Sealants for preventing and arresting pit-and-fissure occlusal caries in primary and permanent molars

A systematic review of randomized controlled trials—a report of the American Dental Association and the American Academy of Pediatric Dentistry

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ABSTRACT

Background. National Health and Nutrition Examination Survey 2011-2012 data indicated that, in the United States, nearly one-fourth of children and over one-half of adolescents experienced dental caries in their permanent teeth. The purpose of this review was to summarize the available clinical evidence regarding the effect of dental sealants for the prevention and management of pit-and-fissure occlusal carious lesions in primary and permanent molars, compared with a control without sealants, with fluoride varnishes, or with other head-to head comparisons.

Type of Studies Reviewed. The authors included parallel and split-mouth randomized controlled trials that included at least 2 years of follow-up, which they identified using MEDLINE (via PubMed), Embase, LILACS, the Cochrane Central Register of Controlled Trials, and registers of ongoing trials. Pairs of reviewers independently conducted the selection of studies, data extraction, risk of bias assessments, and quality of the evidence assessments by using the Grading of Recommendations Assessment, Development and Evaluation approach.

Results. Of 2,869 records screened, the authors determined that 24 articles (representing 23 studies) proved eligible. Moderate-quality evidence suggested that participants who received sealants had a reduced risk of developing carious lesions in occlusal surfaces of permanent molars compared with those who did not receive sealants (odds ratio [OR], 0.15; 95% confidence interval [CI], 0.08-0.27) after 7 or more years of follow-up. When the authors compared studies whose investigators had compared sealants with fluoride varnishes, they found that sealants reduced the incidence of carious lesions after 7 or more years of follow-up (OR, 0.19; 95% CI, 0.07-0.51); however, this finding was supported by low-quality evidence. On the basis of the evidence, the authors could not provide a hierarchy of effectiveness among the studies whose investigators had conducted head-to-head comparisons. The investigators of 2 trials provided information about adverse events, but they did not report any adverse events.

Conclusions and Practical Implications. Available evidence suggests that sealants are effective and safe to prevent or arrest the progression of noncavitated carious lesions compared with a control without sealants or fluoride varnishes. Further research is needed to provide information about the relative merits of the different types of sealant materials.

Key Words. Glass ionomer sealants; resin-based sealants; caries prevention; caries arrest; pit-and-fissure sealants; systematic review.

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Caries prevalence has declined in developed countries over the past several decades; however, many populations within these nations still carry a large burden of this disease.[1] National Health and Nutrition Examination Survey 2011-2012 data indicated that, in the United States, nearly one-fourth of children and over one-half of

Supplemental material is available online.

adolescents experienced dental carious lesions in their permanent teeth.[2] Occlusal surfaces, especially those on permanent molars, contain grooves called pits and fissures that can trap debris and microorganisms, thereby increasing the risk of developing dental carious lesions. Indeed, the caries that are found in the adolescent population are represented disproportionately in the pits and fissures of teeth compared with the smooth surfaces.[3] Fluorides and other caries preventive approaches (for example, mechanical plaque control) seem to be less effective for preventing carious lesions in pit-and-fissure surfaces compared with smooth surfaces.[3] Pit-and-fissure sealants, or simply sealants, were developed to help manage these sites of dental stagnation that are resistant to other therapeutic approaches and contribute to a significant portion of caries disease burden in the population. Sealants are an underused therapy; only 30% of children 6 to 8 years old have at least 1 dental sealant.[4]

Sealants are dental materials that dentists apply to the pit-and-fissure surfaces of teeth. The sealant material penetrates pits and fissures and then hardens, acting as a physical barrier that stops or inhibits the ingress of bacteria and nutrients. Researchers conducted the first clinical trials in the late 1960s and early 1970s using a variety of materials. Today there are multiple commercially available sealant materials, including resin-based sealants such as urethane dimethacrylate or bisphenol A-glycidyl methacrylate monomers that are polymerized by means of either a chemical activation-initiation or a light activation system. Glass ionomer (GI) cements are another type of sealant material that have been widely recognized and used for their fluoride-release properties, which stem from the acid-base reaction between a fluoroaluminosilicate glass powder and an aqueous-based polyacrylic acid solution. Polyacid-modified resin sealants, also referred to as compomers, combine resin-based material found in traditional resin-based sealants with the fluoride-release and adhesive properties of GI sealants. Resin-modified GI sealants are essentially GI sealants with resin components that allow for light polymerization.[5] These dental materials differ in many of their physical properties, including hydrophobicity, fracture resistance, thermal expansion, and bond strength. Also, investigators have found that topical fluoride varnishes (sodium fluoride) substantially prevent dental caries in children and adolescents by decreasing demineralization, promoting remineralization, and possibly inhibiting the effects of bacterial biofilm.[6]

Investigators have conducted a number of systematic reviews to determine the clinical effectiveness, cost-effectiveness, and safety of pit-and-fissure sealants compared with another type of sealant material, a control without sealants, and fluoride varnishes. The authors of 1 review reported that sealants were effective in preventing occlusal and proximal carious lesions in the molars of children when compared with controls without sealants.[7] The authors of this review also reported inconclusive and inconsistent results related to the potential superiority of any of the sealant materials in head-to-head comparisons.[7] The authors of another systematic review suggested that sealants may be more effective than fluoride varnishes in preventing occlusal carious lesions in molars in children, but the quality of the evidence was low.[6] The investigators of both of these systematic reviews[6,7] reported that the authors of most of the included studies did not mention adverse events, and even when authors did mention adverse events, they did not report any adverse events that had occurred in their studies.[6,7]

The purpose of this review was to summarize the available evidence regarding the effect of dental sealants for the prevention of pit-and-fissure occlusal caries in primary and permanent molars on children, adolescents, and adults compared with a control without sealants, with fluoride varnishes, or with another head-to-head comparison to inform the development of a joint evidence-based clinical practice guideline by the American Dental Association and the American Academy of Pediatric Dentistry.[8]

METHODS

This report follows the guidance of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.[9]

Selection criteria for the studies in this review. ***Type of studies.*** We included parallel and split-mouth randomized controlled trials (RCTs) with at least 2 years of follow-up. We excluded quasirandomized trials, nonrandomized trials, and observational studies.

Type of participants. We included studies that involved children, adolescents, and adults from the general population who did or did not have a history of carious lesions and who had either a sound occlusal surface or a noncavitated carious lesion in primary and permanent molars.

Type of interventions. For this systematic review, we defined 4 categories of sealant materials: resin-based sealants, GI cements or GI sealants, resin-modified GI sealants, and polyacid-modified resins. We classified resin-modified GI sealants as a subcategory of the GI sealants category and polyacid-modified resins as a subcategory of the resin-based sealants category.[5] We defined "intervention" as any of the 4 types of sealant materials described previously, irrespective of the application technique. We excluded studies whose investigators used sealant materials that were not

ABBREVIATION KEY. **GI:** Glass ionomer. **GRADE:** Grading of Recommendations Assessment, Development and Evaluation. **PFM:** Permanent first molar. **PM:** Permanent molar. **RCT:** Randomized controlled trial.

commercially available at the time of this review. We defined "comparison" as any type of sealant material irrespective of the application technique, the nonplacement of sealants, or the use of fluoride varnishes.

Type of outcome measures. We defined "caries incidence" as the identification of a new carious lesion on the occlusal surface of a primary or permanent molar that compromised dentin tissue. We defined "lack of retention" as the complete detachment or retention loss of the sealant material from the grooves and pits in the occlusal surface of a tooth with no macroscopically visible sealant material. We defined "adverse effects" as any potential adverse effect defined by the authors of the primary studies. For all outcomes, we grouped the studies into 3 categories according to the length of follow-up: 2 to 3 years, 4 to 7 years, and 7 or more years.

Search methods for the identification of studies. ***Electronic databases.*** We searched MEDLINE (via PubMed), Embase, LILACS, and the Cochrane Central Register of Controlled Trials (CENTRAL) from January 1971 to May 2013. We searched MEDLINE (via PubMed) and the Cochrane Central Register of Controlled Trials (CENTRAL) from June 2013 to May 2016. We used a combination of key words and controlled vocabulary that we adapted for each electronic database. We used filters, such as the Cochrane Highly Sensitive Search Strategy, for identifying randomized trials (Appendix, available online at the end of this article).[10]

Other type of resources. We searched ClinicalTrials.gov to identify completed or ongoing RCTs that were not yet published and indexed in the regular electronic indices. We also screened the reference lists of included studies from previous systematic reviews to ensure that we had not omitted relevant studies. We did not exclude any studies on the basis of the status or language of publication.

Data collection and analysis. ***Selection of studies.*** In the first stage, 2 reviewers (M.T., L.G.) independently screened the titles and abstracts of all retrieved references by using a standardized form. Because they used an inclusive criterion, when the reviewers disagreed on the eligibility status for a particular reference, they included the citation in question at this stage and resolved the disagreement at the full-text screening stage. In the second stage, 2 reviewers independently screened the full text of all potentially eligible studies. They resolved any disagreement by means of discussion. When consensus was elusive, a third reviewer (C.E.), acting as an arbiter, decided final eligibility.

Data extraction and management. Using a standardized form, 2 reviewers (M.T., L.G.) independently extracted data from all the included studies. The form included instructions to extract the main characteristics of the studies, including the type of study design (parallel, split-mouth), population (age, sex, selection criteria, caries history, clinical diagnosis of the occlusal surface to be sealed), type of sealant material and the comparison (nonuse of sealant or an active comparator), and the outcomes (specific definition from the primary study and results). When these reviewers identified discrepancies that they were unable to clarify, a third reviewer (C.E.) acted as arbiter.

Assessment of the risk of bias of included studies. Two reviewers (M.T., A.C.L.) independently conducted an assessment of the risk of bias for each included study by using the Cochrane risk of bias tool.[11] We assessed the following types of bias in each study: selection bias (Was allocation randomized and concealed to ensure comparability between groups?), detection bias (Were the patients and outcome assessors unaware of which treatment was applied?), attrition bias (Were dropout rates sufficiently low to ensure that groups were still comparable at follow-up?), reporting bias (Did investigators selectively report outcomes?), and other sources of bias. For each domain, we determined whether a study had a high, low, or unclear risk of bias. We considered randomization sequence generation and allocation concealment to be the most important domains for the overall assessment of risk of bias. We resolved any disagreements by means of discussion until we reached consensus.

Measures of treatment effect and missing data. We analyzed caries incidence, lack of retention, and adverse events as dichotomous outcomes. For studies in which the investigators reported sealants as being fully retained, partially retained, and not retained, we grouped the fully and partially retained events and compared them with the sealants that were not retained to create the estimate. We calculated odds ratios (OR) and 95% confidence intervals (CI) for both outcomes. For each study, we calculated the proportion of missing participant data, and we determined to what extent the amount of missing data was substantial enough to change the magnitude and direction of the estimates to the point of dramatically changing the conclusions, as suggested by Akl and colleagues.[12] Otherwise, we used complete case analysis.

Assessment of heterogeneity. We conducted the assessment of heterogeneity by following the guidance of the *Cochrane Handbook for Systematic Reviews of Intervention*.[13] We used the χ^2 test to determine the presence of statistical heterogeneity, and we set the level of significance at .1. In addition, we quantified the amount of heterogeneity among studies using the I^2 statistic, in which we considered a value of I^2 40% or less to be unimportant heterogeneity, a value of I^2 from 30% through 60% to be moderate heterogeneity, a value of I^2 from 50% through 90% to be substantial heterogeneity, and a value of I^2 from 70% through 100% to be considerable heterogeneity.

Assessment of publication bias. We conducted the assessment of publication bias by following the recommendations from the *Cochrane Handbook for Systematic Reviews of Intervention*.[14] If we noted that an outcome was informed by more than 10 studies, then we explored publication bias by using funnel plots.

TABLE 1

Levels of quality of evidence (certainty in the evidence).*

QUALITY LEVEL	DEFINITION
High	We are very confident that the true effect lies close to that of the estimate of the effect
Moderate	We are moderately confident in the effect estimate; the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low	Our confidence in the effect estimate is limited; the true effect may be substantially different from the estimate of the effect
Very Low	We have very little confidence in the effect estimate; the true effect is likely to be substantially different from the estimate of effect

* Reproduced with permission of the publisher from Balshem and colleagues.[18]

Data synthesis. Investigators of RCTs who measured the effectiveness of interventions to prevent carious lesions typically used 1 of 2 designs: split-mouth or parallel. In RCTs whose investigators used a parallel design, the investigators allocated study participants to receive either the experimental treatment or a control. In split-mouth trials, the investigators randomly assigned 1 of 2 treatments (for example, sealant versus no sealant) to the same type of tooth on the right and left sides of the participant's mouth. One advantage of conducting split-mouth trials is that these types of RCTs minimize variability among study participants, as the intervention and control teeth are in the same person's mouth. One potential issue, however, is that the preventive benefits of the intervention may carry over to the control teeth. We judged these carryover effects to be minimal for sealants, and therefore, we pooled the findings from studies whose investigators had used each of these designs to create a single effect estimate by using the methodology proposed by Lesaffre and colleagues[15] and Elbourne and colleagues.[16] We used Review Manager (RevMan), Version 5.3 (Cochrane Collaboration) to conduct the analysis. To obtain the pooled estimate, we used the generic inverse-variance method with a random-effects model. When we included fewer than 4 studies in the meta-analysis, we used a fixed-effects model.

Subgroup analysis. We conducted subgroup analysis to determine whether the studies whose investigators had enrolled participants with noncavitated pit-and-fissure occlusal carious lesions, sound occlusal surfaces, and those who had both (that is, a population who had a mix of both sound occlusal surfaces and noncavitated carious lesions) had different treatment effects. For the interaction test, we used a level of significance of .05.

Assessment of the quality of the evidence. We determined the quality of the evidence (certainty in the estimates of effect) for each outcome by using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach.[17] With the GRADE approach, RCTs start as high-quality evidence; however, the quality or certainty in the body of evidence decreases to moderate-, low-, or very low–quality evidence if serious or very serious issues related to risk of bias, imprecision, inconsistency, indirectness, and publication bias are present (Table 1).[18] Two reviewers (M.T., A.C.L.) independently conducted these evaluations.

RESULTS

Results of the search. The search process resulted in 2,869 references, which we screened to assess their titles and abstracts; we excluded 2,419 references at that stage of the search process. Next, we excluded 426 articles, which we had assessed by means of full-text screenings, and we included 24 articles,[1,19-41] which represented 23 studies, in this review (Figure 1).

Characteristics of included studies. We included 24 articles (representing 23 studies) published from 1976 through 2016,[1,19-41] whose investigators had reported data related to the effectiveness of sealants compared with a control without sealants,[1,19-26] fluoride varnishes,[20,22,27] or other head-to-head comparisons.[28-40] Nine studies' investigators used a parallel design,[20,22,24,26,28,31,33,38,39,41] whereas 14 studies' investigators used a split-mouth design.[1,19,21,23,25,27,29,30,32,34-37,40] Table 2 summarizes the characteristics of the included populations, which investigators described as including children and adolescents aged 3 to 16 years who were living in settings with and without water fluoridation. We did not identify any studies that met the selection criteria whose investigators had provided information about the effect of sealants in an adult population.

Risk of bias of included studies. Poor quality of reporting of the included studies prevented us from conducting a complete assessment of the risk of bias. For most of the studies, we assessed the key 3 domains of random sequence generation, allocation concealment, and masking of participants and personnel as having an unclear risk of bias. Of these 3 domains, we determined that allocation concealment was the most serious and underreported methodological issue (Figure 2).

Effects of the interventions. ***Comparison 1. Sealants versus nonuse of sealants.*** *Caries incidence.* The results of 9 studies[1,19-26] (3,542 participants) informed the comparison and outcome for the 2- to 3-year follow-up category. In relative terms, participants who received sealants reduced their risk of developing new carious lesions by 76% (odds ratio [OR], 0.24; 95% confidence interval [CI], 0.19-0.30; $P < .00001$) compared with participants who did not receive sealants. The heterogeneity was moderate (χ^2 $P = .09$; $I^2 = 41\%$); however, the investigators of all of the individual studies reported the same direction of effect with an overlap of CIs (eFigure 1, available online at the end of this article). In a

subgroup analysis conducted to determine whether the treatment effect differed among studies with patients who had noncavitated occlusal carious lesions, sound occlusal surfaces, and a population with mixed features, we did not find statistically significant results (interaction test $P = .58$). We assessed the quality of the evidence for this outcome as moderate, owing to serious issues related to risk of bias (Table 3).

The results of 3 studies[20,21,23] (752 participants) informed the comparison and outcome for the 4- to 7-year follow-up category. In relative terms, participants who received sealants had a reduction in the risk of developing new carious lesions by 79% (OR, 0.21; 95% CI, 0.10-0.44; $P < .0001$) compared with participants who did not receive sealants (eFigure 2, available online at the end of this article). Because the investigators of all 3 of these studies included only participants with sound occlusal surfaces, we did not perform a subgroup analysis. Serious issues of inconsistency (χ^2 $P = .01$; $I^2 = 77\%$) and risk of bias warranted us to determine that low-quality evidence informed this outcome (Table 3).

The results of 2 studies[20,23] (446 participants) informed the comparison and outcome for the 7 or more years of follow-up category. In relative terms, participants who received sealants had a reduction in the risk of developing new carious lesions by 85% (OR, 0.15; 95% CI, 0.08-0.27; $P < .00001$) compared with participants who did not receive sealants (eFigure 3, available online at the end of this article). The heterogeneity was moderate to high (χ^2 $P = .16$; $I^2 = 50\%$); however, the investigators of all of the individual studies found the same direction of effect with an overlap of CIs. Because the investigators of the 2 studies included only participants with sound occlusal surfaces, we did not perform a subgroup analysis. We assessed the quality of the evidence for this outcome as moderate, owing to serious issues related to risk of bias (Table 3).

Lack of retention. The nature of the comparison did not allow us to obtain information to compare the use versus the nonuse of sealants.

Comparison 2. Sealants versus fluoride varnishes. *Caries incidence.* The results of 3 studies[20,22,27] (1,715 participants) informed the comparison and outcome for the 2- to 3-year follow-up category. In relative terms, participants who received sealants had a 73% reduction in the risk of developing new carious lesions (OR, 0.27; 95% CI, 0.11-0.69; $P = .006$) compared with participants who received fluoride varnishes (eFigure 4, available online at the end of this article). In a subgroup analysis conducted to determine whether the treatment effect differed among studies with patients having noncavitated occlusal carious lesions, sound occlusal surfaces, and a population with mixed features, we found statistically significant results (interaction test $P = .04$); however, this subgroup analysis did not explain the heterogeneity of the results. The investigators of both subgroups of studies

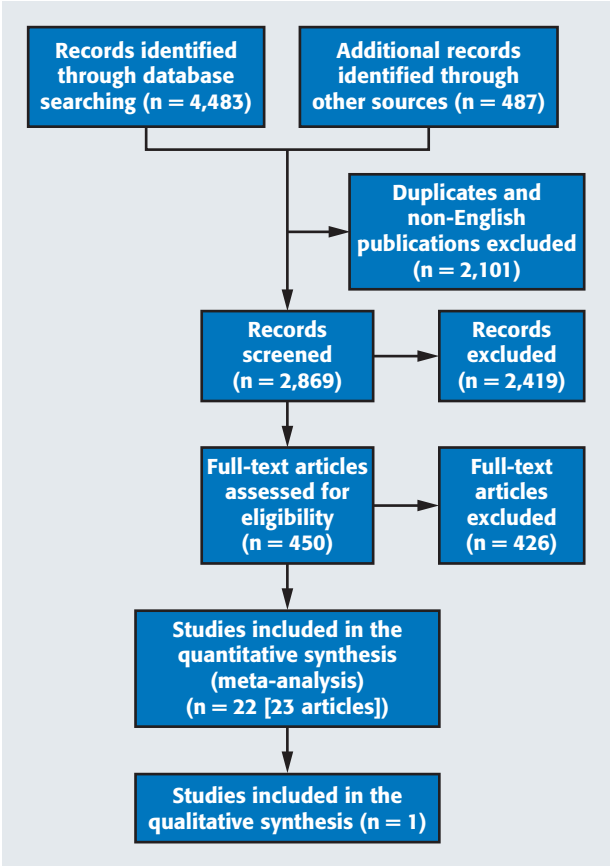

Figure 1. Flowchart of the screening and study selection process.

with sound occlusal surfaces (OR, 0.19; 95% CI, 0.07-0.47; $P = .0004$) and with a mixed population of participants with and without noncavitated carious lesions (OR, 0.66; 95% CI, 0.30-1.44; $P = .3$) found that there was a beneficial effect when using sealants; however, this difference was not statistically significant in the latter study.[22] We assessed the quality of the evidence for this outcome as low, owing to serious issues related to inconsistency (χ^2 $P = .002$; $I^2 = 88\%$) and risk of bias (eTable 1, available online at the end of this article).

The results of 2 studies[20,27] (472 participants) informed the comparison and outcome for the 4- to 7-year follow-up category. In relative terms, participants who received sealants had an 81% reduction in the risk of developing new carious lesions (OR, 0.19; 95% CI, 0.07-0.51; $P = .0008$) compared with participants who received fluoride varnishes (eFigure 5, available online at the end of this article). Because the investigators of the 2 studies included only participants with sound occlusal surfaces, we did not perform a subgroup analysis. We assessed the quality of the evidence for this outcome as low, owing to serious issues of inconsistency (χ^2 $P = .03$; $I^2 = 80\%$) and risk of bias (eTable 1, available online at the end of this article).

TABLE 2

Characteristics of the included studies.

STUDY	COUNTRY	DESIGN	PARTICIPANTS	AGE RANGE, Y (MEAN)
Bojanini and Colleagues,[19] 1976	Colombia	Split-mouth	Children with erupted, sound PM†; setting was not clearly defined	6-8
Richardson and Colleagues,[25] 1980	Canada	Split-mouth	Children with erupted, sound or carious PFM‡; setting was an elementary school clinic	7-8
Houpt and Shey,[27] 1983	United States	Split-mouth	Children with erupted, sound PFM; setting was a dental van (mobile unit)	6-10
Mertz-Fairhurst and Colleagues,[23] 1984	United States	Split-mouth	Children with erupted, sound PFM; setting was a dental school clinic	6-8
Erdogan and Alacam,[21] 1987	Turkey	Split-mouth	Children with erupted, sound PFM; setting was not described	8-10
Arrow and Riordan,[30] 1995	Australia	Split-mouth	Children with sound PFM; setting was a school clinic	7 (0.72)
Bravo and Colleagues,[20] 1996	Spain	Parallel	Children with erupted, sound PM; setting was a school clinic	6-8
Splieth and Colleagues,[1] 2001	Germany	Split-mouth	Children with erupted, sound or carious PFM; setting was a private practice office	5-8
Pereira and Colleagues,[24] 2003	Brazil	Parallel	Children with erupted, sound PFM; setting was a dental school clinic	6-8
Gungor and Colleagues,[37] 2004	Turkey	Split-mouth	Children with erupted PFM; setting was a dental school clinic	7-10
Pardi and Colleagues,[38] 2005	Brazil	Parallel	Children with erupted PFM; setting was a school clinic	7-8
Ganesh and Tandon,[40] 2006	India	Split-mouth	Children with erupted, sound primary molars (Group 1) and erupted, sound permanent molars (Group 2)	Group 1: 3-5 Group 2: 6-7
Amin,[28] 2008	Egypt	Parallel	Children with sound PFM; setting was a dental school clinic	7-10
Barja-Fidalgo and Colleagues,[31] 2009	Brazil	Parallel	Children with erupted PFM; setting was a university dental clinic	6-8
Baseggio and Colleagues,[32] 2010	Brazil	Split-mouth	Adolescents with erupted second PM; setting was a public health service center	12-16
Tagliaferro and Colleagues,[26] 2011	Brazil	Parallel	Children with erupted, sound PFM; setting was a private practice	6-8
Antonson and Colleagues,[29] 2012	United States	Split-mouth	Children with partially erupted PFM; setting not clearly defined, seems to be a university dental clinic	5-9
Chen and Colleagues,[33,41] 2012 (2 reports)	China	Parallel	Children with erupted, carious PFM; setting was at 5 public schools	7-9.1
Dhar and Chen,[35] 2012	India	Split-mouth	Children with erupted PFM; setting was a school clinic	6-10
Liu and Colleagues,[22] 2012	China	Parallel	Children with erupted, sound or carious PFM; setting was a school clinic	Mean = 9.1
Chen and Liu,[34] 2013	China	Split-mouth	Children with erupted, sound PFM; setting was a pediatric department of a university hospital	6.1-8.9
Guler and Yilmaz,[36] 2013	Turkey	Split-mouth	Children with erupted PFM; setting was a dental school clinic	7-13
Haznedaroglu and Colleagues,[39] 2016	Turkey	Parallel	Children with fully erupted, sound PFMs; setting was a university pediatric clinic	7-10

* Information provided corresponds with the first follow-up period of the study.
† PM: Permanent molar.
‡ PFM: Permanent first molar.
§ GI: Glass ionomer.
¶ ppm: Parts per million.

TABLE 2 (CONTINUED)

FLUORIDE EXPOSURE	INTERVENTION	COMPARISON	SEALANT (N)*	COMPARISON (N)*
Community water fluoridation	Resin-based sealant (Delton, Dentsply)	No sealant	42	42
Nonfluoridated community	Self-curing bisphenol A-glycidyl methacrylate sealant (3M)	No sealant	337	337
Community water fluoridation	Sealant (Delton, Dentsply)	Fluoride varnish (no further description)	250	250
Community water fluoridation	Resin-based sealant (Delton, Dentsply)	No sealant	201	201
None	Resin-based sealant (Delton, Dentsply)	No sealant	96	96
None	GI[§] sealant (Ketac-fil, 3M)	Resin-based sealant (Delton, Dentsply)	412	412
Community water fluoridation at 0.07 ppm[¶] of fluoride	Resin-based sealant (Delton, Dentsply)	No sealant; fluoride varnish (Duraphat, Colgate-Palmolive)	238	272
Community water fluoridation at 0.1 ppm. Fluoride tablets used for first year of their life only (48%), and some children took tablets during study (5%). Duraphat fluoride varnish was applied in both groups.	Resin-based sealant	No sealant	176	176
Community water fluoridation	Sealant GI sealant (Ketac bond, 3M)	No sealant; resin-modified GI sealant (Vitremer, 3M)	342	240
Nonfluoridated water; encouraged use of fluoridated toothpaste	Poly-acid modified resin (Dyract Seal, Dentsply)	Resin-based sealant (Delton FS+, Dentsply)	70	70
Community water fluoridation	Resin-modified GI sealant (Vitremer, 3M)	Resin-based sealant (Revolution, Kerr); poly-acid modified resin sealant (Dyract Flow, Dentsply)	97	182
None	GI sealant (Fuji VII, GC)	Resin-based sealant (Concise, 3M)	100	100
Fluoridated toothpaste	Resin-modified GI sealant (Fuji II LC, GC)	Resin-based sealant (Tetric Flow and Helioseal F, Ivoclor Vivadent)	24	54
Fluoridated toothpaste	GI sealant (Fuji IX, GC)	Resin-based sealant (Delton, Dentsply)	21	28
None	Resin-modified GI sealant (Vitremer, 3M)	Resin-based sealant (Fluoroshield, Dentsply)	628	628
Community water fluoridation at 0.7 ppm, and 93% of participants reported using fluoridated toothpaste	Resin-modified GI sealant (Vitremer, 3M)	No sealant	91	86
None	GI sealant (Fuji Triage, GC)	Resin-based sealant (Delton FS+, Dentsply)	27	27
None	GI sealant (Ketac Molar Easymix, 3M)	Resin-based sealant (Clinpro, 3M)	1,282	452
None	GI sealant (Fuji VII, GC)	Resin-based sealant (Clinpro, 3M)	50	50
No community water fluoridation, but 90% of toothpastes sold in area contain fluoride	Resin-based sealant (Clinpro, 3M)	No sealant; fluoride varnish (5% sodium fluoride Duraphat, Colgate-Palmolive)	367	379
Use of 600 ppm fluoridated toothpaste. 6,000 ppm foam applied at every recall visit	GI sealant (Fuji VII, GC)	Resin-based sealant (Concise, 3M)	75	75
Fluoride varnish applied after sealant placement	GI sealant (Fuji VII, GC)	Resin-based sealant (Admira Seal, Voco)	68	66
"Low fluoride" in drinking water	GI sealant (Fuji Triage, GC)	Resin-based sealant (Ultraseal XT, Ultradent)	64	68

The results of 1 study[20] (242 participants) informed the comparison and outcome for the 7 or more years of follow-up category. In relative terms, participants who received sealants had a 71% reduction in the risk of developing new carious lesions (OR, 0.29; 95% CI, 0.17-0.49; $P < .00001$) compared with participants who received fluoride varnishes (eFigure 6, available online at the end of this article). Because the results of only 1 study informed this outcome, we did not perform a subgroup analysis. We assessed the quality of the evidence for this outcome as low, owing to very serious issues related to risk of bias (eTable 1, available online at the end of this article).

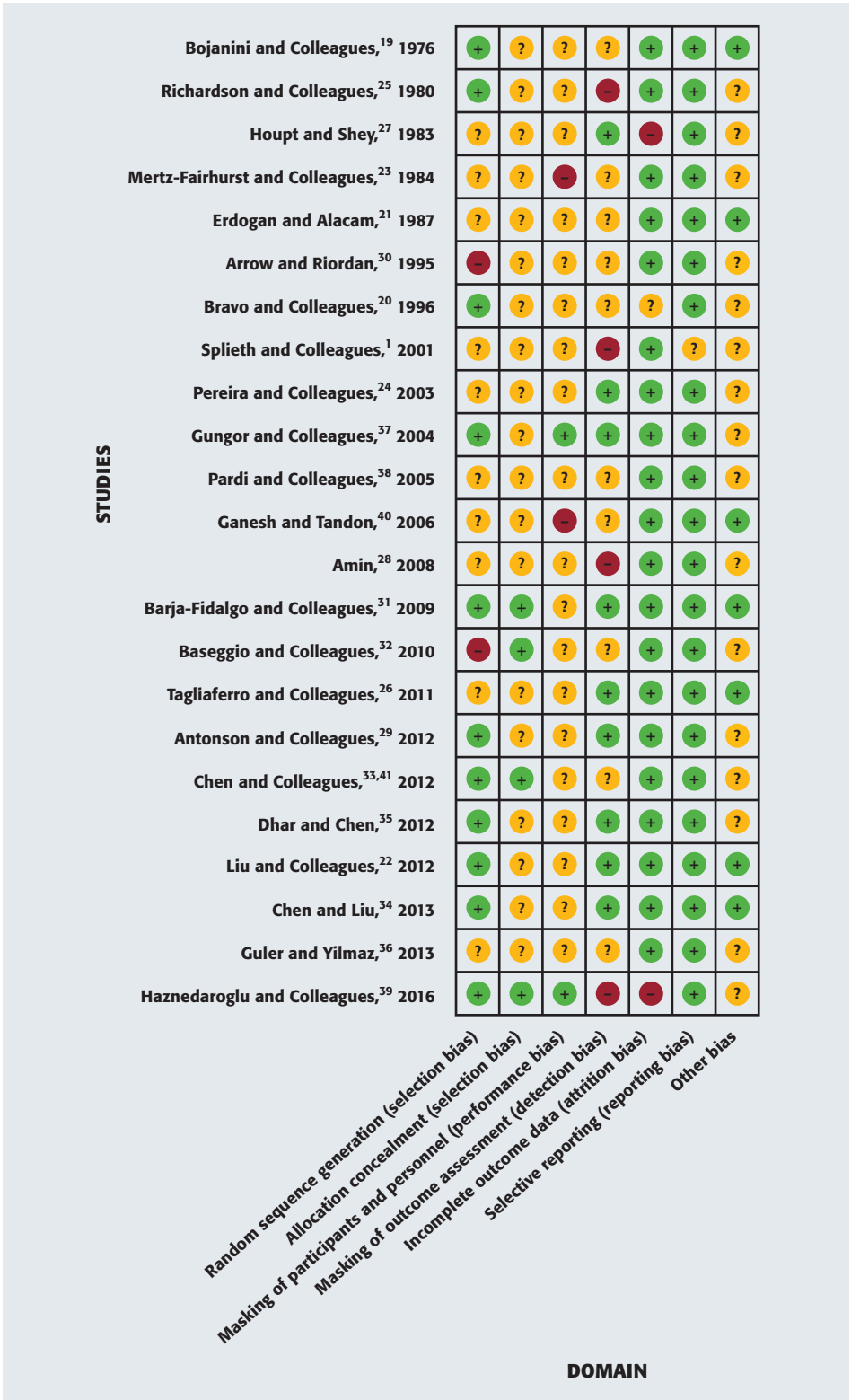

Figure 2. Risk of bias summary: review authors' judgments about each risk of bias item for each included study. +: Low risk of bias. −: High risk of bias. ?: Unclear risk of bias.

Lack of retention. The nature of the comparison did not allow us to obtain information to compare the use versus the nonuse of sealants.

Comparison 3. Glass ionomer sealants versus resin-based sealants. *Caries incidence.* The results of 10 studies[28-30,32-36,38,39] (4,741 participants) informed the comparison and outcome for the 2- to 3-year follow-up category. In relative terms, participants who received GI sealants had a 29% reduction in the risk of developing new carious lesions compared with participants who received resin-based sealants (OR, 0.71; 95% CI, 0.32-1.57); however, this difference was not statistically significant ($P = .39$) (eFigure 7, available online at the end of this article). Owing to limitations in 1 study's[40] data presentation, we did not include that study (200 participants) in the meta-analysis. For that study,[40] the investigators failed to find a clinically or statistically significant difference in caries incidence when they applied GI sealants and resin-based sealants in the occlusal surfaces of primary and permanent molars. In a subgroup analysis conducted to determine whether the treatment effect differed among studies with patients having non-cavitated occlusal carious lesions, sound occlusal surfaces, and a population with mixed clinical

features, we did not find statistically significant results (interaction test $P = .19$). We assessed the quality of the evidence for this outcome as very low, owing to serious issues related to risk of bias, inconsistency (χ^2 $P >$ .00001; $I^2 = 81\%$), and imprecision (Table 4).

The results of 2 studies[31,39] (145 participants) informed the comparison and outcome for the 4- to 7-year follow-up category. In relative terms, participants who received GI sealants had a 63% reduction in the risk of developing new carious lesions compared with participants who received resin-based sealants (OR, 0.37; 95% CI, 0.14-1.00; $P = .05$) (eFigure 8, available online at the end of this article). Because we found only 2 studies to inform this outcome, we did not perform a subgroup analysis. We assessed the quality of the evidence for this outcome as very low, owing to serious issues related to risk of bias and very serious issues related to imprecision (Table 4).

We did not find any studies whose investigators had reported data on the incidence of caries for 7 or more years of follow-up for this comparison.

Lack of retention. The results of 10 studies[28-30,32-36,38,39] (4,741 participants) informed the comparison and outcome for the 2- to 3-year follow-up category. In relative terms, participants who received GI sealants had 5 times greater chance (406% increased chance) of experiencing sealant retention loss compared with participants who received resin-based sealants (OR, 5.06; 95% CI, 1.81-14.13; $P = .002$) (eFigure 9, available online at the end of this article). In a subgroup analysis conducted to determine whether the treatment effect differed among studies with patients who had noncavitated occlusal carious lesions, sound occlusal surfaces, and a population with mixed clinical features, we did not find statistically significant results (interaction test $P = .29$). We assessed the quality of the evidence for this outcome as low, owing to serious issues related to risk of bias and inconsistency (χ^2 $P < .00001$; $I^2 = 96\%$) (Table 4).

The results of 2 studies[31,39] (145 participants) informed the comparison and outcome for the 4- to 7-year follow-up category. In relative terms, participants who received GI sealants had a 108% increase in the risk of experiencing a retention loss compared with the participants who received resin-based sealants (OR, 2.08; 95% CI, 0.15-27.95); however, this difference was not statistically significant ($P = .58$) (eFigure 10, available online at the end of this article). Because only 2 studies informed this outcome, we did not perform a subgroup analysis. We assessed the quality of the evidence for this outcome as low, owing to serious issues related to risk of bias and imprecision (Table 4).

We did not find any studies whose investigators had reported data on the incidence of lack of sealant retention for 7 or more years of follow-up.

Comparison 4. Glass ionomer sealants versus resin-modified glass ionomer sealants. *Caries incidence.* The results of 1 study[24] (344 participants) informed the comparison and outcome for the 2- to 3-year follow-up category. In relative terms, participants who received GI sealants had a 41% increased risk of developing new carious lesions compared with participants who received resin-modified GI sealants (OR, 1.41; 95% CI, 0.65-3.07) (eFigure 11, available online at the end of this article); however, this difference was not statistically significant ($P = .38$). Because only 1 study informed this outcome, we did not perform a subgroup analysis. We assessed the quality of the evidence for this outcome as very low, owing to serious issues related to risk of bias and very serious issues related to imprecision (eTable 2, available online at the end of this article).

We did not find any studies whose investigators had reported data on caries incidence for the 4- to 7-year follow-up category and the more than 7 years of follow-up category.

Lack of retention. The results of 1 study[24] (344 participants) informed this comparison and outcome for the 2- to 3-year follow-up category. In relative terms, participants who received GI sealants had 3 times greater chance (221% increased chance) to experience sealant retention loss compared with the participants who received resin-modified GI sealants (OR, 3.21; 95% CI, 1.87-5.51; $P < .0001$) (eFigure 12, available online at the end of this article). Because only 1 study informed this outcome, we did not perform a subgroup analysis. We assessed the quality of the evidence as moderate, owing to serious issues related to risk of bias (eTable 2, available online at the end of this article).

We did not find any studies whose investigators had reported data on caries incidence for the 4- to 7-year follow-up category and the more than 7 years of follow-up category for this comparison and outcome.

Comparison 5. Resin-modified glass ionomer sealants versus polyacid-modified resin sealants. *Caries incidence.* The results of 1 study[38] (186 participants) informed the comparison and outcome for the 2- to 3-year follow-up category. In relative terms, participants who received resin-modified GI sealants had a 56% reduction in the risk of developing new carious lesions compared with participants who received polyacid-modified resin sealants (OR, 0.44; 95% CI, 0.11-1.82); however, this difference was not statistically significant ($P = .26$) (eFigure 13, available online at the end of this article). Because only 1 study informed this outcome, we did not perform a subgroup analysis. We assessed the quality of the evidence for this outcome as very low, owing to serious issues related to risk of bias and very serious issues related to imprecision (eTable 3, available online at the end of this article).

We did not find any studies whose investigators had reported data on caries incidence for the 4- to 7-year follow-up category and the more than 7 years of follow-up category for this comparison and outcome.

Lack of retention. The results of 1 study[38] that included 186 participants informed the comparison and outcome for the 2- to 3-year follow-up category.[38] In relative terms, participants who received resin-modified

TABLE 3

Evidence profile: sealants compared with nonuse of sealants in pit-and-fissure occlusal surfaces in children and adolescents.*

QUALITY ASSESSMENT						
No. of Studies	**Study Design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considerations**
Caries incidence (follow-up: range 2-3 y)‡						
9	Randomized trials	Serious§	Not serious	Not serious	Not serious	None
Caries incidence (follow-up: range 4-7 y)#						
3	Randomized trials	Serious§	Serious**	Not serious	Not serious	None
Caries incidence (follow-up: range 7 y or more)#						
2	Randomized trials	Serious§	Not serious	Not serious	Not serious	None
Lack of retention (follow-up: range 2-3 y)						
9	Randomized trials	Serious§	Not serious	Not serious	Not serious	None

* Sources: Splieth and colleagues,[1] Bojanini and colleagues,[19] Bravo and colleagues,[20] Erdogan and colleagues,[21] Liu and colleagues,[22] Mertz-Fairhurst and colleagues,[23] Pereira and colleagues,[24] Richardson and colleagues,[25] Tagliaferro and colleagues.[26]
† The percentages (30% and 70%) indicate the control group baseline risk (caries prevalence).
‡ A subgroup analysis conducted to determine whether there was a difference in the caries incidence depending on whether the sealant was placed in patients with noncavitated carious lesions or deep fissures and pits, no caries in the occlusal surface, and a mix of caries free and noncavitated carious lesions, showed no statistically significant differences ($P = .58$). Studies including a mixed population (recruiting both patients with noncavitated initial occlusal caries and caries-free occlusal surfaces) showed a 76% reduction in caries incidence after 2- to 3-y follow-up (odds ratio, 0.24; 95% confidence interval, 0.19-0.30).
§ Most studies were classified as unclear for the "allocation concealment" and "masking" domains.
¶ 4 of 9 studies reported being conducted in water-fluoridated communities.
# Studies only reported data for this outcome in patients who were caries-free. Patients with noncavitated carious lesions or deep pits and fissures were not included in the studies.
** Unexplained heterogeneity ($P < .0001$, $I^2 = 77\%$).
†† 2 of 3 studies reported being conducted in water-fluoridated communities.
‡‡ 2 of 2 studies reported being conducted in water-fluoridated communities.

GI sealants had a 17% increased risk of experiencing sealant retention loss compared with the participants who received polyacid-modified resin sealants (OR, 1.17; 95% CI, 0.52-2.66); however, this difference was not statistically significant ($P = .70$) (eFigure 14, available online at the end of this article). Because only 1 study informed this outcome, we did not perform subgroup analysis. We assessed the quality of the evidence as very low, owing to serious issues related to risk of bias and very serious issues related to imprecision (eTable 3, available online at the end of this article).

We did not find any studies whose investigators had reported data for this comparison with regard to the outcome of lack of sealant retention for the 4- to 7-year follow-up category and the more than 7 years of follow-up category.

Comparison 6. Polyacid-modified resin sealants versus resin-based sealants. *Caries incidence.* The results of 2 studies[37,38] (322 participants) informed the comparison and outcome for the 2- to 3-year follow-up category. In relative terms, participants who received polyacid-modified resin sealants had a 1% increased risk of developing new carious lesions compared with participants who received resin-based sealants (OR, 1.01; 95% CI, 0.48-2.14); however, this difference was not statistically significant ($P = .97$) (eFigure 15, available online at the end of this article). We were unable to find evidence of heterogeneity (χ^2 $P = .39$; $I^2 = 0\%$). Because the investigators of the 2 studies included only participants with sound occlusal surfaces, we did not perform a subgroup analysis. We assessed the quality of the evidence for this outcome as very low, owing to serious issues related to risk of bias and very serious issues related to imprecision (eTable 4, available online at the end of this article).

We did not find any studies whose investigators had reported data on caries incidence for the 4- to 7-year follow-up category and the more than 7 years of follow-up category for this comparison and outcome.

Lack of retention. The results of 2 studies[37,38] (322 participants) informed the comparison and outcome for

TABLE 3 (CONTINUED)

PATIENTS (N)		EFFECT		QUALITY	IMPORTANCE
Sealants	Nonuse of Sealants[†]	Relative Odds Ratio (95% Confidence Interval)	Absolute (95% Confidence Interval)		
194/1,799 (10.8%)	584/1,743 (33.5%)[¶]	0.24 (0.19-0.30)	248 fewer per 1,000 (221-271 fewer)	Moderate	Critical
	30.0%		207 fewer per 1,000 (186-225 fewer)		
	70.0%		341 fewer per 1,000 (288-393 fewer)		
74/368 (20.1%)	206/384 (53.6%)[††]	0.21 (0.10-0.44)	341 fewer per 1,000 (199-433 fewer)	Low	Critical
	30.0%		217 fewer per 1,000 (141-259 fewer)		
	70.0%		371 fewer per 1,000 (193-511 fewer)		
62/215 (28.8%)	170/231 (73.6%)[‡‡]	0.15 (0.08-0.27)	441 fewer per 1,000 (307-554 fewer)	Moderate	Critical
	30.0%		240 fewer per 1,000 (196-267 fewer)		
	70.0%		441 fewer per 1,000 (313-543 fewer)		
Including all sealant material types and tooth preparation techniques, 55.6% of sealants were fully retained at 2 y, and 59.3% were fully or partially retained at 2 y; at 3 y, 56.4% of all sealants were fully retained, and 58.8% were fully or partially retained after 3.6 y				Moderate	Important

the 2- to 3-year follow-up category. In relative terms, participants who received polyacid-modified resin sealants had a 23% reduction in the risk of experiencing sealant retention loss compared with participants who received resin-based sealants (OR, 0.87; 95% CI, 0.12-6.21); however, this difference was not statistically significant ($P = .89$) (eFigure 16, available online at the end of this article). Because the investigators of the 2 studies included only participants with sound occlusal surfaces, we did not perform a subgroup analysis. We assessed the quality of the evidence for this outcome as very low, owing to serious issues related to risk of bias, inconsistency (χ^2 $P = .02$; $I^2 = 81\%$), and imprecision (eTable 4, available online at the end of this article).

We did not find any studies whose investigators had reported data for this comparison with regard to the outcome of lack of sealant retention for the 4- to 7-year follow-up category and the more than 7 years of follow-up category.

Safety of sealants. The investigators of 2 studies[22,42] sought to measure adverse events associated with the use of sealants. The investigators of these RCTs were unable to identify any adverse events among the participants.

DISCUSSION

Summary of the results. The results of this systematic review suggest that children and adolescents who receive sealants in sound occlusal surfaces or noncavitated pit-and-fissure carious lesions in their primary or permanent molars (compared with a control without sealants) experienced a 76% reduction in the risk of developing new carious lesions after 2 years of follow-up. Even after 7 or more years of follow-up, children and adolescents with sealants had a caries incidence of 29%, whereas those without sealants had a caries incidence of 74%. We assessed the quality of the evidence as being moderate, owing to serious issues related to the risk of bias. Furthermore, low-quality evidence (owing to serious issues related to the risk of bias and inconsistency) suggested that sealants applied to the pits and fissures of primary and permanent molars may be more beneficial compared with the application of fluoride varnishes after 7 or more years of follow-up (that is, 290 fewer carious lesions over 1,000; ranging from 176 fewer carious lesions over 1,000, to 381 fewer carious lesions over 1,000). We did not identify any studies whose investigators provided information about the effect of sealants in adults.

The head-to-head analysis of the effect of sealant materials on caries incidence and retention loss did not provide enough evidence for us to reliably offer a description of the relative merits of each sealant material. When making clinical decisions, we suggest that clinicians take into account the likelihood that their patients will experience a lack of retention inherent to the sealant material as well as their ability to isolate and maintain a dry field during placement.

Quality of the evidence. We found moderate-quality evidence for the outcome of caries incidence in the comparison of sealants versus the control without sealants. When we tried to make more specific comparisons, we found that the quality of the evidence decreased to

TABLE 4

Evidence profile: glass ionomer sealants compared with resin-based sealants in pit-and-fissure occlusal surfaces in children and adolescents.*

QUALITY ASSESSMENT						
No. of Studies	**Study Design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considerations**
Caries incidence (follow-up: range 2-3 y)‡,§						
10	Randomized trials	Serious¶	Serious#	Not serious	Serious**	None
Caries incidence (follow-up: range 4-7 y)‡‡						
2	Randomized trials	Serious§§	Not serious	Not serious	Very serious¶¶	None
Caries incidence (follow-up: range 7 y or more)—not reported						
—##	—	—	—	—	—	—
Lack of retention (follow-up: range 2-3 y)						
10	Randomized trials	Serious¶	Serious***	Not serious	Not serious	None
Lack of retention (follow-up: range 4-7 y)						
2	Randomized trials	Serious§§	Not serious	Not serious	Serious†††	None
Lack of retention—not reported						
—	—	—	—	—	—	—

* Sources: Amin,[28] Antonson and colleagues,[29] Arrow and Riordan,[30] Baseggio and colleagues,[32] Chen and colleagues,[33,41] Chen and Liu,[34] Dhar and Chen,[35] Guler and Yilmaz,[36] Pardi and colleagues,[38] and Haznedaroglu and Guner.[39]
† The percentages (30% and 70%) indicate the control group baseline risk (caries prevalence).
‡ A subgroup analysis conducted to determine whether there was a difference in the caries incidence depending on whether the sealant was placed in noncavitated carious lesions or deep fissures and pits, no caries in the occlusal surface, and a mix of caries free and noncavitated carious lesions, showed no statistically significant differences (odds ratio, 1.53; 95% confidence interval, 0.58-4.07; $P = .19$).
§ One additional study including 200 participants that was not included in the meta-analysis due to the data presentation failure to show a clinically or statistically significant difference in caries incidence when glass ionomer sealants and resin-based sealants were placed in the occlusal surfaces of primary and permanent teeth.
¶ Most studies were classified as unclear for the "allocation concealment" and "masking" domains.
# Unexplained heterogeneity ($P < .00001$, $I^2 = 81\%$).
** 95% confidence interval suggests large benefit and a large harm (95% confidence interval, 68% reduction-57% increase).
†† 1 of 10 studies reported being conducted in water-fluoridated communities.
‡‡ Only 2 studies reported this outcome. No subgroup analysis was conducted.
§§ The "randomization" and "allocation concealment" domains were classified as "unclear" risk of bias for most studies.
¶¶ 95% confidence interval suggests a large benefit and a large harm (95% confidence interval, 96% reduction-0% increase).
Dashes indicate data not available.
*** Unexplained heterogeneity ($P \leq .00001$, $I^2 = 97\%$).
††† 95% confidence interval suggests a large benefit and a large harm (95% confidence interval, 85% reduction-2,695% increase).

low or very low for most of the outcomes measured related to the head-to-head sealant comparisons. The main issues we identified among the comparisons related to risk of bias, inconsistency, and imprecision.

Comparison with previous reviews. The authors of 1 Cochrane review published in 2013[7] summarized the effect of sealants compared with a control without sealants and multiple head-to-head comparisons. Although for our study, we differed in the inclusion and exclusion of some of the studies they included, their results also suggested that sealants prevent carious lesions in children and adolescents. Their assessment of the quality of the evidence at different end points also decreased from the shortest to the longest follow-up, in agreement with the results of our evaluation. The authors of another Cochrane review conducted in 2016[43] summarized the evidence on the effect of sealants versus fluoride varnishes in children aged 5 to 10 years. Again, although we differed in the inclusion and exclusion of some studies, their conclusions in relation to the effect of sealants and the assessment of the quality of the evidence coincide with ours.[43] The authors of yet another systematic review published in 2016[44] aimed to determine the effectiveness of high-viscosity GI sealants compared with resin-based sealants. Finally, the authors of a systematic review published in 2016 on the use of adhesive systems under fissure sealants[45] concluded that bonding agents could increase the retention of sealants. These authors did not include dental caries as an outcome, and they further concluded that there was insufficient evidence to make comparisons among different generations of adhesive systems.[45]

TABLE 4 (CONTINUED)

PATIENTS (N)		EFFECT		QUALITY	IMPORTANCE
Glass Ionomer Sealants	Resin-Based Sealants[†]	Relative Odds Ratio (95% Confidence Interval)	Absolute (95% Confidence Interval)		
179/2,727 (6.6%)	141/2,014 (7.0%)[††]	0.71 (0.32-1.57)	19 fewer per 1,000 (36 more-46 fewer)	Very low	Critical
	30.0%		67 fewer per 1,000 (102 more-179 fewer)		
	70.0%		76 fewer per 1,000 (86 more-273 fewer)		
6/61 (9.8%)	19/84 (22.6%)	0.37 (0.14-1.00)	154 fewer per 1,000 (0-228 fewer)	Very low	Critical
	30.0%		163 fewer per 1,000 (0-243 fewer)		
	70.0%		237 fewer per 1,000 (0-454 fewer)		
–	–	–	–	–	Critical
1,875/2,727 (68.8%)	596/2,014 (29.6%)	5.06 (1.81-14.13)	384 more per 1,000 (136-560 more)	Low	Important
46/61 (75.4%)	50/84 (59.5%)	2.08 (0.15-27.95)	158 more per 1,000 (381 more-415 fewer)	Low	Important
–	–	–	–	–	Important

Strength and limitations of this review. The strength of this systematic review lies in the rigor of its methodology, which follows the recommendations in the *Cochrane Handbook for Systematic Reviews of Intervention*.[46] For example, we conducted screening and data extraction in duplicate, pooled the results of split-mouth and parallel design trials, adjusting for the dependence of the observations, and we assessed the quality of the evidence using the GRADE approach.[17] Limitations included our inability to contact primary authors of the studies to clarify issues related to risk of bias or specific study features owing to the fact that most of the included trials were published more than 20 years ago, and the inability to assess publication bias by means of using a funnel plot owing to the limited number of included studies per outcome.

CONCLUSIONS

In summary, we found moderate-quality evidence to suggest that the use of sealants when compared with control groups that did not have sealants reduces the incidence of carious lesions in the occlusal surfaces of permanent molars by approximately 80% in children and adolescents. When comparing this finding with the results associated with fluoride varnishes, we found that sealants still were associated with a reduction in the incidence of carious lesions in the occlusal surfaces of permanent molars of approximately 70%, which, in this case, was supported by low-quality evidence. Also, we found that none of the investigators of the studies reported adverse outcomes. Finally, although in our analysis we failed to find a hierarchy of effectiveness, which prevented us from making strong statements about the relative merits of each sealant material, we did find that sealants compared with no sealants or fluoride varnishes prove superior in preventing carious lesions and arresting the progression of noncavitated carious lesions. ■

SUPPLEMENTAL DATA

Supplemental data related to this article can be found at http://dx.doi.org/10.1016/j.adaj.2016.06.003.

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Appendix.
SEARCH STRATEGIES AND ELECTRONIC DATABASES CONSULTED.

SEARCHES CONDUCTED IN NOVEMBER 2013.

MEDLINE (via PubMed). (("Pit and Fissure Sealants"[Mesh]) OR ((tetric[tiab] OR vitremer[tiab] OR fluoroshield[tiab] OR delton[tiab] OR kerr[tiab] OR lispro[tiab] OR dyract[tiab] OR revolution[tiab] OR oralis[tiab] OR ketac[tiab] OR concise[tiab]) AND sealant*) OR (composite* AND sealant*[tiab]) OR (fissure* AND sealant*) OR (fissure*[tiab] AND sealant*[tiab]) OR (composite* AND sealant*) OR (dent* AND sealant*) OR (sealant* AND resin*) OR (Compomer* AND sealant*) OR (("glass ionomer$" OR "Resins, Synthetic"[Mesh] OR "Resins, Synthetic"[Pharmacological Action] OR "Bisphenol A-Glycidyl Methacrylate"[Mesh] OR glassionomer* OR "Glass Ionomer Cements"[Mesh]) AND sealant*)) AND (randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized[tiab] OR placebo[tiab] OR clinical trials as topic[mesh:noexp] OR randomly[tiab] OR trial[ti] NOT (animals[mh] NOT humans[mh]))

Embase. The following search strategy was linked to the Cochrane Highly Sensitive Search Strategy for identifying randomized trials:

1. 'pit and fissure sealants'/exp
2. fissure* NEAR/6 seal*
3. dental NEAR/6 seal*
4. resin* NEAR/6 seal*
5. compomer* NEAR/6 seal*
6. composite* NEAR/6 seal*
7. exp Glass Ionomer Cements/
8. exp Resins, Synthetic/
9. glass NEXT/1 ionomer* or glassionomer* 10. 7 or 8 or 9 11. seal* 12. 10 and 11 13. 1 or 2 or 3 or 4 or 5 or 6 or 12 14. . (tetric OR vitremer OR fluoroshield OR delton OR kerr OR lispro OR dyract OR revolution OR oralis OR ketac OR concise) .tw.

Cochrane Central Register of Controlled Trials (CENTRAL).

1. fissure*
2. MeSH descriptor: [Composite Resins] explode all trees
3. MeSH descriptor: [Pit and Fissure Sealants] explode all trees
4. MeSH descriptor: [Glass Ionomer Cements] explode all trees
5. dental
6. resin*
7. compomer*
8. sealant*
9. composite*
10. "glass ionomer*"
11. glassionomer*
12. (#2 or #4 or #5 or #6 or #7 or #9 or #10 or #11 or #1) and #8
13. #3 or #12

ClinicalTrials.gov. Dental and sealant

LILACS.

- (selantes OR sellantes OR sealants) OR (pit and fissure sealants) AND ((Pt RANDOMIZED CONTROLLED TRIAL OR Pt CONTROLLED CLINICAL TRIAL OR Mh RANDOMIZED CONTROLLED TRIALS OR Mh RANDOM ALLOCATION OR Mh DOUBLE-BLIND METHOD OR Mh SINGLE-BLINDMETHOD OR Pt MULTICENTER STUDY) OR ((tw ensaio or tw ensayo or tw trial) and (tw azar or tw acaso or tw placebo or tw control$ or tw aleat$ or tw random$ or (tw duplo and tw cego) or (tw doble and tw ciego) or (tw double and tw blind)) and tw clinic$)) AND NOT ((CT ANIMALS OR MH ANIMALS OR CT RABBITS OR CT MICE OR MH RATS OR MH PRIMATES OR MH DOGS OR MH RABBITS OR MH SWINE) AND NOT (CT HUMAN AND CT ANIMALS))
- tetric OR vitremer OR fluoroshield OR delton OR kerr OR lispro OR dyract OR revolution OR oralis OR ketac OR concise [Words] and ((Pt RANDOMIZED CONTROLLED TRIAL OR Pt CONTROLLED CLINICAL TRIAL OR Mh RANDOMIZED CONTROLLED TRIALS OR Mh RANDOM ALLOCATION OR Mh DOUBLE-BLIND METHOD OR Mh SINGLE-BLINDMETHOD OR Pt MULTICENTER STUDY) OR ((tw ensaio or tw ensayo or tw trial) and (tw azar or tw acaso or tw placebo ortw control$ or tw aleat$ or tw random$ or (tw duplo and tw cego) or (tw doble and tw ciego) or (tw double and tw blind)) and tw clinic$)) AND NOT ((CT ANIMALS OR MH ANIMALS OR CT RABBITS OR CT MICE OR MH RATS OR MH PRIMATES OR MH DOGS OR MH RABBITS OR MH SWINE) AND NOT (CT HUMAN AND CT ANIMALS))
- Composta OR composite [Words] AND selante OR sellante [Words] and ((Pt RANDOMIZED CONTROLLED TRIAL OR Pt CONTROLLED CLINICAL TRIAL OR Mh RANDOMIZED CONTROLLED TRIALS OR Mh RANDOM ALLOCATION OR Mh DOUBLE-BLIND METHOD OR Mh SINGLE-BLINDMETHOD OR Pt MULTICENTER STUDY) OR ((tw ensaio or tw ensayo or tw trial) and (tw azar or tw acaso or tw placebo ortw control$ or tw aleat$ or tw random$ or (tw duplo and tw cego) or (tw doble and tw ciego) or (tw double and tw blind)) and tw clinic$)) AND NOT ((CT ANIMALS OR MH ANIMALS OR CT RABBITS OR CT MICE OR MH RATS OR MH PRIMATES OR MH DOGS OR MH RABBITS OR MH SWINE) AND NOT (CT HUMAN AND CT ANIMALS)) [Words]
- resin OR resina [Words] and selante OR sellante [Words] and ((Pt RANDOMIZED CONTROLLED TRIAL OR Pt CONTROLLED CLINICAL TRIAL OR Mh RANDOMIZED CONTROLLED TRIALS OR Mh RANDOM ALLOCATION OR Mh DOUBLE-BLIND METHOD OR Mh SINGLE-BLINDMETHOD OR Pt MULTICENTER STUDY) OR ((tw ensaio or tw ensayo

or tw trial) and (tw azar or tw acaso or tw placebo ortw control$ or tw aleat$ or tw random$ or (tw duplo and tw cego) or (tw doble and tw ciego) or (tw double and tw blind)) and tw clinic$)) AND NOT ((CT ANIMALS OR MH ANIMALS OR CT RABBITS OR CT MICE OR MH RATS OR MH PRIMATESOR MH DOGS OR MH RABBITS OR MH SWINE) AND NOT (CT HUMAN AND CT ANIMALS)) [Words] [Words]

- ionômero [Words] and selante OR sellante [Words] and ((Pt RANDOMIZED CONTROLLED TRIAL OR Pt CONTROLLED CLINICAL TRIAL OR Mh RANDOMIZED CON-TROLLED TRIALS OR Mh RANDOM ALLOCATION OR Mh DOUBLE-BLIND METHOD OR Mh SINGLE-BLINDMETHOD OR Pt MULTICENTER STUDY) OR ((tw ensaio or tw ensayo or tw trial) and (tw azar or tw acaso or tw placebo ortw control$ or tw aleat$ or tw random$ or (tw duplo and tw cego) or (tw doble and tw ciego) or (tw double and tw blind)) and tw clinic$)) AND NOT ((CT ANIMALS OR MH ANIMALS OR CT RABBITS OR CT MICE OR MH RATS OR MH PRIMATESOR MH DOGS OR MH RABBITS OR MH SWINE) AND NOT (CT HUMAN AND CT ANIMALS)) [Words]
- Bisphenol A-Glycidyl Methacrylate [Words] and selante OR sellante [Words] and ((Pt RANDOMIZED CONTROLLED TRIAL OR Pt CONTROLLED CLINICAL TRIAL OR Mh RANDOMIZED CONTROLLED TRIALS OR Mh RANDOM ALLOCATION OR Mh DOUBLE-BLIND METHOD OR Mh SINGLE-BLINDMETHOD OR Pt MULTICENTER STUDY) OR ((tw ensaio or tw ensayo or tw trial) and (tw azar or tw acaso or tw placebo ortw control$ or tw aleat$ or tw random$ or (tw duplo and tw cego) or (tw doble and tw ciego) or (tw double and tw blind)) and tw clinic$)) AND NOT ((CT ANIMALS OR MH ANIMALS OR CT RABBITS OR CT MICE OR MH RATS OR MH PRIMATES OR MH DOGS OR MH RABBITS OR MH SWINE) AND NOT (CT HUMAN AND CT ANIMALS)) [Words]

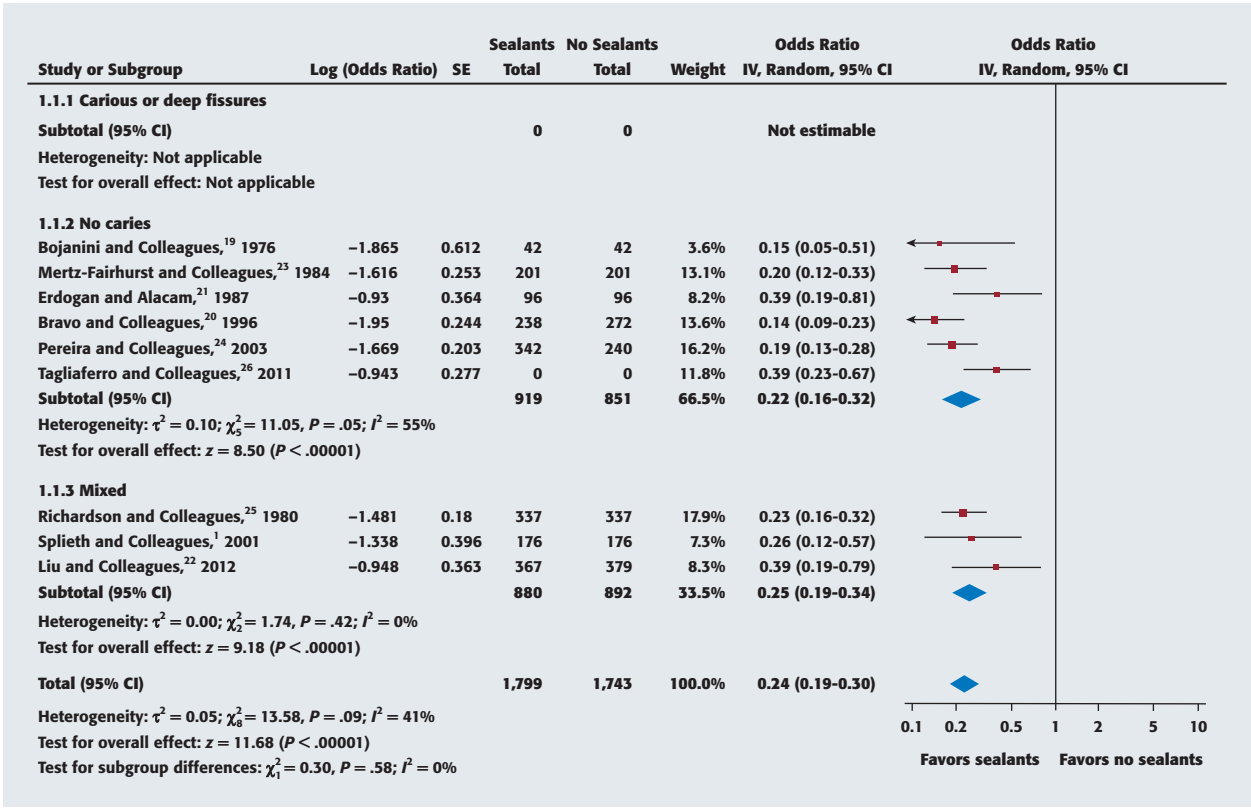
SEARCHES CONDUCTED IN FEBRUARY 2014 AND MAY 2016

PubMed. (("Pit and Fissure Sealants"[Mesh]) OR ((tetric[tiab] OR vitremer[tiab] OR fluoroshield[tiab] OR delton[tiab] OR kerr[tiab] OR lispro[tiab] OR dyract [tiab] OR revolution[tiab] OR oralis[tiab] OR ketac[tiab] OR concise[tiab]) AND sealant*) OR (composite* AND sealant*[tiab]) OR (fissure* AND sealant*) OR (fissure* [tiab] AND sealant*[tiab]) OR (composite* AND sealant*) OR (dent* AND sealant*) OR (sealant* AND resin*) OR (Compomer* AND sealant*) OR (("glass ionomer$" OR "Resins, Synthetic"[Mesh] OR "Resins, Synthetic"[Pharmacological Action] OR "Bisphenol A-Glycidyl Methacrylate"[Mesh] OR glassionomer* OR "Glass Ionomer Cements"[Mesh]) AND sealant*)) AND (randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized[tiab] OR placebo[tiab] OR clinical trials as topic[mesh:noexp] OR randomly[tiab] OR trial[ti] NOT (animals[mh] NOT humans[mh]))

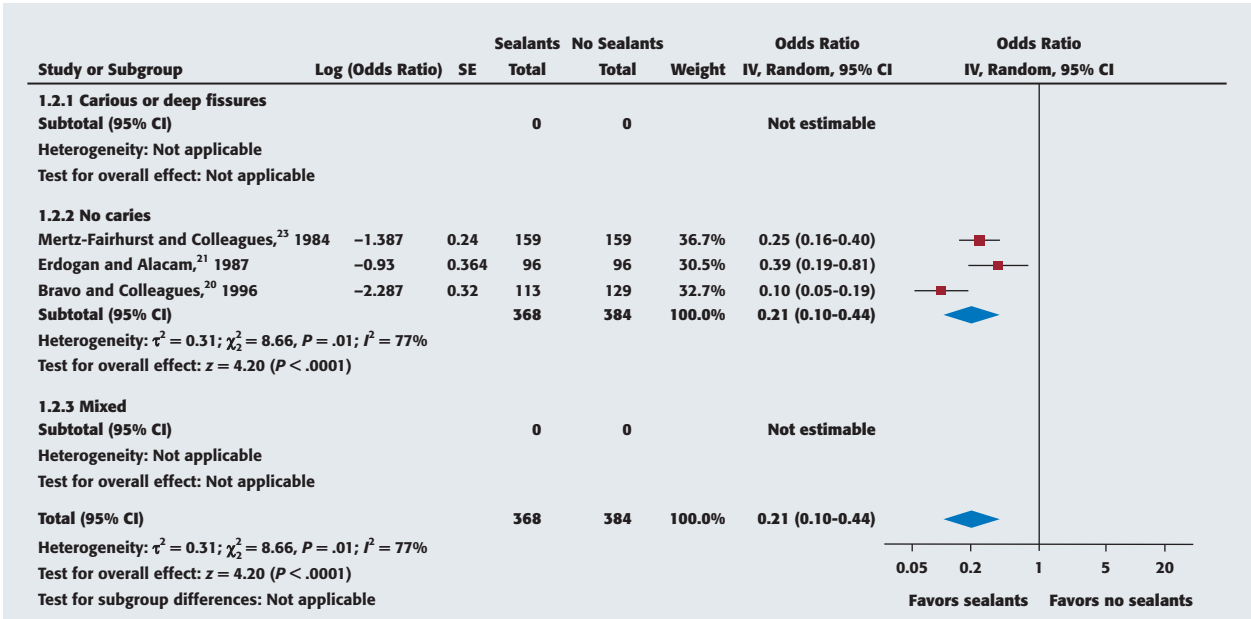
Cochrane Central Register of Controlled Trials (CENTRAL).

1. fissure*
2. MeSH descriptor: [Composite Resins] explode all trees
3. MeSH descriptor: [Pit and Fissure Sealants] explode all trees
4. MeSH descriptor: [Glass Ionomer Cements] explode all trees
5. dental
6. resin*
7. compomer*
8. sealant*
9. composite*
10. "glass ionomer*"
11. glassionomer*
12. (#2 or #4 or #5 or #6 or #7 or #9 or #10 or #11 or #1) and #8
13. #3 or #12

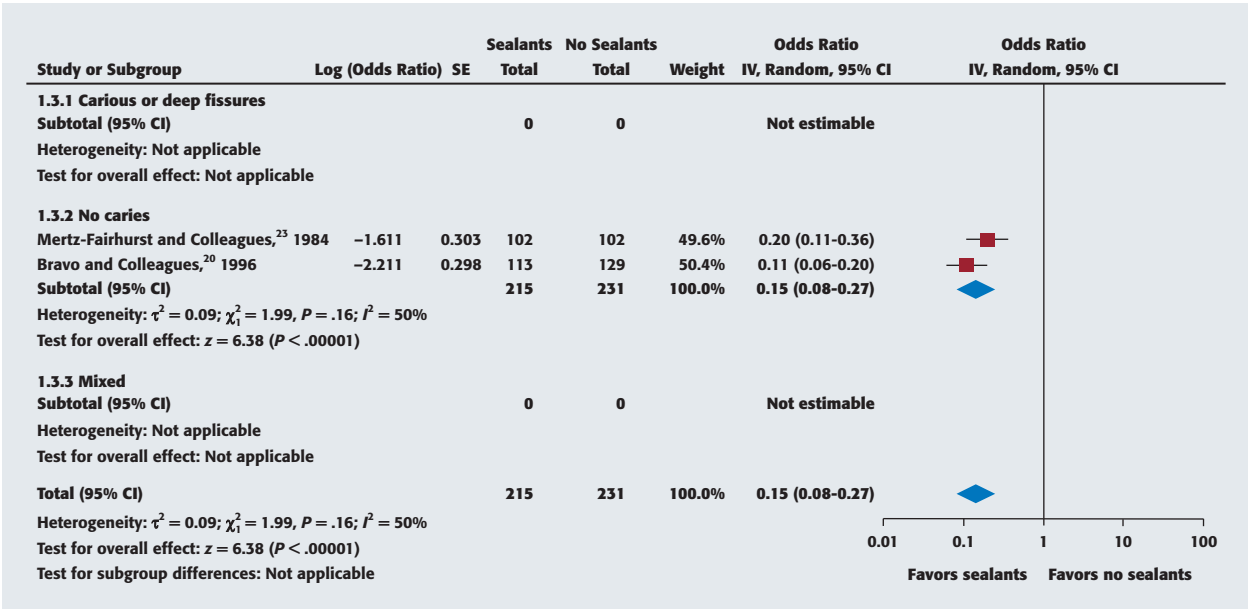
ClinicalTrials.gov. dental AND sealant



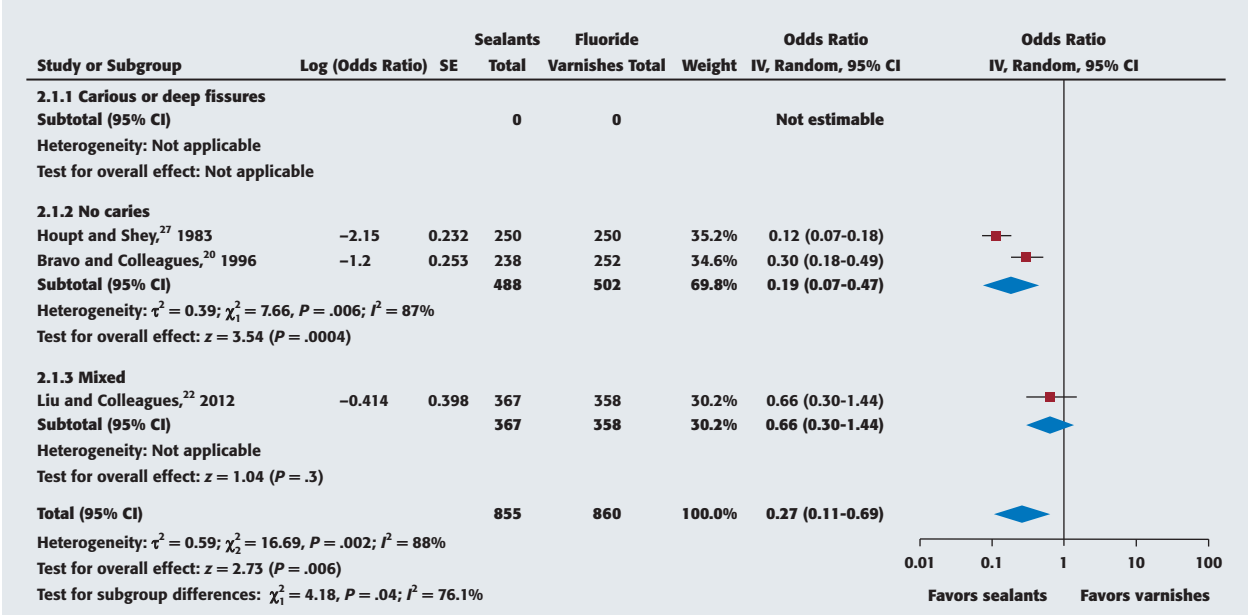
eFigure 1. Forest plot of comparison. 1. Sealants versus nonuse of sealants, outcome: 1.1 Caries incidence (2-3 years). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.



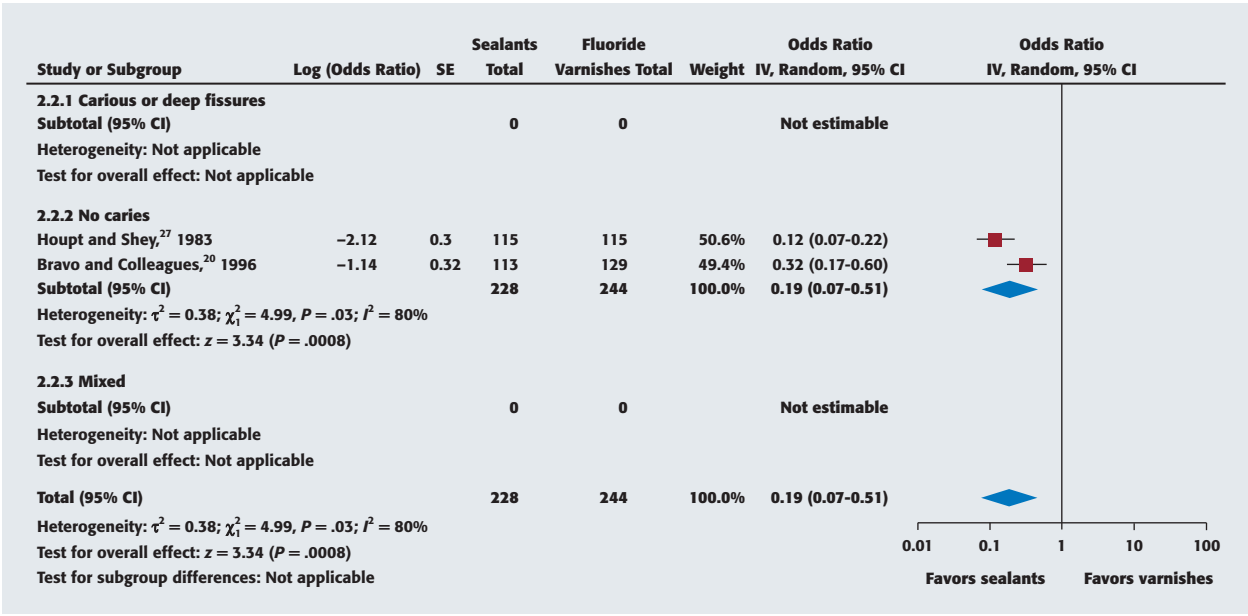
eFigure 2. Forest plot of comparison. 1. Sealants versus nonuse of sealants, outcome: 1.2 Caries incidence (4-7 years). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.



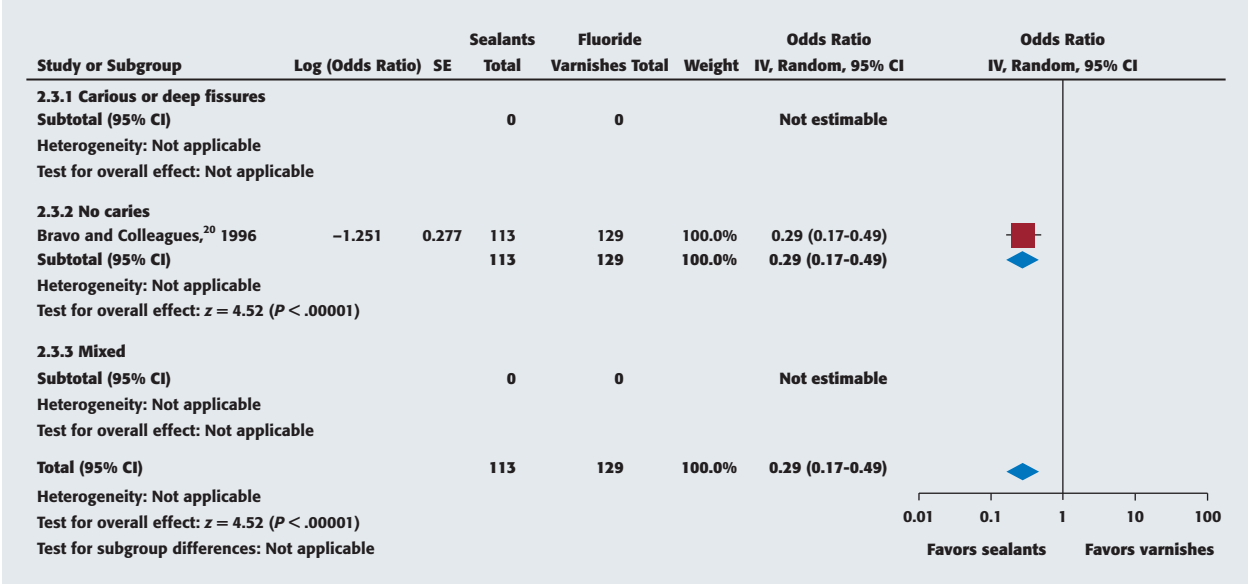
eFigure 3. Forest plot of comparison. 1. Sealant versus nonuse of sealant, outcome: 1.3 Caries incidence (7 years or more). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.



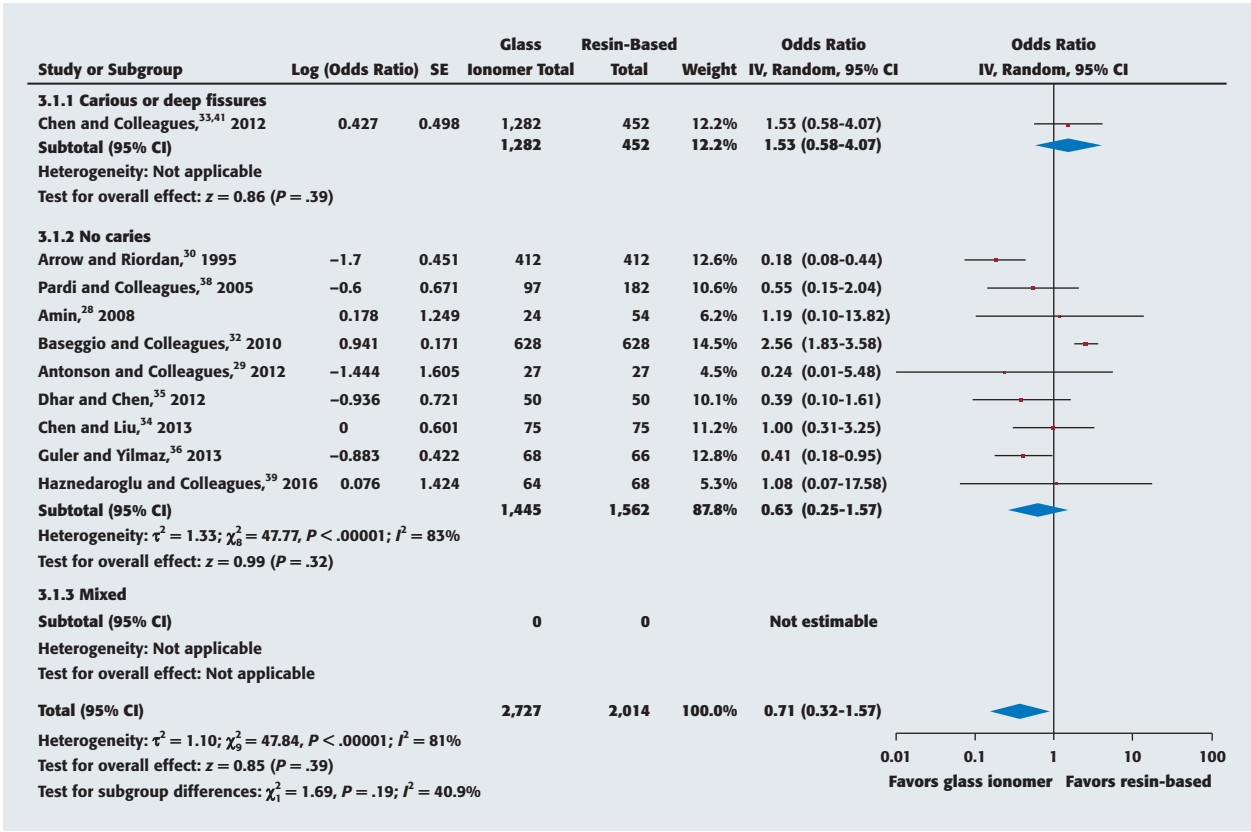
eFigure 4. Forest plot of comparison. 2. Sealants versus fluoride varnishes, outcome: 2.1 Caries incidence (2-3 years). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.



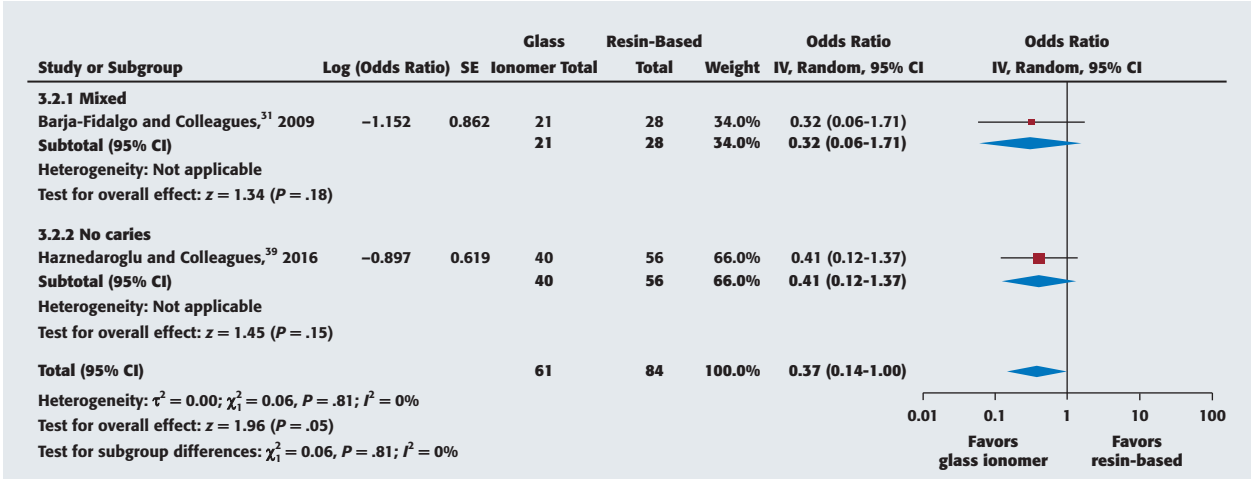
eFigure 5. Forest plot of comparison. 2. Sealants versus fluoride varnishes, outcome: 2.2 Caries incidence (4-7 years). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.



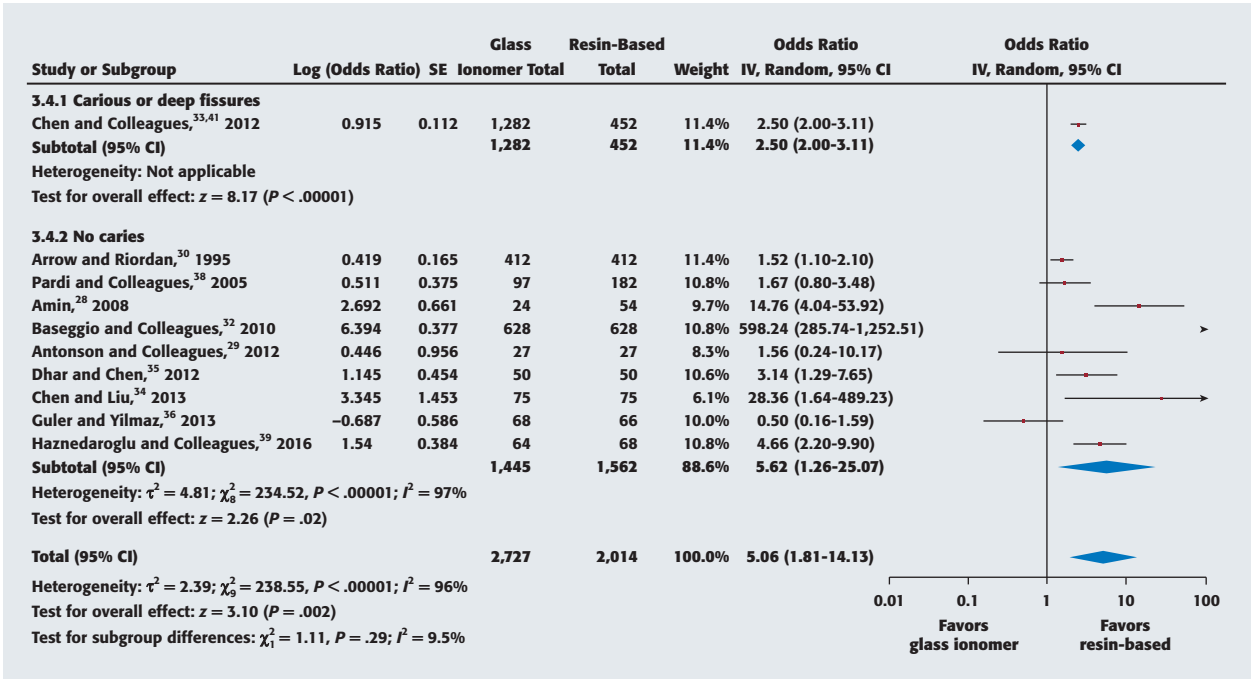
eFigure 6. Forest plot of comparison. 2. Sealants versus fluoride varnishes, outcome: 2.3 Caries incidence (7 years or more). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.



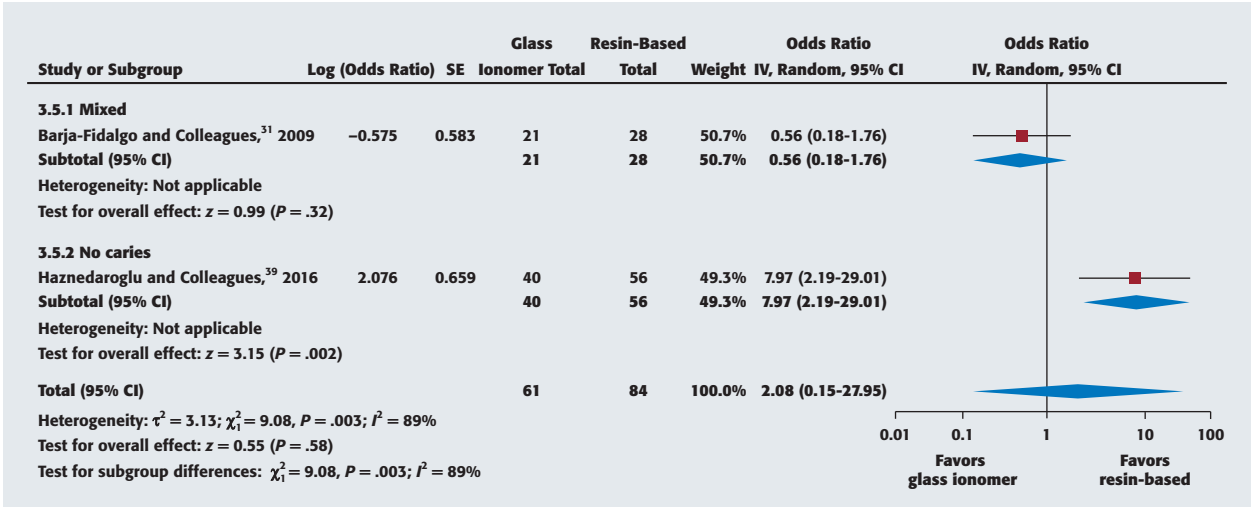
eFigure 7. Forest plot of comparison 3. Overall: Glass ionomer sealants versus resin-based sealants, outcome: 3.1 Caries incidence (2-3 years). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.



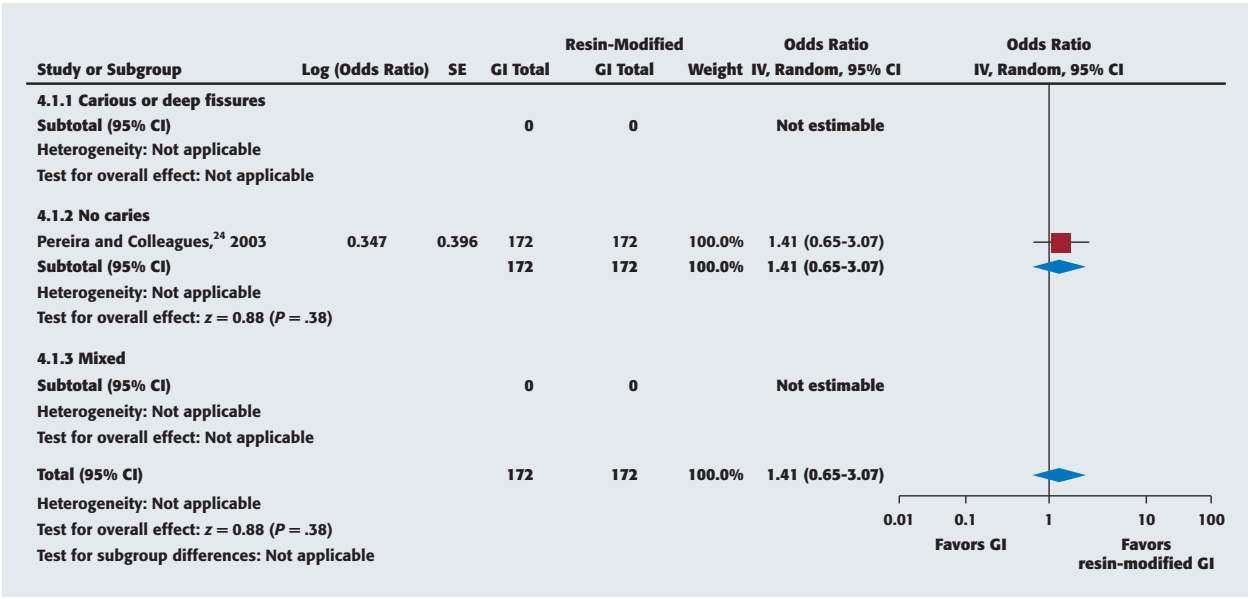
eFigure 8. Forest plot of comparison. 3. Overall: Glass ionomer sealants versus resin-based sealants, outcome: 3.2 Caries incidence (4-7 years). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.



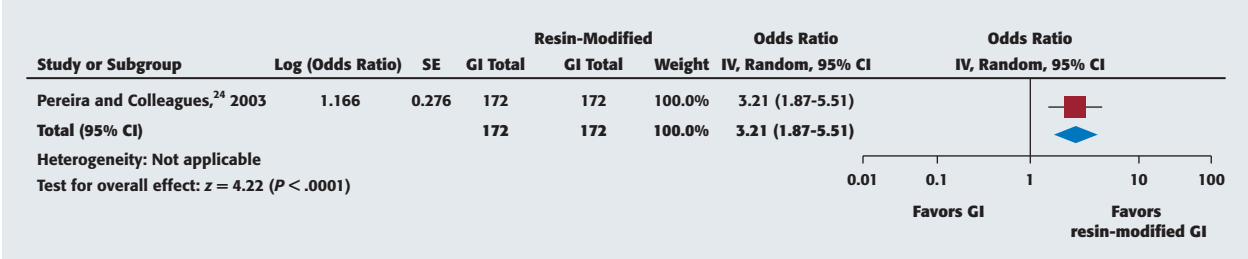
eFigure 9. Forest plot of comparison. 3. Overall: Glass ionomer sealants versus resin-based sealants, outcome: 3.4 Lack of retention (2-3 years). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.



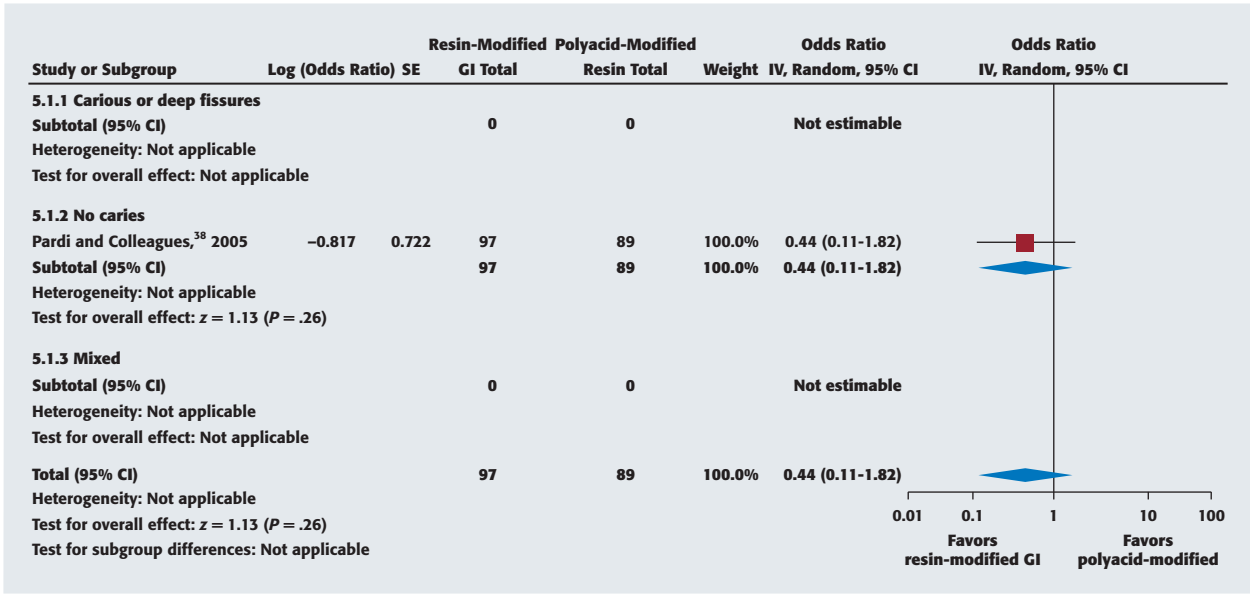
eFigure 10. Forest plot of comparison: 3. Overall: Glass ionomer sealants versus resin-based sealants, outcome: 3.5 Lack of retention (4-7 years). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.



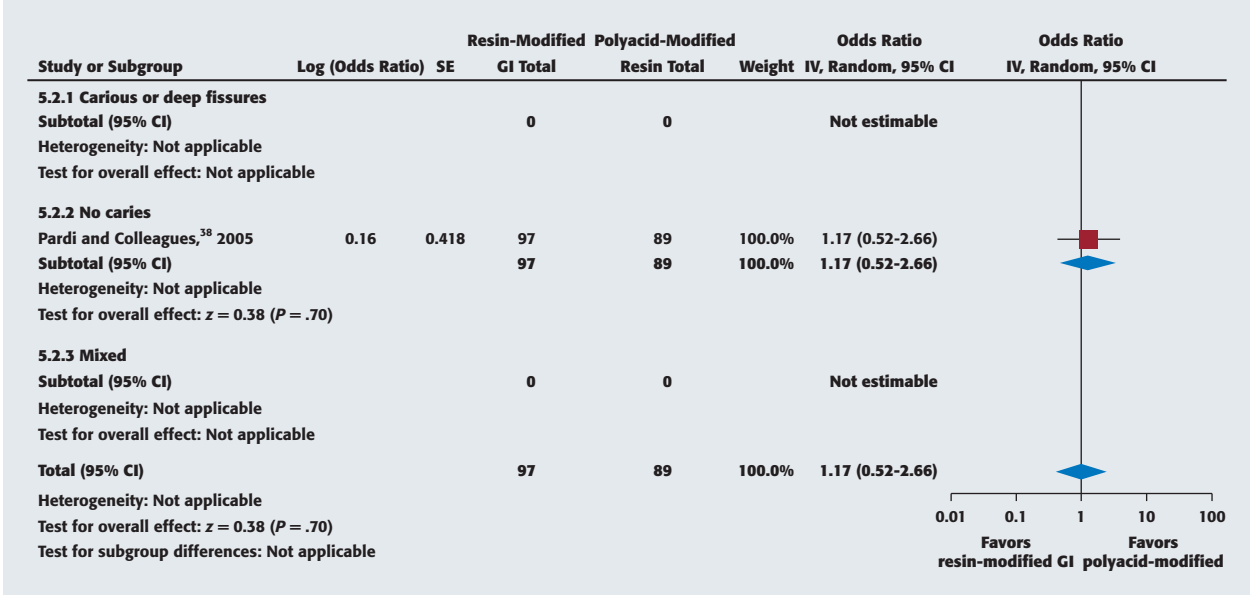
eFigure 11. Forest plot of comparison. 4. Glass ionomer sealants versus resin-modified glass ionomer sealants, outcome: 4.1 Caries incidence (2-3 years). CI: Confidence interval. GI: Glass ionomer. IV: Inverse-variance. SE: Standard error.



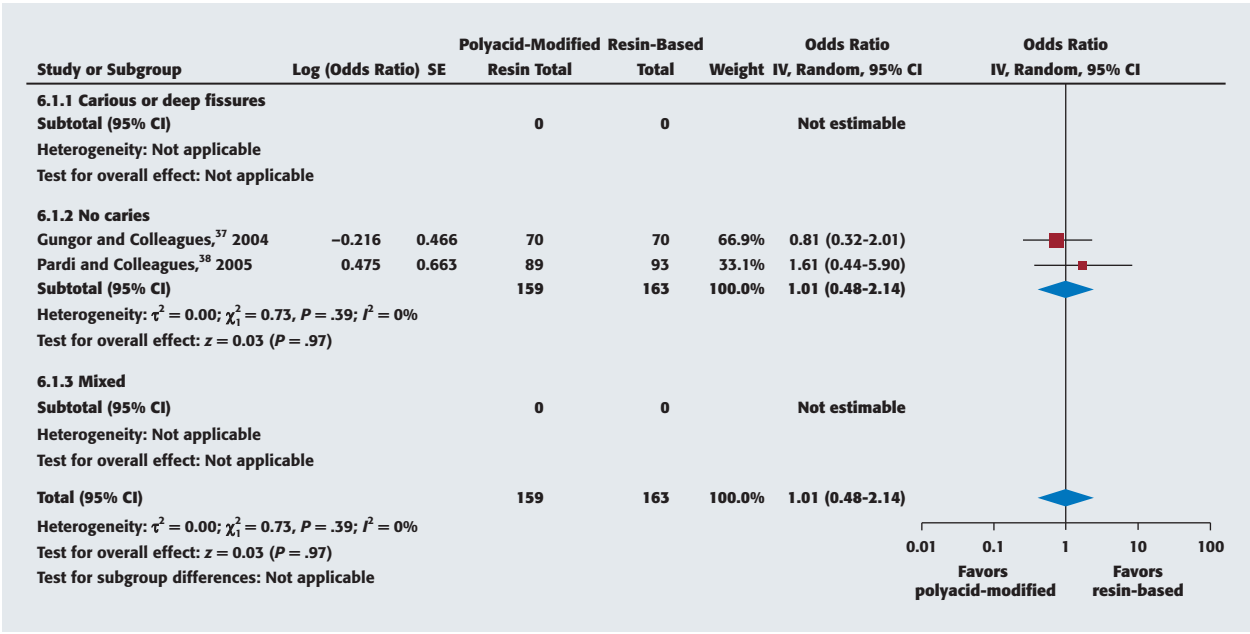
eFigure 12. Forest plot of comparison. 4. Glass ionomer sealants versus resin-modified glass ionomer sealants, outcome: 4.4 Lack of retention (2-3 years). CI: Confidence interval. GI: Glass ionomer. IV: Inverse-variance. SE: Standard error.



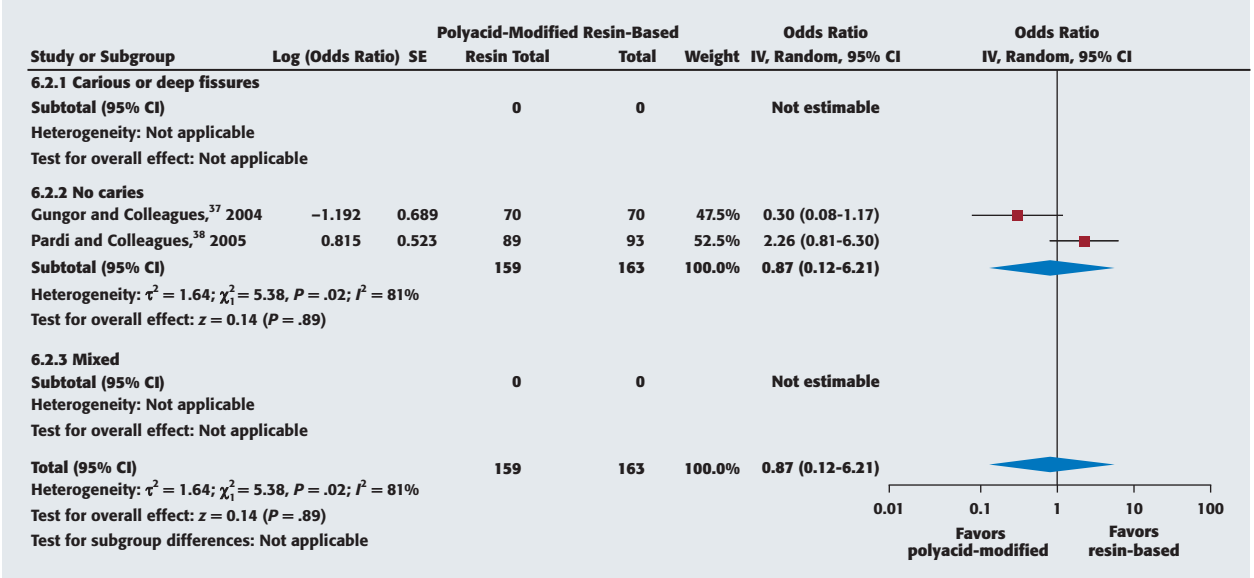
eFigure 13. Forest plot of comparison. 5. Resin-modified glass ionomer sealants versus polyacid-modified resin sealants, outcome: 5.1 Caries incidence (2-3 years). CI: Confidence interval. GI: Glass ionomer. IV: Inverse-variance. SE: Standard error.



eFigure 14. Forest plot of comparison. 5. Resin-modified glass ionomer sealants versus polyacid-modified resin sealants, outcome: 5.2 Lack of retention (2-3 years). CI: Confidence interval. GI: Glass ionomer. IV: Inverse-variance. SE: Standard error.



eFigure 15. Forest plot of comparison. 6. Polyacid-modified resin sealants versus resin-based sealants, outcome: 6.1 Caries incidence (2-3 years). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.



eFigure 16. Forest plot of comparison. 6. Polyacid-modified resin sealants versus resin-based sealants, outcome: 6.2 Lack of retention (2-3 years). CI: Confidence interval. IV: Inverse-variance. SE: Standard error.

eTABLE 1

Evidence profile: sealants compared with fluoride varnishes in pit-and-fissure occlusal surfaces in children and adolescents.*

QUALITY ASSESSMENT						
No. of Studies	**Study Design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considerations**
Caries incidence (follow-up: range 2-3 y)‡						
3	Randomized trials	Serious§	Serious¶	Not serious	Not serious	None
Caries incidence (follow-up: range 4-7 y)**						
2	Randomized trials	Serious§	Serious††	Not serious	Not serious	None
Caries incidence (follow-up: range 7 y or more)						
1	Randomized trials	Very serious§	Not serious	Not serious	Not serious	None
Lack of retention (follow-up: range 2-3 y)						
2	Randomized trials	Serious§	Not serious	Not serious	Not serious	None

* Sources: Bravo and colleagues,[20] Liu and colleagues,[22] and Houpt and colleagues.[27]
† The percentages (30% and 70%) indicate the control group baseline risk (caries prevalence).
‡ A subgroup effect was identified for this outcome ($P = .04$). Patients who were caries-free (odds ratio, 0.19; 95% confidence interval, 0.07-0.47) and mixed population (odds ratio, 0.66; 95% confidence interval, 0.30-1.44).
§ Most studies were classified as unclear for the "allocation concealment" and "masking" domains.
¶ Unexplained heterogeneity ($P = .0002$, $I^2 = 88\%$).
# 2 of 3 studies reported being conducted in water-fluoridated communities.
** The studies only reported the outcome in patients who were caries-free.
†† Unexplained heterogeneity ($P = .03$, $I^2 = 80\%$).
‡‡ 2 of 2 studies reported being conducted in water-fluoridated communities.
§§ The study reported being conducted in water-fluoridated communities.

eTABLE 1 (CONTINUED)

PATIENTS (N)		EFFECT		QUALITY	IMPORTANCE
Sealants	**Fluoride Varnishes[†]**	**Relative Odds Ratio (95% Confidence Interval)**	**Absolute (95% Confidence Interval)**		
66/855 (7.7%)	364/860 (42.3%)[#]	0.27 (0.11-0.69)	258 fewer per 1,000 (87-349 fewer)	Low	Critical
	30.0%		196 fewer per 1,000 (72-255 fewer)		
	70.0%		313 fewer per 1,000 (83-496 fewer)		
46/228 (20.2%)	131/244 (53.7%)[‡‡]	0.19 (0.07-0.51)	356 fewer per 1,000 (165-462 fewer)	Low	Critical
	30.0%		225 fewer per 1,000 (121-271 fewer)		
	70.0%		393 fewer per 1,000 (157-560 fewer)		
30/113 (26.5%)	72/129 (55.8%)[§§]	0.29 (0.17-0.49)	290 fewer per 1,000 (176-381 fewer)	Low	Critical
	30.0%		189 fewer per 1,000 (126-232 fewer)		
	70.0%		296 fewer per 1,000 (167-416 fewer)		
Including all sealant material types and tooth preparation techniques, 55.6% of sealants were fully retained at 2 y, and 59.3% were fully or partially retained at 2 y; at 3 y, 56.4% of all sealants were fully retained, and 58.8% were fully or partially retained at 3 y				Moderate	Important

eTABLE 2

Evidence profile: glass ionomer sealants compared with resin-modified glass ionomer sealants in pit-and-fissure occlusal surfaces in children and adolescents.*

QUALITY ASSESSMENT						
No. of Studies	**Study Design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considerations**
Caries incidence (follow-up: range 2-3 y)‡						
1	Randomized trials	Serious§	Not serious	Not serious	Very serious¶	None
Caries incidence (follow-up: range 4-7 y)—not reported						
—**	—	—	—	—	—	—
Caries incidence (follow-up: range 7 y or more)—not reported						
—	—	—	—	—	—	—
Lack of retention (follow-up: range 2-3 y)						
1	Randomized trials	Serious§	Not serious	Not serious	Not serious	None
Lack of retention (follow-up: range 4-7 y)—not reported						
—	—	—	—	—	—	—
Lack of retention (follow-up: range 7 y or more)—not reported						
—	—	—	—	—	—	—

* Source: Pereira and colleagues.[24]
† The percentages (30% and 70%) indicate the control group baseline risk (caries prevalence).
‡ Only 1 study reported this outcome. No subgroup analysis was included.
§ All domains were classified as unclear, including the "allocation concealment" and "masking" domains.
¶ The 95% confidence interval suggests an appreciable benefit and an appreciable harm (95% confidence interval, 45% reduction-207% increase for caries incidence).
# The study was conducted in water-fluoridated communities.
** Dashes indicate data not available.

eTABLE 2 (CONTINUED)

PATIENTS (N)		EFFECT		QUALITY	IMPORTANCE
Glass Ionomer Sealants	Resin-Modified Glass Ionomer Sealants[†]	Relative Odds Ratio (95% Confidence Interval)	Absolute (95% Confidence Interval)		
27/172 (15.7%)	20/172 (11.6%)[#] 30.0% 70.0%	1.41 (0.65-3.07)	40 more per 1,000 (37 fewer-171 more) 77 more per 1,000 (82 fewer-268 more) 67 more per 1,000 (97 fewer-178 more)	Very low	Critical
–	–	–	–	–	Critical
–	–	–	–	–	Critical
149/172 (86.6%)	115/172 (66.9%)	3.21 (1.87-5.51)	198 more per 1,000 (122-249 more)	Moderate	Important
–	–	–	–	–	Important
–	–	–	–	–	Important

eTABLE 3

Evidence profile: resin-modified glass ionomer sealants compared with polyacid-modified resin sealants in pit-and-fissure occlusal surfaces in children and adolescents.*

QUALITY ASSESSMENT						
No. of Studies	**Study Design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considerations**
Caries incidence (follow-up: range 2-3 y)‡						
1	Randomized trials	Serious§	Not serious	Not serious	Very serious¶	None
Caries incidence (follow-up: range 4-7 y)—not reported						
—**	—	—	—	—	—	—
Caries incidence (follow-up: range 7 y or more)—not reported						
—	—	—	—	—	—	—
Lack of retention (follow-up: range 2-3 y)						
1	Randomized trials	Serious§	Not serious	Not serious	Very serious††	None
Lack of retention (follow-up: range 4-7 y)—not reported						
—	—	—	—	—	—	—
Lack of retention (follow-up: range 7 y or more)—not reported						
—	—	—	—	—	—	—

* Source: Pardi and colleagues.[38]
† The percentages (30% and 70%) indicate the control group baseline risk (caries prevalence).
‡ Only 1 study reported this outcome. No subgroup analysis was conducted.
§ All risk of bias domains were classified as unclear.
¶ 95% confidence interval suggests a large benefit and a large harm (95% confidence interval, 89% reduction-82% increase). Only 9 events are informing this outcome.
# The study was conducted in water-fluoridated communities.
** Dashes indicate data not available.
†† 95% confidence interval suggests a large benefit and a large harm (95% confidence interval, 48% reduction-166% increase). Only 27 events are informing this outcome.

eTABLE 3 (CONTINUED)

PATIENTS (N)		EFFECT		QUALITY	IMPORTANCE
Resin-Modified Glass Ionomer Sealants	Polyacid-Modified Resin Sealants[†]	Relative Odds Ratio (95% Confidence Interval)	Absolute (95% Confidence Interval)		
3/97 (3.1%)	6/89 (6.7%)[#]	0.44 (0.11-1.82)	37 fewer per 1,000 (49 more-60 fewer)	Very low	Critical
	30.0%		141 fewer per 1,000 (138 more-255 fewer)		
	70.0%		193 fewer per 1,000 (109 more-496 fewer)		
–	–	–	–	–	
–	–	–	–	–	
15/97 (15.5%)	12/89 (13.5%)	1.17 (0.52-2.66)	19 more per 1,000 (60 fewer-158 more)	Very low	Important
–	–	–	–	–	
–	–	–	–	–	

eTABLE 4

Evidence profile: polyacid-modified resin sealants compared with resin-based sealants in pit-and-fissure occlusal surfaces in children and adolescents.*

QUALITY ASSESSMENT						
No. of Studies	**Study Design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considerations**
Caries incidence (follow-up: range 2-3 y)‡						
2	Randomized trials	Serious§	Not serious	Not serious	Very serious¶	None
Caries incidence (follow-up: range 4-7 y)—not reported						
—**	—	—	—	—	—	—
Caries incidence (follow-up: range 7 y or more)—not reported						
—	—	—	—	—	—	—
Lack of retention (follow-up: range 2-3 y)						
2	Randomized trials	Serious§	Serious††	Not serious	Serious‡‡	None
Lack of retention (follow-up: range 4-7 y)—not reported						
—	—	—	—	—	—	—
Lack of retention (follow-up: range 7 y or more)—not reported						
—	—	—	—	—	—	—

* Sources: Gungor and colleagues[37] and Pardi and colleagues.[38]
† The percentages (30% and 70%) indicate the control group baseline risk (caries prevalence).
‡ The studies only reported the outcome in patients who were caries-free. No subgroup analysis was conducted.
§ The 2 studies were classified as "unclear" risk of bias for the domain "allocation concealment."
¶ 95% confidence interval suggests a large benefit and a large harm (95% confidence interval, 52% reduction-114% increase).
# 1 of 2 studies reported being conducted in water-fluoridated communities.
** Dashes indicate data not available.
†† Unexplained heterogeneity ($P < .00001$, $I^2 = 97\%$).
‡‡ 95% confidence interval suggests a large benefit and a large harm (95% confidence interval, 88% reduction-521% increase).

eTABLE 4 (CONTINUED)

PATIENTS (N)		EFFECT		QUALITY	IMPORTANCE
Polyacid-Modified Resin Sealants	Resin-Based Sealants[†]	Relative Odds Ratio (95% Confidence Interval)	Absolute (95% Confidence Interval)		
16/159 (10.1%)	16/163 (9.8%)[#]	1.01 (0.48 to 2.14)	1 more per 1,000 (49 fewer-91 more)	Very low	Critical
	30.0%		2 more per 1,000 (129 fewer-178 more)		
	70.0%		2 more per 1,000 (133 more-172 fewer)		
–	–	–	–	–	
–	–	–	–	–	
15/159 (9.4%)	15/163 (9.2%)	0.87 (0.12-6.21)	11 fewer per 1,000 (80 fewer-294 more)	Very low	Important
–	–	–	–	–	
–	–	–	–	–	