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Original

Caries-preventive effect of glass ionomer and resin-based fissure sealants on permanent teeth: a meta analysis

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Abstract: The purpose of this quantitative systematic review was to appraise the evidence on the caries-preventive effect of glass ionomer cement (GIC) in relation to resin-based fissure sealants. Nine English and two Portuguese databases were searched (15 January 2008). Randomized clinical trials and systematic reviews were considered for inclusion. Trial exclusion criteria were: drop-out rates > 33%; no randomization; baseline differences in groups not statistically adjusted; and no clinically important outcomes were presented. Two authors reviewed the articles independently. The outcome measure for the caries preventive effect was caries absence on sealed teeth. Of the 112 identified articles, 25 were selected for review. Of these, 14 were excluded and 11 accepted (8 trials; 3 systematic reviews). The accepted reviews provided no evidence of superiority of either sealant material. Six trials were included for meta-analysis. The pooled odds ratio was 0.96, 95% CI 0.62-1.49, indicating no difference in the caries-preventive effect of GIC and resin-based fissure sealant material. This systematic review with meta-analysis found no evidence that either material was superior to the other in the prevention of dental caries. Thus, both materials appear equally suitable for clinical application as a fissure sealant material. (J Oral Sci 51, 373-382, 2009)

Keywords: glass ionomer cement; resin composite; fissure sealing; meta-analysis.

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Introduction

Pits and fissures of posterior molar teeth are considered to be highly susceptible to the adhesion of microorganisms and, consequently, caries. Therefore, a significant amount of tooth decay occurs at these sites. Fissure sealants are used to prevent occlusal caries with 71% percent of occlusal decay preventable after a once-off fissure sealant application (1). The evidence for the efficacy and cost-effectiveness of sealants in reducing occlusal caries in molars has been highlighted in a number of articles in highly rated journals (1-5). The most commonly used sealant material is resin composite (6-8). Its caries-preventive effect relies on the sealing of pits and fissures through micro-retention, created through tags after enamel acid etching. However, these are easily destroyed by saliva contamination, which reduces micro-retention and consequently, the caries-preventive effect (9). Under the generally wet conditions in the oral cavity, Glass Ionomer Cement (GIC) offers an alternative. Owing to its hydrophilic properties, GIC is not as moisture-sensitive as hydrophobic resin (10). It has been suggested that the 'gold standard' in caries prevention through sealant administration should not be based on physical (material retention on the tooth surface) but rather, on biological outcomes (11). Such biological outcomes are measured in relation to the absence of caries in pits and fissures after sealant application. So far, three systematic reviews (2,11,12) including appraisals on the effectiveness of GIC fissure sealant have been published. One of these, by Mejare et al. (12), did not include a direct comparison between GIC and resin-based sealants. Two other systematic reviews (2,11) have compared the effect of GIC with that of resin based fissure sealants. One of these was a Cochrane Systematic Review (2) that used strict inclusion criteria, which resulted in a large number of

trials being excluded from the final analysis. The systematic review by Beiruti et al. (11) excluded studies lacking sufficient reported statistics for calculation of relative and attributable risk. In all these three systematic reviews, only English databases were searched and English articles reviewed. Additionally, the inconclusive findings reported in each of these reviews were based on the authors' assessment of each included trial using a PICOS (patient; intervention; controls; outcome; study authors' conclusions) format and a narrative synthesis of the included articles. However, the disadvantage of a narrative synthesis in systematic reviews is that bias may be introduced if the outcomes of some studies are inappropriately stressed over others (13). The advantages of a meta-analysis over narrative synthesis are that it provides the chance to detect a treatment effect as statistically significant ($P < 0.05$) and to improve the estimation of a treatment effect by quantifying its outcome, thus making its estimation more precise (13). Therefore, whilst methodological weaknesses limit what can be inferred in terms of efficacy, the cumulative weight of evidence (as highlighted, where possible, in a meta-analysis) provides a more objective assessment of a systematic analysis of the literature. The inconclusive findings reported in the three published systematic reviews may reflect the opposite should a meta-analysis of trials that report on the same outcome be added. Indeed, this has been shown to be the case in a number of systematic reviews where the individual studies had varied outcomes but the cumulative weight of the evidence (done by pooling together the results of trials with similar outcomes) were found to be conclusive for that particular outcome (14-16).

Due to the lack of a conclusive quantitative analysis in past reviews, the aim of this systematic review is not only to extend the evidence search and review to non-English clinical trials, but also to conduct a meta-analysis in order to quantitatively appraise the current evidence regarding the caries-preventing effect of GIC in comparison to that of resin-based fissure sealants for the first time.

Materials and Methods

Search strategy

The literature search covered nine Anglophone databases: Biomed Central, Cochrane Oral Health Reviews, Cochrane Library, Directory Of Open Access Journals, Expanded Academic ASAP PLUS, Meta Register Of Controlled Trials – mRCT, PubMed, Science-Direct, Research Findings Electronic Register – ReFeR and two Lusophone databases: Bibliografia Brasileira Em Odontologia – BBO, Literatura Latino-Americana E Caribenha Em Ciências Da Saúde – LILACS. In order to search databases, strings of search terms were constructed, consisting of relevant text words and Boolean links. The string of English search terms: *"(GIC sealant* OR Glass ionomer cement sealant) AND (caries OR tooth decay)"* was used to search the Anglophone databases and the string of Portuguese search terms: *"SELANTE" [Palavras] and "CIMENTOS DE IONOMEROS DE VIDRO" [Palavras] and "CARIE" [Palavras]"* was used to search the Lusophone databases. All publications listed in the databases until 15 January 2008 were included in the search.

Inclusion and exclusion criteria

Both clinical trials and systematic reviews by other authors were eligible for inclusion. Publications were included from the search results on the basis that their titles

Table 1 Exclusion criteria for trials and literature reviews

Trials	Literature reviews
Drop-out rate > 33%	Focus on population or intervention not clearly stated in title and abstract
Patients and clinicians not 'blinded' where possible and appropriate	Article methodology describes no clear inclusion and exclusion criteria for reviewed publications
Baseline differences among groups not statistically adjusted	Article methodology describes no clear search strategy, key words and databases used and includes no study-by-study critique table or discussion of study qualities
Clinically important outcomes for patients not assessed	
No *in vivo* or *in situ* study design	
No randomization/ quasi-rendomization method reported	

and abstracts were in accordance with broad inclusion criteria: (i) titles/abstracts were relevant to the review objective; and (ii) the article was published in English, German, Portuguese or Spanish. Where only a relevant title without a listed abstract was available, a full copy of the publication was assessed for inclusion. In accordance with published recommendations (17), included articles were reviewed independently by two reviewers. Disagreements were resolved through discussion and consensus. After review, articles were accepted only if they complied with all the exclusion criteria described in Table 1. In cases of multiple reports regarding the same trial, the report covering the longest period and lacking the exclusion criteria was accepted. For the systematic reviews, only a descriptive analysis was attempted.

Data extraction from accepted trials

The outcome measure of the caries preventive effect was the caries absence on sealed teeth. Two reviewers (VY and SM) independently extracted data from the accepted articles, using a pilot-tested data-extraction form that included information contained in Table 2. Wherever

Table 2 Details of accepted trials

Authors	Study design	Test material	Control material	Participants / teeth	Age (years)	Tooth	Application	Follow-up Period (years)	Drop-out (%)	Caries preventive Effect	
										Test material	Test material
Lovadino JR et al. (32)	RCT (SM)	Chelon Fil	Delton	22 children	6-11	1st permanent molars	Single	1	31.8% children (7/22) lost GIC – 80% total retention Resin – 33.33% total retention	100% caries free	100% caries free
Tostes M (33)	RCT (SM)	1.Ketac Cem 2.Fluoroshield 3.Fluor varnish	No treatment	25 children	6-8	1st permanent molars	Single	2	12% children (3/25) lost GIC – 100% partially or total lost Resin – 63.7% partially or total lost	1.13% of teeth in Resin Group decayed at 24 months 2.27% in GIC group 2.27% in F varnish group. No statistical significance among all 4 groups	2.27% of teeth in control group decayed $P > 0.05$
Karlzen-Reuterving G and van Dijken JWV (34)	RCT (SM)	Fuji III	Delton	47 (26 girls; 21 boys) 148 1st molars	7	1st molar	Single	3	4.3% children (2/47) lost GIC – 72.2% partially lost; 98% total loss Resin – 20.8% partially lost; 0% total loss	Carious teeth: 1.4% of GIC F/S teeth	Carious teeth: 4.2% of resin sealed teeth
Arrow P et al. (35)	RCT (SM)	Ketac Fil	Delton	465 pairs of molars in 465 children	7	1st molar	Single	3.64	10.8% (50/465) children drop-out > 60% of both sealants lost 62% GIC lost at 44 months 100% resin lost at 44 months	Carious teeth: 1.5% (6/415) RR=0.19 (CI 0.09-0.4)	Carious teeth: 7.5% (31/415)
Williams B et al. (36) (Only 2 year results reviewed)	RCT (SM)	Fuji III	Delton	860 sealants placed in 228 children	6-8	1st molar	Single	2	31% (71/157) children lost at 2 years; GIC – 93% (274/295) lost Resin – 18% (55/295) lost	Carious teeth: 6.4% (19/295)	Carious teeth: 1.4% (4/295)
Songpaisan Y et al. (31) (Part 1)	RCT (PG)	1. Fuji III	1. No treatment	512 children with ≥ 3 1st molars assigned to 4 groups (Control; 3 Test)	7-8	1st molar	Single and repeated for GIC if missing at 6 months; Topical fluoride applied at baseline,6,12 months	2	14% (73/512) lost at 2 years. At 24 months, 96% GIC F/S lost	1. DFS –for 1st molars reduced by 52%; mean DMFS for whole mouth reduced by 51.3% compared to control	DMFS score increased from 0.43 at baseline to 1.63 at 2 years
		2. Fujii III	2. No treatment							2. DFS –for 1st molars reduced by 74%; mean DMFS for whole mouth reduced by 64.7% compared to control	
Songpaisan Y et al. (31) (Part 2)	RCT (PG)	1. Fuji III	1. No treatment	752 children with ≥ 3 1st molars assigned to 4 groups (Control; 3 Test)	12-13	Molar teeth	1. Single and repeated for GIC if missing at 6 months; Topical fluoride applied at baseline, 6,12 months	2	11% (81/752) lost at 2 years. At 2 years, 99% of GIC F/S lost; 15% of Resin F/S lost.	1. DFS – for molars reduced by 31%; mean DMFS for whole mouth not significant when compared to control	Resin based sealants performed significantly better than GIC sealants when mean DFS scores were compared at 2 years
		2. Fujii III	2. No treatment				2. Single			2. DFS – for 1st molars reduced by 20%; mean DMFS for whole mouth not significant when compared to control	
		3. Delton (LC)	3. No Treatment				3. Single			3. DFS – for 1st molars reduced by 93%; mean DMFS for whole mouth significantly lower than control	
Kerrvanto-Seppälä S et al. (38)	RCT (SM)	Fujii III Chemical cure	Delton (LC)	599 children who received sealants on 2nd molars	12-16 yrs	2nd molars	GIC = single / Resin = defective sealants resealed	3	20%	Caries preventive effect of resin fissure sealant 74.1% (95% CI 43.4-88. 13%) and rate difference 3.2% (95% CI 1.44-4.98%). Relative Risk for GIC sealed surfaces having dentin caries 3.9 (95%CI 1.77-8.42)	
Rock WP et al. (37)	RCT (SM)	GIC (Baseline)	Resin (Fluoro-shield – contains F – Light Cure)	86 children received GIC F/S on one side of mouth and Resin F/S on contra-lateral side	7-8	1st molar	single	3	At 3 years, 24% (21/86) lost to follow-up. At 3 years, 0% GIC F/S intact; 70% Resin FS intact.	At 3 years, caries present in 13.8% of GIC F/S teeth;	At 3 years, caries present in 3.2% of Resin Filled teeth. Statistically significant.

GIC = glass ionomer cement; RMGIC = resin modified glass ionomer cement; RCT = randomized-control trial; SM = split-mouth; PG = parallel group; LC = light cured; F/S = fissure sealant; RR = relative risk

possible, missing data was calculated from information given in tables and text of trials in order to complete the 2×2 table for meta analysis. Disagreements between reviewers during data extraction were resolved through discussion and consensus.

It was anticipated that the majority of studies eligible for inclusion would be split-mouth in design. The split-mouth study design is commonly used in dentistry to test interventions and has the advantage of having an individual serve as both the experiment and control. In this study design, one or more pairs of teeth (e.g. primary molars) form the unit of randomization. Strictly, these pairs are not independent and should be analyzed as "paired data" on a patient basis. However, similar to other reviews where split-mouth trials are included (2), it was decided to analyze the pairs independently as it would have meant that most trials considered for inclusion here would have been excluded.

Quality of trials

The quality assessment of the included trials was undertaken independently by two reviewers (VY and SM). The quality assessment process was piloted using trials not included in this review and subsequently; quality assessment rating scored by both the reviewers was derived by consensus within the review group. Four main quality criteria were examined:

1) Generation of randomization sequence (Allocation), recorded as:
(A) Adequate – e.g. computer generated random numbers, table of random numbers.
(B) Unclear.
(C) Inadequate – e.g. case record number, date of birth, date of administration, alternation.

2) Allocation concealment, recorded as:
(A) Adequate – e.g. central randomization, sequentially numbered sealed opaque envelopes.
(B) Unclear.
(C) Inadequate – e.g. open allocation schedule, unsealed or non-opaque envelopes.

3) Blind outcome assessment, recorded as:
(A) Yes.
(B) Unclear.
(C) No.
(D) Not used/possible.

4) Completeness of follow up (clear explanation for withdrawals and loss-to-follow-up in each treatment group) assessed as:
(A) Yes, drop outs less than 30%.
(B) Yes, drop outs more than 30%.
(C) No explanation.

Meta-analysis

The caries absence and caries presence in sealed teeth were treated as dichotomous data. Trials were assessed for their clinical and methodological heterogeneity following Cochrane guidelines (13). Trials were considered homogenous, if they did not differ substantially in the following clinical and methodological aspects: age of patients; follow-up period; type of sealant material used; frequency of sealant material application; as well as measured outcome. Only trials considered to be clinically and methodologically homogenous were included for meta-analysis, for which the fixed effects model of the meta-analysis software, RevMan 4.2 was used. The differences in the caries preventive effect were computed on the basis of odds ratios (OR) from each trial and the respective 95% confidence interval (CI). Studies were assigned a Mantel-Haenszel weight in direct proportion to their sample size.

Results

From the initial search results, 112 articles were identified, 25 of which were selected for review. Independent review of these 25 articles resulted in further exclusion of 2 reviews (8,18) and 12 trials (19-30). Table 3 provides information on the reasons for exclusion. Four trials (19,20,23,29) were excluded because the drop-out rates of participants were greater than 33%. The trial by Boksman et al. (21) was abandoned 6 months into the 3-year trial period, because only 1.7% of the GIC fissure sealants placed were available for evaluation.

Eight trials (31-38) and three literature review articles (2,11,12), were accepted and thus formed the basis for the evaluation of evidence regarding the caries-preventive effect of GIC versus that of resin-based fissure sealants.

Description of accepted reviews

Three literature reviews (2,11,12) were accepted. The Cochrane systematic review (2) sought to evaluate the caries preventive effect of resin and GIC cements in trials comparing these two interventions with each other or with a placebo (or no treatment). The strict inclusion and exclusion criteria meant that 40 of the 56 studies included for review were excluded, e.g. split-mouth trials, in which the authors did not present data in a paired way were excluded in this review without the attempt to calculate the missing data from available information. These criteria added to the strength of methodological rigor of this review

Table 3 Excluded articles and main reasons for exclusion

Authors	Reason for exclusion
Forss H and Halme E (19)	Drop-out rate = 42%
Mejare I and Mjor IA (20)	No randomization method described; Adult drop-out rate = 38% (no information on drop-out rate for children)
Boksman L et al. (21)	Drop-out rate = 98.3% of sealants; Trial abandoned at 6 months
Herle GP et al. (22)	No randomized controlled, *in vivo* or *in situ* study
Poulsen S et al. (23)	Drop-out rate = 35.2%
Yip H-K and Smales RJ (18)	Article methodology describes no clear search strategy, key words and databases used, no clear inclusion and exclusion criteria for reviewed publications and includes no study-by-study critique table or discussion of study qualities
Simonsen RJ (8)	Article methodology describes no clear search strategy, key words and databases used, no clear inclusion and exclusion criteria for reviewed publications and includes no study-by-study critique table or discussion of study qualities
Basting RT et al. (24)	No randomized controlled, *in vivo* or *in situ* study
Navarro MFL et al. (25)	Groups not comparable (GIC group has high caries experience; Resin group has low caries experience); No randomization method stated; No adjustment of baseline differences in groups)
Ganesh and Shobha (26)	No randomized controlled, *in vivo* or *in situ* study
Kantovitz KR et al. (27)	No randomized controlled, *in vivo* or *in situ* study
Delfino CS et al. (28)	No randomized controlled, *in vivo* or *in situ* study
Beiruti N et al. (29)	Drop out rate greater than 50% after 5 years
Poulsen S et al. (30)	This study was part of a larger study involving 386 children who participated in a randomized-control trial comparing GIC (Fuji III) and a resin sealant (Delton) for caries preventive effect and retention of sealant material. The authors undertook a secondary data analysis of a portion of the children (n = 153) with 364 site pairs and a set of bitewings and analysed the data, comparing the caries preventive effect of the sealants using clinical and radiological diagnostic criteria for caries detection. The sample was thus conveniently selected (only children with bitewing x-rays) and was a secondary analysis of a portion of the participants (n = 153). Therefore true randomization was lacking and the study was excluded.

but resulted in similar findings in the review presented by Mejare et al. (12): although there was evidence regarding the effectiveness of resin sealants, the evidence related to GIC based sealants was perceived to be less convincing or incomplete. Moreover, the results from the comparison of resin sealants and GIC sealants were conflicting, as two of the assessed trials (23,31) were in favor of resin, while one trial (35) reported that GIC fissure sealants performed significantly better at 44 months after placement. As the results of these trials differed substantially, the authors did not attempt a meta-analysis.

The second review by Mejáre et al. (12) did not include trials comparing one type of fissure sealant material with another. Therefore, trials that pitted GIC fissure sealants against resin-based sealants for a variety of outcome measures were excluded. All of the 13 studies assessed in the review by Mejáre et al. (12) contained control groups that did not receive any intervention (i.e., fissure sealant caries preventive effect per tooth/child was compared to 'no treatment'). Of these studies, none was graded as providing "high value" evidence; only 2 were graded as offering "moderate" evidence and most were rated as having "limited value". The main outcome measures were relative risk reduction (the number of decayed occlusal surfaces in the controls minus the number of decayed surfaces in the sealed teeth, divided by the number of decayed surfaces in the controls) or prevented fraction (caries increment in the control minus caries increment in the sealed group, divided by the caries increment in the controls). The relative risk reductions reported were variable; ranging between 4% and 93% for all of the studies assessed. A meta-analysis, reporting on the caries-preventive effect of a single application of resin-based fissure sealants on the occlusal surfaces of 1st molars, showed that the relative risk of developing caries in a fissure-sealed tooth in relation to an untreated control was 0.67 (Confidence interval 95% CI: 0.55-0.83), which corresponded to a relative risk reduction of 33%. Only 2 of the 13 studies in the Mejáre et al. (12) review dealt specifically with GIC-type fissure sealants (31,39). Both trials reported significant caries preventive effects for GIC sealants but the strength of the evidence was rated as being of limited value. Consequently the authors' concluded that the evidence regarding use of GIC fissure sealants was incomplete.

The systematic review by Beiruti et al. (11) was critical of the Cochrane (2) and Mejáre et al. (12) reviews, as the former excluded many trials and the latter only considered trials in which the control groups did not receive an intervention. Beiruti et al. (11) also limited their search to Medline and PubMed database entries to December 2004 and analyzed articles published in English only (94 publications identified and 12 analyzed). Of these, only randomized-control trials (RCT) were analyzed, from which a relative risk (RR) or an attributable risk (AR) could be calculated as an outcome measure for a caries-preventive effect. The GIC materials were categorized as medium viscosity, low-viscosity, and low-viscosity resin-modified (cavity liner). The resin-based materials were grouped into 'auto-cured' and 'light-cured'. Although such methodology was conceived as being more appropriate for reviewing trials comparing GIC and resin based sealants, the conclusions reached were similar to that regarding the Cochrane Review: that no evidence is provided regarding the relative superiority of resin-based or GIC sealants materials in preventing caries development in pits and

fissures over time.

Description of accepted trials

Of the 8 clinical trials (31-38) included in this systematic review (Table 2), 7 followed a split-mouth study design (32-38) and 1 was a parallel-group study (31). In the split-mouth trials, the unit of randomization was the tooth. The split-mouth trials reported significantly different follow-up periods and sample sizes. All teeth under investigation were 1st permanent molars in children 6 to 11 years old, except in the trial by Kervanto-Seppälä et al. (38). In this trial, the caries-preventive effect of GIC versus resin sealants was investigated in the 2nd molars only, of children aged 12-16 years. In all split-mouth studies except the trial by Tostes (33), the interventions were randomly allocated to tooth surfaces within each pair of teeth per patient (either 1 or 2 pairs of molar teeth). In contrast, the trial by Tostes (33) randomized the teeth of each child in order to receive 3 interventions, with the fourth selected molar serving as a control (Table 2).

With the exception of the Kervanto-Seppälä et al. (38) trial, where children were clinic attendees, all the other trials (31-37) covered children recruited from local schools. All the trials provided a clear description of the interventions given (Table 2) but only 2 trials (31,35) provided information on baseline caries prevalence in the form of DMFT/dmft scores: DMFT 1.81 ± 1.84 for 12-13 year olds (31) and dmft 1.64 ± 2.45 for the mean age 7 years (35).

Two trials (31,36) reported a fluoride concentration ranging from 0.1 to 0.7 ppm in the water supply. Five trials (32-35,38) provided no information about the water fluoride concentration. Only three trials (31,36,38) gave information about inter/intra-examiner reliability by means of kappa scores and none of the included trials examined the effect of potential confounders on their reported results. Only 2-year data was accepted of one trial, which also reported on 4-year results. The 2-year data was chosen due to the high drop-out rate (49%) after 4 years (36).

Quality of accepted trials

Table 4 provides information about quality aspects assessed for included studies. Only one study (31) could be regarded as a randomized controlled trial with a parallel group design. All the others were split-mouth studies, which are regarded as quasi-randomized. Details about loss-to-follow-ups were reported in all included studies. Treatment allocation was rated A (Adequate) (36,37) in two trials, B (Unclear) in five (32-34) and C (Inadequate) in the remaining two (35,38).

Studies that compared GIC with Resin Sealants

Of the 8 accepted trials (31-38) that compared the caries-preventive effect of GIC and resin sealants, 4 trials were found in favor of resin sealants (31,36-38), 3 trials (32-34) found that both were effective, and 1 trial (35) favored GIC over resin sealants.

The Songpaisan et al. trial (31) compared GIC, resin and 0.5% hydrofluoric acid against a control group receiving no treatment. However, resin was applied only in children aged 12-13 years, whereas the other interventions were placed in children 7-8 years old and 12-13 years old. Although each intervention was only compared against the control group, data presented in tables in this trial enabled this research team to compare resin and GIC sealants. It was found that resin sealants performed significantly better than GIC sealants when mean DFS scores were compared at 24 months (Table 2).

The Kervanto-Seppälä et al. (38) trial studied 2nd permanent molars only, and the GIC sealant was applied only once in a 3-year follow-up period, while the resin

Table 4 Quality assessment of accepted studies

Study	Randomization	Allocation	Allocation Concealment	Blinding	Drop-outs
Lovadino JR et al. (32)	Quasi-randomized	B - Unclear	B - Unclear	D - Not possible	B 7/22 (31.8%)
Tostes M (33)	Quasi-randomized	B - Unclear	B - Unclear	D - Not Possible	A 3/25 (12%)
Karlzen-Reuterving G and van Dijken JWV (34)	Quasi-randomized	B - Unclear	B - Unclear	D - Not Possible	A 2/47 (4.3%)
Arrow P et al. (35)	Quasi-randomized	C - By use of month of birth	B - Unclear	D - Not Possible	A 50/465 (10.8%)
Williams B et al. (36) (2 year results)	Quasi-randomized	A - By use of computer generated random numbers	B - Unclear	D - Not Possible	B 71/157 (31%)
Songpaisan Y, et al. (31) (Part 1)	Randomized	B - Unclear	B -Unclear	D - Not Possible	A 73/512 (14%)
Songpaisan Y, et al. (31) (Part 2)	Randomized	B - Unclear	B - Unclear	D - Not Possible	A 81/752 (11%)
Kerrvanto-Seppälä S et al. (38)	Quasi-randomized	C - By use of birthday	B - Unclear	D - Not Possible	A 20%
Rock WP et al. (37)	Quasi-randomized	A - By use of random number tables	B - Unclear	D - Not Possible	A 21/86 (24%)

sealants were resealed during annual evaluations, in the event of being defective or lost.

The trials by Lovadino et al. (32) and Arrow et al. (35) reported significantly greater retention rates for GIC sealants when compared to resin sealants. However, all the other trials reported exactly the opposite; i.e., significantly lower retention rates for GIC sealants. Tostes (33) found no statistically significant difference in the caries preventive effect between the intervention and control groups after 2 years.

Meta-analysis

The assessment for clinical and methodological heterogeneity between trials showed that the two trials (31,38) differed substantially from the others. The Songpaisan et al. (31) trial had DMFT/DFS increment as the outcome measure. The Kerrvanto-Seppälä et al. (38) trial used repeated application of the resin-based sealant material throughout the investigation and included older children (aged 12-16 years). Therefore, neither trial was included in the meta-analysis.

All six of the other trials (32-37) used split-mouth design, had caries incidence on sealed teeth as the outcome measure, used single material application during the investigation, included children aged between 6 to11 years and compared a low-viscosity GIC against a resin-based sealant material. These trials were consequently included for meta-analysis. Data was not presented in a paired way in 3 trials (34,36,37). However, it was possible to calculate the missing data from information provided in the tables (36,37) and in the results section of these articles (34). The result of the meta-analysis is shown in Figure 1. The pooled odds ratio (0.96, 95% CI 0.62-1.49) suggests that neither material is more effective in preventing dental caries in pits and fissures.

Discussion

This meta-analysis was the first to include non-English databases in its systematic literature search to the topic of caries preventive effect of GIC-based fissure sealants in comparison to resin-based materials. Although no publications in the German and Spanish languages were identified, five Portuguese articles (24,25,28,32,33) were included for review and two were accepted (32,33). However, despite this broader approach, other aspects in the methodology might have contributed to limitations in its results: (i) not all relevant publications were listed in the selected databases (ii) not all relevant publications were published in English, German, Portuguese or Spanish; (iii) the chosen strings of search terms may not have been broad enough to have captured all articles listed in the databases. Thus, some relevant studies may not have been identified.

In the three accepted reviews included (2,11,12), methodological issues have been highlighted as being an important determinant in decisions to include or exclude trials. The split-mouth study design is commonly used in dentistry to test interventions and includes the advantage of having an individual serve as both experimental subject and control. However, Mejáre et al. (12) have cautioned against this study design as "randomized", as the common practice of including children with at least one pair of caries-free molars results in exclusion of caries-active children. An obvious selection bias is thus created, as not all children will have the same chance to participate. Mejáre et al. (12) have rightfully suggested that the split-mouth trial design should therefore be regarded as "quasi-randomized". Thus, reviews where inclusion criteria include only randomized-

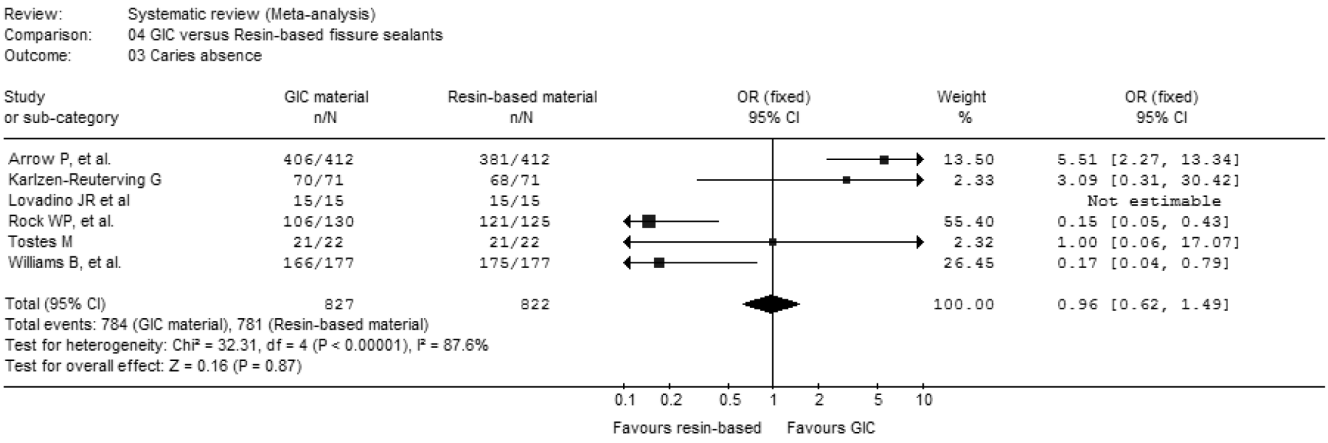

Fig. 1 Caries preventive effect of GIC and resin based fissure sealants.
CI = confidence interval; OR = odds ratio; N = total number of sealants; n = number of sealants with caries absent.

control trials should, in theory, exclude trials that use the split-mouth study design. Additionally, in order to reduce selection bias, trials that seek to assess the caries-preventive effect of fissure sealants should aim to recruit children soon after the eruption of their first molars.

Previous publications (2,12,40) have highlighted a number of factors that could potentially affect the caries-preventive effect of fissure sealants. Only some of the trials have reported on these factors. They include: (a) baseline caries prevalence in the study population (31,35); (b) number of applications of sealant material – single or repeated (31-37); (c) type of sealant material (27-37); (d) follow-up period (31-37); (e) type of tooth and location in jaw (31-37); (f) fluoride content of drinking water (31,36,37); (g) operator factors (31,36); (h) role of other simultaneous preventive measures, e.g., topical fluoride application (none); and (i) frequency of eating sugary snacks (none). The appropriateness of some of the outcomes reported, especially in the GIC trials, should be noted, as these sealants are effective long after being regarded as "lost" or "partially lost" (31,36). This lower/ poor retention rate has been reported in many systematic reviews (2,9,12,41). It has been hypothesized that although the GIC sealants appear clinically as "partially" or "totally" lost, the opening of the fissures remain sealed and the effectiveness of GIC is attributable to the isolation of bacteria from nutrients in the substrate below early carious lesions that have been sealed, the release of fluoride into the dentin or a combination of both factors (41).

In contrast, resin-based sealants have been shown to lose almost all of their protective effect once their retention is lost (36). Hence, the measured outcome of interest when comparing GIC and resin-based sealants should be caries incidence/increment, rather than retention. Resin and GIC sealants both demonstrated a caries-preventive effect, as confirmed in previous systematic reviews (2,11,12). The result of this meta-analysis is in agreement with these previous findings. It is important to note that all accepted trials investigated only obsolete low-viscosity GIC materials and were restricted to 2-3 years. New, high-viscosity GIC materials have been introduced for sealing pits and fissures (29). Clinical application of these materials for sealing fissures differs from the application of low-viscosity GICs. While the latter are applied onto pits and fissures in thin consistency, using a hand instrument, a gloved index finger coated with petroleum jelly (42) is used with pressure to apply high-viscosity glass-ionomer materials. This procedure may achieve deeper fissure penetration of the GIC material than is achieved through the application of thin low-viscosity GIC with a hand instrument. Such deeper fissure penetration of the material may support its higher retention in pits and fissures. Van't Hof et al. (43) showed in a meta-analysis a full retention rate of 72% of high-viscosity GIC fissure sealants, as compared to 50% of low-viscous GIC material, after 3 years. Beiruti et al. (29) reported a four times higher chance of preventing caries in pits and fissures when using high-viscosity GIC applied through finger pressure, than in using resin-based fissure sealants, after 5 years. These results are in contrast to those presented in this meta-analysis and may be indications of the effectiveness of GIC-based fissure sealants in the future. Further high-quality randomized control trials are needed in order to confirm such initial findings.

GIC and resin based sealants exhibited significant caries preventive effects. This systematic review with meta-analysis found no evidence that either material was superior to the other in the prevention of dental caries. Therefore, both materials appear to be equally suitable for clinical application as fissure sealant materials. Further high-quality randomized control trials are needed in order to investigate the caries-preventive effect of high-viscosity GIC compared to resin-based fissure sealant material.

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