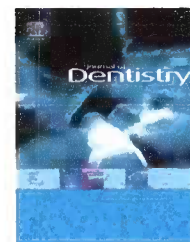




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# Glass ionomer ART sealants in Chinese school children—6-year results<sup>☆</sup>

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## ABSTRACT

**Objective:** To evaluate longitudinally ART sealants placed in Chinese school children under field conditions.

**Method:** 191 ART sealants were placed in 140 children, aged 11–14 years, by five assistant dentists in four secondary schools in Deyang, Sichuan Province, China. Teeth selected for sealing were those with pits and fissures that were deep or showing early enamel caries. Teeth were excluded if there was obvious cavitation extending into dentine. Standard instruments and procedures for ART sealants were used. The material used was a high-viscosity glass-ionomer (Ketac-Molar, 3MESPE) that was inserted into the pits and fissures with the “press-finger” technique. The status of the sealants was evaluated annually over 6 years after placement by the same examiner who was not involved in the placement of the sealants using explorers, mouth-mirrors and an intra-oral fibre-optic light. No missing sealants were replaced during the study.

**Results:** 107 sealants (56% of the original) were examined after 6 years. The cumulative survival rates of the sealants (partially or fully retained) after 2, 4 and 6 years were 79%, 68% and 59%, respectively. Caries prevention lagged the fall in sealant survival but remained high throughout the study period, being over 90% in the first 4 years and 85% after 6 years.

**Conclusions:** ART sealants placed under field conditions in Chinese schoolchildren have a high retention rate. Missing sealants should be replaced to maintain their preventive efficacy.

**Clinical significance:** The sealing of pits and fissures can be an effective caries preventive approach. Resin-based sealants have the disadvantage in that they require an optimal level of moisture control during placement. In children and in outreach situations glass ionomer ART sealants, which are more moisture tolerant, can offer a viable alternative.

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## 1. Introduction

Evidence suggests that up to 90% of dental caries lesions in schoolchildren occur in pits and fissures.<sup>1–3</sup> The concept of sealing vulnerable pits and fissures for the prevention of caries

dates from the early 1920s but sealants only became an efficacious intervention with the introduction of resin-based sealants some 40 years ago.<sup>4,5</sup>

One disadvantage of resin-based sealants is the need to maintain a very dry operating field since moisture contamination during placement is the most frequently cited reason

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for sealant failure.<sup>6</sup> In the traditional dental office setting and in adult patients optimal moisture control might not be so problematic, but in children moisture control might be compromised. Similarly, for care delivered in outreach situations devoid of compressed air and suction, resin-based sealants are usually not an option.

Originally developed in the 1970s, glass ionomer was first described for use as fissure sealants by McLean and Wilson.<sup>7</sup> Glass ionomer is a promising material for sealants since it is considered to be moisture tolerant during the placement procedure; it bonds physico-chemically to enamel and dentine without etching and slowly releases fluoride that can be cariostatic.<sup>8</sup> Glass ionomer specially developed for sealant use has a low powder to liquid ratio and small particle size to enable it to “flow” like resin-sealants into pits and fissures.<sup>9</sup> Unfortunately, such glass ionomer sealants have much poorer retention than resin-based sealants although the caries preventive ability between the materials remains equivocal.<sup>10,11</sup>

The concept of fissure sealing with a type II restorative glass-ionomer introduced into the pits and fissures using positive pressure exerted from an instrument or finger can be ascribed to Blagojevic and Mount.<sup>13</sup> Early studies using such an approach showed promising results when compared to resin sealants.<sup>13,14</sup> The ART approach uses a similar “finger-press” technique to condense the filling material into a cleaned carious cavity while simultaneously sealing residual pits and fissures, thus producing a “sealant restoration”.<sup>15</sup> ART sealants, not to be confused with ART restorations which use the same “press-finger” technique, are recommended for early enamel caries and for caries susceptible pits and fissures where there is no frank cavitation.<sup>15</sup>

To date, rather few studies have been published examining the survival of ART sealants and most of these have been of relatively short duration. The objective of this analysis was to describe the survival of ART sealants placed under field conditions in Chinese school children over a 6-year period.

## 2. Materials and methods

This study was conducted in all four urban secondary schools in Deyang City, Sichuan Province, in western China from 1996 to 2002.

All children in their first year of secondary school, mostly aged 12–13 years, were invited to participate in an oral health survey. The childrens' parents were informed of the survey through the school and were free to opt for their children not to participate. Two dentists (CJH and ECML) then clinically examined the participant children to assess their caries status and treatment needs. The former was assessed according to criteria recommended by the World Health Organization (1987), which did not provide for the scoring of pre-cavitated caries lesions.<sup>16</sup> Tooth treatment needs criteria followed those recommended by WHO with the exception that sealants were indicated only for teeth with signs of early enamel caries lesions without cavitation or with deep pits and fissures.

ART sealants were offered to all screened children with an indicated need for sealants. Teeth that were judged sound with shallow pits and fissures or teeth with obvious cavitation

extending into the dentine were excluded from sealant placement. No refusals were encountered.

All treatment was provided in the schools in late 1996 by five local assistant dentists after they had received a theoretical and hands-on training course in ART provided by an international expert in the approach (CJH) to ensure consistency in its application. No ancillary assistance was available during the provision of the treatment. The children were treated in the supine position by using tables available in the schools as a patient support. Lighting was provided by mains-powered portable lights. All treatment was accomplished using only hand-instruments following procedures as described by Frencken and Holmgren.<sup>15</sup> Isolation was achieved solely through the use of cotton wool rolls.

The pits and fissures were gently cleaned of plaque and food debris with the tip of an explorer ensuring that the tip was not forced into the pits and fissures. The occlusal surface was then washed by rubbing with a moistened cotton wool pellet. After drying the occlusal surface with dry pellets, it was conditioned for 10 s using the liquid component of the glass ionomer material used subsequently for sealing. The pits and fissures were then washed and dried as before. The material used as sealant was a hand-mix, high-viscosity glass ionomer (Ketac Molar, 3MESPE, Seefeld, Germany) that is recommended for use with the ART approach. This was mixed strictly according to the manufacturer's instructions taking care to ensure the correct powder to liquid ratio. The mixed material was then placed into all the pits and fissures and then pressed into the depths using positive pressure from a gloved index finger lubricated with Vaseline, known as the “press-finger” technique. The occlusion was checked with articulating paper and any excess material was removed with a carver or excavator. No varnish or additional petroleum jelly was used to protect the glass ionomer.

The clinical status of the ART sealants was evaluated three months after placement and then annually for 6 years. One examiner (ECML), who was not involved in providing the sealants, performed all the evaluations. WHO periodontal probes, sharp sickle-shaped explorers, plane front-surface mirrors and an intra-oral fibre-optic light source were used in all the examinations. At each evaluation duplicate examinations were carried out on about 10% of the sealants selected randomly.

The retention of ART sealants was recorded according to the codes and criteria shown in Table 1. Only teeth with sealants that were completely missing or replaced by a restoration were classified as retention failures. The caries status of the surfaces that had received an ART sealant was also scored following the codes and criteria shown in Table 2. A caries lesion was scored at the level of cavitation into dentine. Teeth with caries in fissures previously sealed or adjacent to sealants were considered to be prevention failures. In addition, restorations placed in fissures that had previously been sealed were considered to be both sealant and prevention failures.

The collected data were entered onto a Microsoft Excel worksheet and analyzed using SPSS software for Windows on a personal computer. Actuarial life-table analysis was used in sealant survival estimations and the Wilcoxon (Gehan) test

**Table 1 – Codes used for the evaluation of the retention of ART sealants.**

Code	Criteria
0	Sealant completely retained
1	Sealant partially retained
5	Sealant missing
6	Sealant missing, replaced by a restoration
7	Tooth missing, exfoliated or extracted
9	Sealant not assessed, child not present

was used to compare survival estimations between operators and tooth types.<sup>17</sup>

### 3. Results

A total of 1179 children were screened for the need for sealants. Inter-examiner reliability on tooth status at baseline as assessed by the Kappa statistic was very good (Kappa = 0.82). The DMFT and DMFS of these children were 0.51 (s.d. = 2.1) and 0.74 (s.d. = 2.1), respectively. Of these, 140 children were indicated for and received ART sealants. The mean age of these children at baseline was 12.5 years (s.d. = 0.6) with a DMFT and DMFS of 1.2 (s.d. = 1.5) and 1.9 (s.d. = 2.5), respectively. Of the 191 sealants placed, 55% were placed in lower first molars, 24% were in lower second molars, and 14% in upper first molars.

At the 6-year examination, 56% ( $n = 107$ ) of the sealed teeth were available for assessment. Results of the duplicate examinations on sealant status showed very good to excellent intra-examiner reproducibility with kappa values ranging from 0.78 to 1.0 over the 6 years of examinations.

Table 3 shows the status of the sealants at the 2-, 4- and 6-year examinations. Over half of the sealants were retained, either fully (35%) or partly (23%) after 6 years. Fig. 1 shows the results of the life-table analysis. The cumulated proportion survival of fully and partly retained sealants after 6 years was 59% (s.e. = 4%). The survival curves show that over the first 2 years there was a fall in sealant survival of around 10%;

**Table 2 – Codes used for recording the caries status of the teeth that had received an ART sealant.**

Code	Criteria
0	No caries, including sealant present
1	Sealant missing, exposed surface hard (arrested caries)
2	Sealant missing, caries present on exposed surface
3	Caries related to the sealant
6	Sealant missing, a restoration placed
7	Tooth missing, exfoliated or extracted
9	Sealant not assessed, child not present

**Table 3 – Status of the ART sealants after 2, 4 and 6 years (percentages).**

Sealant status	Year 2	Year 4	Year 6
	N = 184	N = 130	N = 107
Success, completely retained	62	50	35
Success, partially retained	17	18	23
Failed, sealant missing	20	29	37
Failed, replaced by a restoration	1	3	5

thereafter the fall became linear at about 5% per year. Extrapolation by fitting a linear regression line showed that the average half-life for sealant retention was of the order of 7 years. There was no statistically significant difference in survival between upper first permanent molars, lower first permanent and lower second permanent molars ( $p = 0.3$ ).

Table 4 shows the caries status of the teeth sealed at baseline after two, four and 6 years. Up to the year-4 examination, more than 90% of the teeth that had received a sealant had not developed a cavitated dentinal caries lesion although only 50% of the sealants were fully retained. Cavitated dentinal caries lesions in relation to a partly retained sealant were rare; none being detected in year-2 and year-4 examinations and only two lesions (2%) detected at the 6-year examination. A further 13 teeth (12%) which developed cavitated dentinal caries lesions were in teeth that had total loss of sealants. Four of these teeth exhibited a hard surface consistent with an appearance of an arrested lesion. Five teeth (5%) had a restoration placed in the pit or fissure that had previously been sealed. Fig. 1 shows that the survival of the tooth in terms of caries prevention lagged behind the fall in sealant survival but remained high throughout the study period, being over 90% in the first 4 years and 85% after 6 years. Of the teeth that developed caries during the observation period, 31% were within the same year as total sealant loss, 53% one year after and 5%, 16% and 11% at 2, 3, 4 years, respectively after total sealant loss.

A comparison of the survival rates of sealants obtained from life table analysis revealed that sealants placed by one of the dentists had a very much higher success rate over the 6-year period ( $p < 0.001$ ) (Fig. 2).

### 4. Discussion

This analysis used data from a larger study that was primarily established to evaluate the clinical performance of ART restorations on a longitudinal basis.<sup>18</sup> While 3-year results for ART sealants from this study have been published,<sup>19</sup> there remains a paucity of studies on ART sealants using high-viscosity glass ionomer, although the ART approach was developed some 25 years ago.<sup>20,21</sup> Unfortunately, with the exception of two Syrian studies,<sup>22,23</sup> most ART sealant studies are of relatively short duration<sup>24,25</sup> and this current analysis is the first to report on the 6-year survival outcomes for ART sealants.

The length of the study meant that, although the sample attrition rate in this study was low up to the 3-year evaluation,<sup>19</sup> thereafter the rate increased as children left school to seek employment or to follow higher education.



**Table 4 – Caries status of teeth sealed at baseline after 2, 4 and 6 years (percentages).**

Caries status	Year 2	Year 4	Year 6
	N = 184	N = 130	N = 107
No caries, including sealant present	98	92	81
Sealant missing, exposed surface hard (arrested caries)	0	0	4
Sealant missing, caries present on exposed surface	1	5	8
Caries related to the sealant	0	0	2
Sealant missing, a restoration placed	1	3	5

Substantial efforts were therefore required to follow the participants over this time. This was achieved through telephone contacts and by visits to multiple sites in order to reduce the attrition rate to just over 40% for the 6 years.

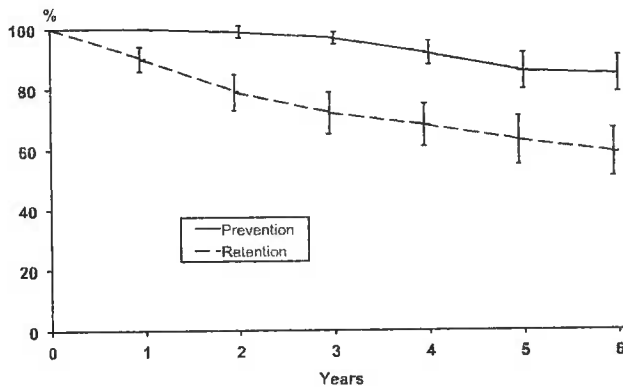
The short term results from the present study are consistent with the 3-year survival results for ART sealants reported by Frencken et al., in Zimbabwe, for children of a similar age using Fuji IX<sup>®</sup>, another high viscosity glass ionomer,<sup>24</sup> and with the 2-year survival results from Chen et al. for ART sealants, using Ketac Molar<sup>®</sup>, in 7-9 year-old Chinese children.<sup>26</sup> Much poorer survival results for ART sealants have been reported in the two 5-year studies using ART sealants in young Syrian children.<sup>22,23</sup> In these studies, the cumulative survival for fully or partially retained ART sealants was in the region of only 12% after 5 years which compares very poorly with the 59% survival after 6 years in this present study. The difference could be due to several factors including the age when the sealants were provided in the Syrian subjects with the possible problems with saliva control. It should, however, be noted that the poor results in one of the Syrian studies were not restricted to ART sealants since only 14% of resin-based sealants were retained after 5 years.<sup>27</sup>

An earlier study on ART sealants in Zimbabwe, using a glass ionomer not specifically formulated for ART, reported only 50% sealants survival after 3 years.<sup>27</sup> The better results for ART sealants seen when high-viscosity glass ionomers are used are probably because they are faster setting and thus achieve moisture resistance earlier; they are stronger and more wear resistant.

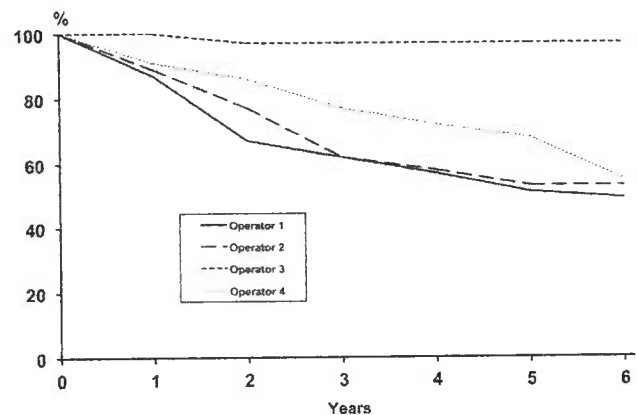
In the current study, as with some previous ART sealant studies,<sup>24,26,27</sup> the criteria for selection of teeth to be sealed were teeth with signs of early enamel caries lesions without cavitation or with deep pits and fissures. The sealing of teeth with early caries lesions might be contrary to common practice for the placement of sealants,<sup>28</sup> a review by Griffin et al., concluded that the sealing of non-cavitated caries lesions in permanent teeth is effective in reducing caries progression.<sup>29</sup> In this respect there might also be an advantage in terms of cost effectiveness if sealant applications are targeted only to teeth with early enamel occlusal caries lesions.<sup>30</sup>

Many previous research reports and reviews have principally addressed sealant retention, a proxy outcome of sealant success. The true biological endpoint is whether the sealant procedure has been able to prevent or arrest a dental caries lesion. This endpoint must take precedence especially for bioactive materials such as glass ionomers that exert a role that is not limited to sealing. More recent reviews have addressed the caries preventive effect of sealants, the reason why sealants are placed in the first place.<sup>31</sup> In the present study, the majority of non-cavitated occlusal caries lesions sealed with ART sealants placed under field conditions failed to progress to cavitation over a period of 6 years. This is important since non-invasive management of early lesions, such as the placement of sealants, can prevent the tooth being entered into the repeat restoration cycle with the associated lifetime costs.<sup>32</sup>

It is interesting to observe that cavitation due to caries occurred very rarely in ART sealed teeth even when the



**Fig. 1 – Life-table analysis showing the cumulated proportion survival of fully and partly retained sealants in terms of retention and caries prevention (error bars show the 95% confidence intervals of the estimated mean).**



**Fig. 2 – Life-table analysis showing the cumulated proportion survival of fully and partly retained sealants according to operator.**

sealant was partially missing; only two cases were observed. In addition, cavitation was relatively infrequent even when the sealant was clinically totally missing. This might be due to some glass-ionomer still being retained in the deeper parts of the fissure and therefore continuing to offer protection against caries even though the sealant was clinically undetectable,<sup>33</sup> or hyper-mineralisation of the pits and fissures by the glass ionomer.<sup>34</sup> Conversely, some of the previously sealed surfaces did progress to cavitation and therefore, if the objective of a sealant programme is to totally prevent cavitation on occlusal surfaces, then teeth in which there has been a total loss of sealant should be resealed. In a school oral health programme, yearly oral health screening by, for example in the Chinese situation, a suitably trained school nurse, could rapidly detect those children who had missing sealants. Further studies would be required to ascertain whether this would be economically justified.

In this study, restorations placed in fissures that had previously been sealed were considered to be both a sealant and a prevention failure. This might have led to a small overestimate of preventive failure since it is possible that dentists in Deyang, as elsewhere,<sup>28</sup> intervene restoratively at a stage earlier than when there is frank cavitation.

Although all operators had followed a hands-on training course on the ART approach, as with other ART sealant studies, an operator effect was observed with one operator having a far higher success rate than the other operators. There did not appear to be any obvious reason for this difference.

One limitation of this study was that a control group of subjects who did not receive sealants or a positive control using resin-based sealants was not included. This is because, the objective of this study, which started in 1996, shortly after the first ART field studies, was to evaluate on a longitudinal basis the survival of ART sealants placed under field conditions. Therefore the prevented fraction of the ART sealants in preventing pit and fissure caries in this study population could not be assessed.

The 1995 Chinese National Oral Health Survey reported the overall DMFT for 12 year olds in China to be 1.03 (DT = 0.91, MT = 0.01, FT = 0.11) while that for Sichuan children of the same age was 0.52 (DT = 0.45, MT = 0.01, FT = 0.16). This is very close to the results for the children indicated for sealants at the screening examination. However, those children who entered the sealant component of this study had a caries experience, expressed by both the DMFT and the DMFS diagnosed at the cavitation level, which was over twice that of all the children screened. This implies that the caries risk for the study children, was potentially higher than the 1995 norm for Deyang schoolchildren, which could be considered to be generally low.

It could also be hypothesized that if the sealants had been placed at an earlier age on only the lower teeth this would have resulted in a considerable reduction of teeth requiring restoration or extraction. For example, in the 1179 children who were screened at the start of the study, 269 ART restorations were required at baseline because of the presence of cavitation and 47 teeth were indicated for extraction.<sup>18</sup> If the children had been screened at an earlier age and sealants placed for those teeth diagnosed with enamel caries or to be at

risk to caries, development of caries into dentine would have been avoided. Additional research is required to compare the relative cost effectiveness of ART and resin-based sealants carried out under similar operating conditions in both high and low risk to caries populations.

The findings of this study suggest that ART sealants using a high-viscosity glass-ionomer provide a useful alternative to resin-based sealants for situations where conventional dental equipment might not be available or where moisture control might prove problematic. The armamentarium required for ART sealants is extremely minimal comprising only a mirror, probe, tweezers and placement instrument. This has a direct bearing on the cost and practicability of establishing a sealant programme and the setting where it can be provided. For example, for a school based sealant programme there would be no need for the expensive portable equipment required for resin-based sealant provision. Moreover, in situations where there is an unreliable electrical source, as exists in many developing countries, resin sealants would not be an option. One concern however with the use of high-viscosity glass-ionomers for fissure sealants is that the standard dose-size provided by manufacturers is tailored more to the amount required for a small restoration than for a sealant even if more than one sealant is provided per quadrant at a time. This results in wastage of the material with obvious cost implications. In this respect manufacturers should investigate the possibility of smaller dose-sizes specifically for ART sealants, thereby reducing the unit cost per sealant.

With China's rapid modernization and a shift to a more western and cariogenic diet there is a risk that there could be an explosion of dental caries unless effective countrywide oral health preventive strategies are adopted. One component must be the appropriate use of fluoride with emphasis on fluoride toothpaste,<sup>35</sup> possibly combined with arresting caries treatment for primary teeth,<sup>36</sup> linked with the use of ART sealants for permanent teeth, notwithstanding the need for further corroborative research on these two latter approaches. In this respect, the feasibility and affordability of an oral health package involving school-based toothbrushing with fluoride toothpaste,<sup>37,38</sup> combined with arresting caries treatment and a targeted ART sealant programme delivered in schools should be evaluated.

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## 5. Conclusion

ART sealants placed under field conditions in Chinese schoolchildren have a high retention rate. Missing sealants should be replaced to maintain their preventive efficacy.

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## Conflict of interest

None declared.

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