it was not a common feature evaluated.

According to the results of the analyzed studies, thick increments of composite resin can be used in deep cavities with a single insertion [21]. The application of sonic energy can overcome the limitations of the incremental and bulk fill techniques without rheological modification. The incremental layers induce high tensions in the interfacial margins [30,34], causing a higher failure rate of the restorative material. In these studies, there was a low percentage of adhesive failure. However, the fluid consistency bulk fill technique presented lower scores (2.33% Charlie) regarding the retention variable, according to Bayraktar et al. [21]. Similar parameters were found in the results of Alkurdi and Abboud [16], who justified the failure of two regular bulk fill restorations without sonic energy through the hypothesis of non-complete conversion of resin monomers. In the analysis of restorations performed with Sonic Fill, all were 100% successful in retention in the different clinical trials evaluated [13,16,17,21].

Polymerization shrinkage is a phenomenon inherent to resin materials, and the stresses of this shrinkage [34,35] can decrease the quality of marginal adaptation. In this regard, using sonic energy in single-increment composite resins obtained a 100% Alpha score in two clinical trials [13,21]. Although the studies by Alkurdi and Abboud [16] and Rashmi et al. [17] presented restorations with a Bravo score for this criterion (one and two Bravo scores, respectively), they were not statistically significant after one year. In the comparative groups, only one study presented an alpha score for marginal adaptation using the incremental technique (CPP) [21]. In this same study, Charlie scores were observed for two other comparative groups of bulk fill resins without using sonic energy (FBF with regular consistency P60 occlusal coverage and Tetric Evoceram Bulkfill, respectively).

Marginal infiltration and secondary caries are criteria generally associated with poor marginal adaptation [36]. Dental elements that received sonified restorations did not show secondary caries in any of the included studies [13,16,17,21]. However, even with 100% Alpha scores for marginal adaptation, incremental resin, and bulk fill restorations without sonic energy showed a recurrence of caries. In the study by Bayraktar et

al. [21], the regular consistency bulk fill technique and its combination with the fluid consistency showed 4.65% Charlie for the presence of secondary caries. In the same study, the incremental resin restorations showed 2.66% Charlie for this criterion. Even though the difference between the results was insignificant, they were associated with possible failures during the insertion of the material into the cavity, such as contamination by saliva [21]. The higher marginal integrity observed in the study by Rashmi et al. [17] was related to the consistency of the material during application, whereas the *in vitro* study by Petrovic et al. [33] observed better integrity in the restorative margins and lower penetration of pigments into composite resins using sonic activation.

The color change in the restorative margins may be associated with a greater propensity for failure and degradation of the adhesive interface over time [20]. In the study by Atabek et al. [20], which compared incremental composite resins to bulk fill resins using sonic energy, identical scores were observed for the variable marginal discoloration at the end of two years of follow-up (Bravo 3.33%). These findings were related to the hydrolytic degradation expected in self-etching adhesives [35,37] and not to the difference between the two types of composite resins and techniques used [13]. Similar results were found in the other two studies [16,17], which compared the use of sonic energy in single-increment composite resins with incremental composite resins and bulk-fill resins without using the sonic system. In the study by Bayraktar et al. [21], a 100% Alpha score was reported for marginal discoloration in the final SonicFill evaluation. In comparison, the other groups presented 2.33% Bravo for restorations in incremental resin and single-filling consistency resins. Regular without the application of sonic energy and 4.66% Bravo for fluid bulk fill composite resins without sonic energy. The use of the adhesive suggested by the manufacturer of each restorative material analyzed and the sonic vibration on the composite resins of the intervention group may be related to the success of the result presented [21].

Other studies considered postoperative sensitivity to be a disadvantage of resin restorations in posterior teeth [21,38]. Its presence may be associated with the absence of coating of the sonified sonified sonified complex in deep cavities [39]. No postoperative sensitivity was observed in restorations using sonic energy [16,17,21], except in the group analyzed by Atabek et al. [20], which did not use calcium hydroxide coating in deep cavities. Bayraktar et al. [21] associated a low sensitivity frequency with using a self-etching adhesive system. However, in this study and that of Alkurdi and Abboud [16], the incremental group and the bulk fill group without using sonic energy still presented negative results for this criterion. In addition, they observed a more significant occurrence of postoperative sensitivity in premolar teeth. They associated this finding with a smaller thickness of dentin under the pulp chamber of these elements, which may have caused pulpal irritation due to residual monomer [16].

The material's color stability was similar in the different types of restorations evaluated in the studies. However, in only one of the studies, SonicFill received a 100% Alpha score for this criterion [16]. The non-statistical difference in the results analyzed between the groups of the different studies may be associated with the presence of small-sized filler particles and the urethane dimethacrylate (UDMA) polymer matrix present in the organic matrix of the resins used, which may promote better resistance to color change [16,21].

After evaluating the USPHS criteria in the included studies, it was observed that despite the slight statistical difference between the analyzed techniques, the group using sonic energy presented the best scores [13,16,21]. The success of variables such as marginal adaptation, surface roughness, and fracture was associated with the presence of sonic energy and the fact that Sonicfill presents a more significant amount of load when compared to other resin materials (85.3% by weight) [13,16,21,29]. The sonic vibration on the resin provides

greater mobility to free radicals, facilitating the adaptation of the material to the cavity and positively impacting other criteria, such as marginal infiltration and the absence of secondary caries [40].

Conclusion

No significant differences were observed regarding the longevity of restorations performed by the incremental technique and single-increment composite resin restorations (with and without the use of sonic energy), the certain of evidence was very low, so no conclusion can be taken whether the use or not of sonicated composite resin restorations is better or not. Considering the fact that this technique is recent in the literature, even assuming the null hypothesis, the results are highly satisfactory since the application of sonic energy is being compared to the incremental use of composite resins, sedimented as the gold standard in dentistry.

Authors' Contributions

LSM	https://orcid.org/0000-0003-1538-3326	Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review and Editing and Visualization.
FFG	https://orcid.org/0000-0001-8338-9303	Validation, Formal Analysis, Data Curation, Writing - Original Draft, Writing - Review and Editing and Visualization.
JSB	https://orcid.org/0000-0002-6245-6260	Methodology, Validation, Investigation, Writing - Original Draft, Writing - Review and Editing and Visualization.
TKSF	https://orcid.org/0000-0003-1340-9967	Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review and Editing, Visualization, Supervision, Project Administration and Funding Acquisition.
KRR	https://orcid.org/0000-0002-6055-3905	Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review and Editing, Visualization, Supervision, Project Administration and Funding Acquisition

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

Financial Support

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

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.

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