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Review

Caries-preventive effect of resin-based and glass ionomer sealants over time: a systematic review

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Abstract – *Introduction:* The difference in preventing dentine lesion development between resin-based and glass ionomer sealant materials is unclear. Two recently published reviews were unable to conclude on the difference because the comparison was an exclusion criterion in one review and there were statistical shortcomings in the relevant papers in the other (Cochrane) review. *Objectives:* The aim of the present investigation was to carry out a systematic review on the caries-preventive effect of these two types of sealant materials under more liberal exclusion criteria concerning the statistical presentations in the publications. *Methods:* Based on five exclusion criteria, the literature search in the electronic libraries PubMed and MEDLINE and the publications retrieved in the Cochrane review, revealed 12 eligible publications for analyses. A variety of glass ionomers and resin-based sealant materials had been applied in the included studies. Attributable risk (AR) was chosen rather than relative risk (RR), as used in the Cochrane review, because RR is very instable in a low caries population. *Results:* There was no consistent pattern observed with respect to the caries-preventive effect of either resin-based or glass ionomer sealants. Therefore, it was impossible to calculate an overall AR. *Conclusions:* There is no evidence that either resin-based or glass ionomer sealant material is superior to the other in preventing dentine lesion development in pits and fissures over time.

Key words: caries prevention; glass ionomer; resin-based; sealants; systematic review

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Sealing pits and fissures is considered a cost-effective way of preventing caries development over a great number of years (1–3). It is generally believed that, if the adhesion property of the sealant material is high, the retention of the sealant is secured (4, 5). The length of retention of sealants and hence resealing after loss of part of the material is, therefore, seen as an important factor in preventing caries development in pit and fissures (6, 7). If the length of retention is considered as the outcome variable for the success of sealants, there is no doubt that resin-based materials score highest of the materials that have been used to seal pits and fissures (4, 5, 8). However, the use of resin-based sealants is not advisable in situations in which the pits and fissures to be sealed cannot be kept moisture-free (5, 9). Such a situation occurs very frequently in the wet oral cavity of a young child. This implies that resin-based materials should not be used if such an unfavourable situation occurs. The use of glass ionomer is recommended instead, but this is considered a temporary measure only (9, 10). This advice is based on a physical outcome (retention) and not on a biological outcome (caries prevention), which, after all, is the prime reason for applying the sealant.

Auto-cured glass ionomers have the added advantage that they do not require electricity and can, therefore, be applied everywhere. If the gold standard in caries prevention through sealants is purely based on a physical outcome, it would deprive many people in areas where there is no

electricity and who are in need of having teeth sealed, from receiving protection through sealants. There is, therefore, a need to investigate the caries-preventive effect of resin-based and glass ionomer sealants over time.

At the 1995-IADR (International Association of Dental Research) symposium on Minimal Intervention Techniques for Dental Caries, Simonsen (11) reported the results of a critical review on glass ionomer cements used as fissure sealants. Based on the six studies that compared resin-based and glass ionomer sealants, Simonsen (11) concluded that 'retention for resin-based sealants is better than for glass ionomer sealants, but differences in caries prevention remain equivocal'. Recently, two structured reviews on the caries-preventive effect of sealants in pits and fissures have been published (12, 13). The review by Mejàre et al. (12) excluded the analysis of differences between glass ionomer and resin-based sealants. The Cochrane review by Ahovuo-Saloranta et al. (13) could not conclude on the caries-preventive effect of glass ionomer sealants versus resin-based sealants.

It was surprising to see the large number of publications devoted to the comparison of resin-based versus glass ionomer sealants and the less number of publications selected for the Cochrane review (13). Most of the publications were excluded because of statistical shortcomings (no pairwise presentation). The aim of the present study was to reconsider the present literature and find a more efficient way to deal with the caries-preventive effect of glass ionomer versus resin-based sealants in a systematic review.

Materials and methods

Search strategy

The search of the literature was carried out using the electronic libraries PubMed and MEDLINE and used the publications retrieved in the Cochrane review. The inclusion criterion was studies in which the caries-preventive effect of resin-based sealants was compared with that of glass ionomer sealants. The following keywords and search patterns were used: 'pit and fissure sealants' or 'fissure sealants' or 'fissure sealing' or 'sealants' (and) 'glass ionomer cements' or 'glass-ionomer cements' or 'GIC' or 'GI cements' or 'polyalkenoate cements' or 'resin-modified glass ionomer cements' (and) 'composite resin' or 'resin-based' or 'resin composite'. The unlimited time search for publications in the English language in both libraries until December 2004 revealed 94 publications. On the basis of abstracts of these publications, 16 publications that had reported about the comparison of resin-based and glass-ionomer sealants were selected. This exercise was carried out independently by two observers (NB and JF). Searching the references of these 16 publications revealed three additional publications (14–16), increasing the total number of initial eligible publications for review to 19.

To be able to analyse the results of the reported studies in these publications, a set of exclusion criteria were set up. These were formulated as follows: (i) not a randomized controlled clinical trial; (ii) no comparison of caries-preventive effect reported; (iii) follow-up period shorter than 1 year; (iv) results not presented at the surface level; (v) no sufficient statistics reported to calculate the relative risk (RR) or attributable risk (AR).

Different types of glass ionomer and resin-based material used for sealing pits and fissures have been reported in the publications referred to. Because of the diversity in types of glass ionomer used, three categories were distinguished. These were medium-viscosity (silver containing plus medium-viscosity), low-viscosity, and low-viscosity resin-modified (cavity liner). The resin-based materials were categorized into auto- and light-cured.

Statistical analyses

There are basically three effect measures on dichotomous outcomes (yes/no caries) used in epidemiological studies, i.e. RR, odds ratio (OR) and AR. In order to calculate the 95% confidence interval (95% CI) for these effect measures in a split-mouth study (Table 1), a contingency table is required. The numbers in the contingency table from all included publications were independently retrieved by JF and WPH. Agreement existed in all publications except for one. Consensus was reached after consultation with the biostatistician (MvH).

Only three publications had presented the caries-preventive effect in a paired manner, i.e. a full-cell contingency table (17–19), taking into account the pairs in the split-mouth studies. In the other publications, only the marginal totals of the contingency table had been reported. This made it impossible to estimate the OR (OR $= b/c$ in Table 1). The RR may be estimated from the marginals as: RR $= (c + d)/(b + d)$ and the AR as: AR $= (c + d)/N - (b + d)/N$ (Table 1). It is not possible to calculate exactly the standard error of the RR or that of the AR if only marginals are

Table 1. Contingency table describing caries incidence in a split-mouth study for N pairs of resin composite and glass ionomer (GIC) sealants

	Resin composite		Marginal distribution
	Sound	Caries	
GIC			
sound	a	b	$a + b$
Caries	c	d	$c + d$
Marginal distribution	$a + c$	$b + d$	N

Estimators for relative risk (RR) and attributable risk (AR) and their standard errors (SE) are given. The number of concordant pairs is $a + d$, and there are $b + c$ discordant pairs. 95% CI may be calculated as estimate ±2SE.
$RR = (c + d)/(b + d)$.
$SE(\ln(RR)) = \text{sqrt}[(c + b)/\{(c + d)(b + d)\}]$.
$AR = (c + d)/N - (b + d)/N = (c - b)/N$.
$SE(AR) = \text{sqrt}[(c + b)/N^2]$.

presented, because the required total number of discordant pairs ($b + c$ in Table 1) is not known. This number of discordant pairs ($b + c$), required to calculate the SE, was guessed in this situation by the maximum of the caries marginals [max(B,D); Table 2]. The validity of this estimator was checked using the data of the three publications that reported a full contingency table. The three true numbers of discordant pairs 43, 23 and 31 were estimated by 44, 23 and 31, respectively, indicating that the estimator could be used to calculate the 95% CI.

Both, AR and RR are well-recognized effect measures, but Ahovuo-Saloranta et al. (13) do not discuss their choice for RR. In the present publication, the AR rather than the RR is chosen, which is very instable in low caries populations, leading to extremely large 95% CI. In the retrieved literature, three publications had applied the RR whereas seven publications suggest (implicity) the application of the AR measure.

Results

Application of the exclusion criteria to the initial 19 eligible publications resulted in the exclusion of seven publications (Table 3) through which 12 publications remained for analyses. All the included publications had used a split-mouth study design.

The following publications report about one and the same study but at different years of evaluation: Forss et al. (20) (year 2) and Forss and Halme (17) (year 7); Williams et al. (14) (year 2) and Williams and Winter (21) (year 3.8). Within publications, results of caries-preventive effect by different years of evaluation have been presented. This resulted in five outcomes at evaluation year 1, seven outcomes at evaluation year 2, six outcomes at evaluation year 3 to 3.8, and one outcome at both evaluation year 4 and 7.

The caries incidence in sealed surfaces, the AR and 95% CI for the caries-preventive effect of the combinations of resin-based and glass ionomer sealants by years of follow up is presented in Table 4. The first column in Table 4 presents reasons for (in-) exclusion of publications by Ahovuo-Saloranta et al. (13). The difference in exclusion of publication between the Cochrane and

Table 2. Estimation of the number of discordant pairs from the marginals (A, B, C, D) of the contingency table (as in Table 1) for two situations (i.e. D is largest and B is largest) in a split-mouth study with N pairs

	$B < D$ (max $= D$)			$D < B$ (max $= B$)		
	Sound	Caries	Marginal	Sound	Caries	Marginal
Minimum						
Minimum possible number of discordant pairs						
Sound	C	$A - C = D - B$	A	A	0	A
Caries	0	B	B	$C - A = B - D$	D	B
Marginal	C	D	N	C	D	N
Maximum						
Maximum possible number of discordant pairs						
Sound	$A - D = C - B$	D	A	$A - D = C - B$	D	A
Caries	B	0	B	B	0	B
Marginal	C	D	N	C	D	N
Average of both extreme numbers of discordant pairs	$[(D - B) + (B + D)]/2 = D$		or $= \max(B,D)$	$[(B - D) + (B + D)]/2 = B$		

The estimation procedure results in: Number of discordant pairs is max(B,D), to be used for the calculation of the standard error in the attributable risk.

Table 3. Listing and reason for exclusion of publication according to inclusion criteria

	No RCT	No comparison of caries-preventive effect	Less than 1 year duration	Results not at surface level	Not possible to calculate RR or AR
Boksman et al. (31)		*	*		
De Luca-Fraga et al. (32)		*			*
Mejàre and Mjör (30)					*
Songpaisan et al. (33)				*	*
Winkler et al. (34)	*				
Smales et al. (16)		*	*		
Smales and Wong (35)					*

the present study is to a very large part due to the absence of paired data in the publications. The table further shows that the AR values of the individual studies are not homogeneously distributed which makes it impossible to calculate an overall AR.

Homogeneity in results was only observed in the combination of light-cured resin composite versus low-viscosity resin-modified glass ionomers as cavity liners. The two studies reporting on this combination (22, 23) showed a statistically significant difference in preventing dentine lesion development between the two types of sealants, with light-cured resin composites performing better.

The combinations light- and auto-cured composite resin versus low-viscosity glass ionomer sealants constituted the largest number of studies; six in total. Five of these six studies had reported results of ≥3 years. There were two studies that showed a statistically significant difference in caries prevention between the two types of sealants. In one study (21), the low-viscosity glass ionomer sealant performed better after 3.8 years, whereas in the other (19) the auto-cured resin composite sealant had performed better after 3 years.

There were four studies which had reported results longer than 3 years: 3.6 years (18); 3.8 years (21); 4 years (24); 7 years (17). Of these four studies, two showed a statistically significant difference in preventing dentine lesion development between the two types of sealants (Table 4). In both these studies, the AR to develop dentine lesions was higher in occlusal surfaces sealed with resin composite than in those sealed with glass ionomer material; AR is 6.1 with 95% CI of 3.4–8.8 (18) and AR is 6.0 with 95% CI of 2.0–9.9 (21).

Discussion

Most probably, the per-protocol methodology of the Cochrane review had made it impossible to analyse most of the studies in which resin-based and glass ionomer sealants were compared. Exclusion of publications in the Review was to a large part due to the presentation of the data in an unpaired way, which made the calculation of the SE in the RR, the eventual effect estimate, impossible. However, for many studies an unbiased point estimate for AR could be calculated from the data in these publications but not the interval estimate. As many unbiased point estimates constitute the valid evidence, they may not be neglected in a systematic review or meta-analysis.

An evidence-based outcome on the difference in caries-preventive effects between the two types of sealants is wanted. Many dentists use glass ionomer as the sealant because resin-based material is either not available or cannot be used because of absence of electricity. The outcome of a structured review like the present study will assist these dentists in providing evidence-based preventive care and would complete the two reviews referred to earlier.

To overcome the methodological problems encountered in the Cochrane review, we decided to use the AR. In general, health policy decisions should be based on ARs and insight into disease mechanisms should be based on RRs. In this context, the use of ARs is more logical than that of RRs. Unfortunately, the absence of homogeneity of the AR in the studies included made it impossible to calculate an overall AR.

The fact that there was no obvious pattern with respect to the caries-preventive effect of the two types of sealant materials in the studies included indicate that there is no evidence that either of the sealant materials prevent caries development better than the other. The conclusion of the critical review by Simonsen (11) that 'differences in caries prevention between resin-based and glass ionomer sealants remain equivocal' still holds true, despite the increase in the number of sealant comparison studies since 1995.

Table 4. Caries incidence in sealed surfaces, attributable risk (AR) and 95% confidence interval (CI) for the caries-preventive effect of resin-based and glass ionomer sealants by years of follow up for various combinations of types of sealants

Combinations of sealant materials used in the included publications	(In)/excluded in Cochrane review	Years of follow up	Incidence in RC sealants (%)	Incidence in GIC sealants (%)	AR (%)	95% CI of AR	*P*-value
Auto-cured RC vs low-viscosity GIC							
Karlzen-Reuterving and van Dijken (29)	Excluded (a)	1	2.8	0.0	2.8	−1.2 to 6.7	NS
Sipahier and Ulusu (15)	Excluded (a)	1	5.8	7.0	−1.2	−6.9 to 4.5	NS
Karlzen-Reuterving and van Dijken (29)	Excluded (a)	2	2.8	1.4	1.4	−2.5 to 5.3	NS
Williams et al. (24)	Excluded (a)	2	2.0	7.1	−5.1	−8.2 to −2.0	<0.01
Karlzen-Reuterving and van Dijken (29)	Excluded (a)	3	4.2	1.4	2.8	−2.0 to 7.6	NS
Poulsen et al. (19)	Included	3	6.3	21.4	−15.0	−21.4 to −8.7	<0.01
Williams et al. (24)	Excluded (a)	4	7.2	9.9	−2.7	−6.9 to 1.5	NS
Light-cured RC vs low-viscosity GIC							
Williams et al. (14)	Not retrieved	2	16.6	12.8	3.8	0.6 to 7.0	0.04
Forss et al. (20)	Excluded (a)	2	4.6	4.6	0.0	−3.5 to 3.5	NS
Williams and Winter (21)	Not retrieved	3.8	19.1	13.2	6.0	2.0 to 9.9	<0.01
Forss and Halme (17)	Excluded (b)	7	16.5	23.7	−7.2	−17.1 to 2.7	NS
Auto-cured RC vs medium-viscosity GIC							
Mills and Ball (36)	Excluded (c)	1	0.0	0.0	0.0	−4.4 to 4.4	NS
Mills and Ball (36)	Excluded (c)	2	0.0	0.0	0.0	−4.4 to 4.4	NS
Arrow and Riordan (18)	Included	3.6	7.5	1.5	6.1	3.4 to 8.8	<0.01
Light-cured RC vs low-viscosity RMGIC							
Raadal et al. (22)	Excluded (d)	1	0.0	2.2	−2.2	−4.8 to 0.3	NS
Rock et al. (23)	Excluded (a)	1	0.6	4.4	−3.8	−7.1 to −0.4	0.03
Raadal et al. (22)	Excluded (d)	2	0.0	3.7	−3.7	−7.0 to −0.4	0.02
Rock et al. (23)	Excluded (a)	2	1.5	12.1	−10.6	−16.7 to −4.5	<0.01
Raadal et al. (22)	Excluded (d)	3	0.0	7.4	−7.4	−12.0 to −2.7	<0.01
Rock et al. (23)	Excluded (a)	3	3.1	18.5	−15.4	−22.9 to −7.8	<0.01

Negative/positive AR indicates that the resin composite sealants had caused less/more dentine lesions than the glass ionomer sealant.
(a), no paired data reported; (b), reason not stated; (c), dropout too high; (d), data reported in unusual way.
RC, resin composite; GIC, glass ionomer cement; RMGIC, resin-modified glass ionomer cement.

There were different types of glass ionomers used in the studies analysed ranging from cavity liners of low-viscosity resin-modified to medium-viscosity glass ionomer. It maybe no surprise that, because of the very low rate of retention, low-viscosity cavity liners resin-modified glass ionomer cement showed a low caries-preventive effect in comparison with light-cured resin composite sealants (22, 23). From the remaining three studies that showed a statistically significant difference in caries-preventive effect between the two types of sealants, two had used a low-viscosity and one a medium-viscosity glass ionomer in comparison with one auto- and two light-cured resin composites. It is remarkable that in the two studies (18, 21) in which a medium-viscosity and a low-viscosity glass ionomer sealant prevented dentine lesion development significantly better than resin composites, the difference in sealant retention between the two types of materials was minimal. In contrast, the difference in sealant retention between the two types of materials used in the third study (19), in which an auto-cured resin composite sealant prevented dentine lesion development better than a low-viscosity glass ionomer sealant, was high. If the length of retention of the sealant was considered a proxy to increased caries prevention in pits and fissures, one would expect that a more viscous glass ionomer, than the frequently used low-viscosity type (Fuji III), would provide superior sealant retention results.

In recent years, high-viscosity glass ionomers have been used as fissure sealants (25–27). These materials were placed in pits and fissures as part of the ART approach under finger pressure to secure a good penetration and adhesion (28). The complete loss of these high-viscosity glass ionomer sealants was reported to be much lower; 26% after 2 years (26), 28% (27) and 29% (25) after 3 years than observed for the complete loss of low-viscosity glass ionomer sealants (Fuji III) after 3 years; 39% (29), 54% (17), 84% (30), 89% (19) and 93% (24). It is, therefore, worth investigating the retention and the caries-preventive effect of these high-viscosity glass ionomers, applied according to the ART procedure using finger pressure, in comparison with resin-composite sealants in a well-designed clinical trial. The outcome of such an investigation would assist the dentists in improving preventive care to their clientele, whether they are employed in areas that are deprived of basic dental equipments and personnel or in areas that are well utilized and staffed but face difficulties in applying resin composite sealants under less-than-ideal circumstances. We conclude that there is no evidence that either resin-based or glass ionomer sealant material is superior in preventing caries development in pits and fissures over time.

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