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# Loss of sealant retention and subsequent caries development.

S. Tianviwat[1], V. Chongsuvivatwong[2] and B. Sirisakulveroj[3]

*[1]Prince of Songkla University, Faculty of Dentistry, Songkhla, Thailand. [2]Prince of Songkla University, Epidemiology Unit, Faculty of Medicine, Songkhla, Thailand. [3]Songkhla Provincial Health Office, Dental Public Health Division, Songkhla, Thailand*

***Objectives*** To assess the transition process of sealant retention and to determine the effect of sealant loss on subsequent caries. ***Risk design*** A follow-up study from the day sealants was applied by dental nurses, every six months over a period of 30 months. ***Setting*** Mobile dental clinics at primary schools in Songkhla, Thailand. ***Participants*** 206 first grade primary school children, with 383 first permanent molars. ***Outcome measures*** Intermediate outcomes were: three categories of sealant retention: full retention, partial retention and missing sealant. The final outcome was whether occlusal caries was present or not. ***Results*** The percentages of occlusal surfaces of first permanent molars which were at risk (caries free) at time points 6, 12, 18, 24 and 30 months which became carious during the subsequent six months were 2.4, 8.00, 7.4, 5.4 and 6.1 respectively. Caries incidence was highest in the first year after sealing. Odds ratio of conversion from non-caries to caries between partial retention and missing sealant was 3.07 and between full retention and missing sealant, 0.27. ***Conclusion*** Under high caries risk and low retention rate settings, partial retention posed a high risk of caries, suggesting an urgent need to improve sealant performance.

*Key words: Dental caries, dental sealant, first permanent molars, mobile dental clinic, odds ratio, primary school children*

## Introduction

In many developed countries, community sealant programmes, especially school sealant programmes, have been successfully employed (Messer *et al.*, 1997; Parnell *et al.*, 2003). In Thailand, such programmes have been implemented for eight years in many areas via mobile dental clinics in order to increase accessibility for sealants. However, the results revealed a questionable preventive effect for example an evaluation showed 70-78% sealant loss (Thipsoontornchai, 2003; Tianviwat *et al.*, 2001).

Studies reported that partial retention has a lower caries rate than non-sealed teeth or missing sealant teeth (Ismail and Gagnon, 1995), while others indicated that partial retention and missing sealant shows no difference of caries preventive effects (Chesnutt *et al.*, 1994). All of these studies, however, were conducted in developed countries where the risk of caries is low and the services are in well-equipped clinics. In developing countries with high caries rates and where sealant programmes are run from a mobile clinic, the effect of sealant loss, which is common, on caries risk has never been examined. This knowledge can help evaluate cost-effectiveness of the sealant programme in developing countries in addition to the attempt to improve sealant retention.

The objective of the present study was to evaluate the effect of sealant status (full, partial and missing retention) on subsequent caries risks.

## Method

The design was a longitudinal single group study, with a school-based sealant programme. A concurrent control group was considered not possible due to the fact that the sealant programme was accepted as a standard national service. However, since retention is a significant property of the sealant, the comparison of caries risk could be made between teeth in which previously placed sealants were fully retiained, partially retained or lost completely.

Among the 14 Southern provinces of Thailand, Songkhla is one of the most developed provinces, but it has high caries prevalence both in primary dentition and in permanent dentition. The dental division (2002) reported that the average dmft is 7.4 among 5-6- year-old children and the average DMFT is 1.9 among 12-year-old children. Among 19 Contracting Units for Primary Care (CUP), 12 of them have implemented mobile dental services including sealants. The services are school-based carried out by the dental health section of the community hospital, which visits all schools at least once a year. Each school visit lasts 1-2 days. The mobile dental clinic, with portable field equipment, was transported from the CUPs to schools by a van. The equipment includes a patient chair, a portable artificial light, an operator stool, a master unit with slow-speed and high-speed handpieces with a triple syringe, a portable suction and a light polymerization unit. The temporary clinics are usually set up in an available area at the schools.

The target population of this study was first grade primary school children who had fully erupted and caries-free first permanent molars. Multi-stage random sampling was employed. Six out of 12 CUPs were randomly selected and then one or two schools from 12-40 schools in each selected CUP were used. The final total number of schools selected was 11. In each selected school, all eligible children with parental or guardian consent were

Correspondence to: Dr. Sukanya Tianviwat, Prince of Songkla University, Faculty of Dentistry, Department of Preventive Dentistry, Songkhla, 90112, Thailand. E-mail:sukanya.ti@psu.ac.th

included. For all children, the selected teeth were sealed by six dental nurses who attended a refresher course at the Faculty of Dentistry during 1999-2000. For sample size calculation, the main hypothesis to test the difference of proportion of caries among partial retention and missing sealant was based on, $\alpha = 0.05$ and $\beta = 0.20$. It was expected that the ratio of partial retention to missing sealant would be 1:1, and the proportion of caries among partial retention would be 0.15 and among missing sealant would be 0.27 (Tianviwat et al., 2001). For each group, the required sample size was 160. Taking into account that 10% of the subjects would have complete retention, and the average eligible teeth per subject being two and loss to follow-up rate of subjects being 10, the total sample size was then 355 teeth from 198 subjects. The acquired sample size in this study was 206 children.

Caries-free first permanent molars with deep grooves were chosen for this study. Light cure white sealant was used (Concise®, 3M dental products). The application was carried out according to the manufacturer's instructions. All subjects were then followed up at an interval of six months over a period of 30 months for sealant retention, caries and hygiene of the teeth by the same dentist. The follow-up examinations were performed at schools using artificial light, mouth mirrors, standard explorers and dental probe. Sealant retention, which was the intermediate outcome, was classified as fully retained, partially retained and missing sealant, according to Simonsen's criteria (Simonsen, 1991). The detection of caries or final outcome was discoloration of the occlusal surface and sticking with gentle probing. The Debris Index of Simplified Oral Hygiene Index was applied to measure hygiene of each sealed teeth. Reproducibility of the examiner's results was tested by two examinations, three days apart, on 15 children. The Kappa value for agreement was 0.75 for sealant retention and caries, and 0.74 for hygiene of teeth. The examiner was the first author, S. Tianviwat.

All data were entered using Epidata version 2.1b (Lauritsen, *et al.*, 2001-2003) and R programme version 2.0.1 (R Development Core Team, 2004). Descriptive statistics were used to report the frequency of sealant retention and caries, and transition probability from one state to another state of sealant retention. Three states of the sealed teeth were defined as (Figure 1): full retention (F), partial retention (P) and missing sealant (M), which was the absorbing state. The cycle length was six months. The Markov process is defined as;

$$X_i=(X_{i1},..,X_{iTi}),$$

which represent the observed states for the $i^{th}$ subject from the first to the last point of time, $T_i$, which is different discrete time points. The Markov model assumes that the current response variable is dependent on the history of immediate previous response. Therefore, the mathematical definition of the probability that a sealed tooth experienced a change in each state within a specified time period is;

$$(N_0^{'} - N_t^{'})/N_0^{'}.$$

Where $N_0^{'}$ represents the number of the teeth eligible to transit at the beginning of the interval, and $N_t^{'}$ represented the number of teeth remaining eligible to transit at time $t$ or the end of the interval (Miller and Homan, 1994).

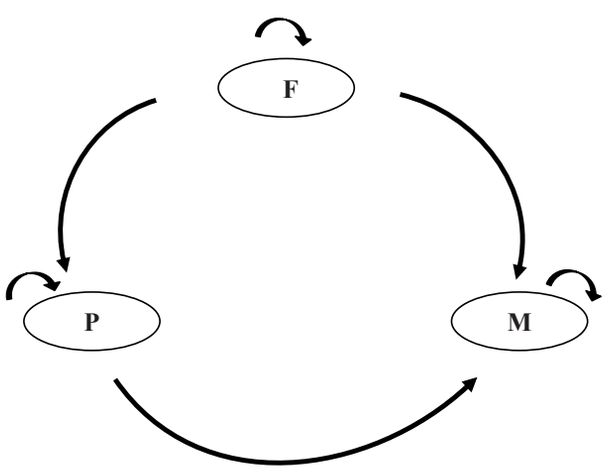
The hypothesis tested in this study was that preceding incomplete retention (partial retention or missing sealant) among caries-risk children under poor conditions of sealant application might affect the current caries status on the sealed surface. However, other factors such as preceding hygiene of the tooth, gender, jaw and baseline caries risk of the individual child should be adjusted for.

Multi-level logistic regression using "glmmPQL" in libraries "nlme" (Pinheiro, *et al.*, 2004) and "MASS" (Venables and Ripley, 2002) under the R software was employed in order to deal with the hierarchical structure of the data, which in this study observed more than one tooth of each child. The random intercept model expressed as (Snijder and Bosker, 1999);

$$\log\left(\frac{P_{ijt_i}}{1-P_{ijt_i}}\right) = \gamma_{000}+U_{oj0}+\beta_1 x_{1ij(t-1)_i}+\beta_2 x_{2ij(t-1)_i}+\beta_3 x_{3ij0}+\beta_4 x_{40j0}$$

Where $P_{ijt_i}$ was the probability of getting caries of the $i^{th}$ tooth of the $j^{th}$ child. $\gamma_{000}$ was the population average intercept of the logit and $U_{oj0}$ was the random deviation from this average for the $j$ child. $x_{1ij(t-1)_i}$, $x_{2ij(t-1)_i}$ and $x_{3ij0}$ were individual tooth preceding retention status, preceding hygiene of the tooth and upper/lower jaw. $x_{40j0}$ was gender of the child. Random effects were from the intercept or the individual subjects. In other words, the model allowed individual children to have a different random baseline risk of caries while the effect of retention and other covariates were assumed equal for all children. The results are displayed as the coefficients, standard errors, and odds ratios ($e^{\beta}$) of each independent variable.

The study was approved by the Ethical Committee of the Faculty of Dentistry, Prince of Songkla University. After examination, oral health education was provided and caries cases were referred to responsible CUPs for proper treatment.




*F = full retention*
*P = partial retention*
*M = missing sealant*

**Figure 1.** *Markov model for sealant retention*

**Table 1** Distribution of sealant retention and caries by follow-up time among 332 complete follow-up teeth.

| *Time (t)* | *Full* | | *Partial n (C)* | *Missing n (D)* | *Caries status* | | |
|---|---|---|---|---|---|---|---|
| | n (A) | % of preceding stage (B) | | | Previous caries (E) | New caries (F) | % caries among preceding at risk teeth (G)* |
| 0 | 332 | - | - | - | - | - | - |
| 6 | 223 | 67.16 | 76 | 25 | - | 8 | 2.41 |
| 12 | 182 | 81.61 | 91 | 25 | 8 | 26 | 8.02 |
| 18 | 136 | 74.72 | 99 | 41 | 34 | 22 | 7.38 |
| 24 | 115 | 84.55 | 86 | 60 | 56 | 15 | 5.43 |
| 30 | 102 | 88.69 | 76 | 67 | 71 | 16 | 6.13 |

* $G_t = F_t / (A+C+D)_{t-1}$

**Table 2.** Transition probabilities "from full retention" among occlusal surfaces of 332 sealed permanent molars by times.

| *Time (months)* | | *Full* | *Partial* | *Missing* |
|---|---|---|---|---|
| 6 | *From full retention to state* | .67 | .25 | .08 |
| 12 | | .82 | .18 | 0 |
| 18 | | .75 | .23 | .02 |
| 24 | | .85 | .15 | 0 |
| 30 | | .89 | .11 | 0 |

**Table 3.** Transition probabilities "from partial retention" among occlusal surfaces of 332 sealed permanent molars by time*.

| *Time (months)* | | *Partial* | *Missing* |
|---|---|---|---|
| 12 | *From partial retention to state* | .88 | .12 |
| 18 | | .80 | .20 |
| 24 | | .81 | .19 |
| 30 | | .87 | .13 |

*no data at six months since all teeth start from "full" stage.

**Table 4.** Coefficient, standard error, odds ratio and p-value from multi-level logistic regression with random intercept.

| *Variables* | *β* | *SE* | *OR* | *P-value* |
|---|---|---|---|---|
| Partial retention [1] | 1.12 | 0.33 | 3.07 | <0.01* |
| Full retention [1] | -1.31 | 0.36 | 0.27 | <0.01* |
| Hygiene level 2 [2] | -0.22 | 0.27 | 0.80 | 0.42 |
| Hygiene level 3 [2] | 0.81 | 0.28 | 2.24 | <0.01* |
| Lower jaw | 0.64 | 0.23 | 1.89 | 0.01* |
| Girl | -0.07 | 0.33 | 0.93 | 0.83 |

Random effects: Intercept = -3.46
Standard Deviation = 1.69

Reference value: [1] : Missing sealant
[2] : Hygiene of the sealed tooth level 0 and 1 combined

*Significance level, p-value less than 0.05

## Results

### *Baseline characteristics*

Twenty-two children (with 51 teeth) out of 206 children (383 teeth) were lost to follow-up sometime during the follow-up period, mainly due to moving to other schools. Thus, 184 children (78 boys and 106 girls) remained in the analysis.

### *Sealant retention and caries*

The distribution of sealant retention and caries among 332 teeth, which had completed follow-up, is presented in Table 1. The rate of any sealant loss (100%-column B) tended to decrease with time. During the first cycle, 2.4% of sealed teeth were affected by caries. After this the rate ranged between 5.4-8.0%. Of the 332 sealed teeth, 102 (30.7%) fully retained the sealant and 245 (73.9%) were caries free at 30 months.

### *Transition probability of sealant retention*

The transition probabilities (Tables 2-3) from one state to another varied with time. Starting each cycle among those with full retention (Table 2), the chance of losing the sealant partially was high but decreased over time. From Table 3, among the teeth, which already had partial retention, the chance of becoming completely unsealed was between 0.12 and 0.20.

### *Effect of preceding sealant status and current caries*

In Table 4, using missing sealant as the reference group, partial retention significantly increases odds of getting caries by three times, whereas full retention reduces the odds by three quarters after adjustment for preceding hygiene of the tooth, jaw and gender.

## Discussion

In this study, the incidence of sealant loss was high, as was the overall caries risk. The first six months was the most vulnerable period for sealant retention, as only two-thirds remained intact, while one quarter became partially lost. Caries incidence surged in the second and subsequent six months. Compared with missing sealant, partial loss increases the risk for caries in the subsequent six months by three times, whereas complete retention effectively prevents caries.

Early loss of sealant retention may be related to saliva contamination which is difficult to avoid in a mobile dental clinic. The higher incidence of sealant loss when compared with other studies conducted in developed countries (Bravo *et al.,* 1996; Wendt *et al.,* 2001) might be explained by various factors including application conditions, the type of operator and baseline caries risk (Llodra *et al*., 1993). However, the rate of sealant loss was less than the previous evaluation in the same province (Tianviwat *et al.,* 2001). This improvement might have been the result of the training.

Post-sealed caries in the first six months may be due to some initial or arrested caries missed in the pre-sealant screening and included in the service. Clinical diagnosis of fissure caries is a complicated and frequently unreliable procedure. Sealant has been advocated despite incipient caries based on the evidence that there is only minimum progression of caries under sealant as long as the sealant remains intact (Mertz-Fairhurst *et al.,* 1986). In the setting of high sealant loss as ours, this recommendation may need to be reviewed.

Our findings showed possible harmful effects of partial loss. The odds of becoming carious within a six-month period is three times higher for teeth with partial retention compared with totally missing sealant teeth and over 11 times higher if full retention is the reference group (further details of the analysis is available from the authors). This result is in contrast to the previous findings (Chesnutt *et al.*, 1994; Ismail and Gagnon, 1995). The reported effectiveness of partial retention was explained by resin tags on the groove, which can still prevent caries. In our setting, with difficulty in controlling moisture under field conditions, this kind of resin tag may not exist, leaving a bare fissure surface for caries to develop. Moreover, the ledge presenting in partial loss of sealant might promote food and bacteria to impact in the same way as it occurs in a broken filling. However, the risk of partially retained sealant teeth to become caries was much higher than other studies. Partial retention of sealant seems to enhance other existing local risk factors that need further investigation.

The association between sealant loss and caries in this study was based on longitudinal observation. Partial retention was shown to precede caries. However, the design does not exclude the possibility that these two outcomes (sealant loss and caries) are, in fact, results from one or more common factors. In other words, there might be a local condition that promotes caries and at the same time accelerates sealant loss. For example, caries prevalence in primary dentition, which is known to be associated with caries in permanent dentition (Li and Wang, 2002), is also associated with sealant loss (Bravo *et al*., 1996). Moreover, deep fissure morphology, which is significantly related to having less penetration ability in sealants (Duangthip and Lussi, 2003) may affect its subsequent retention. Such explanations need to be examined by further research.

Our study had a six monthly follow-up schedule, which showed a relatively low rate of loss to follow-up (11% in 30 months) allowing for closer examination of the changes. The data however contains no information on any unsealed group, making it impossible to calculate protective efficacy of the sealant.

Failure to have full retention is thus an important risk factor for caries. Further attempts should be made to achieve higher full retention rate. Comparisons between such a mobile service for school children, who have low accessibility to oral health care, and hospital-based services with better equipment for moisture control but poor accessibility for school children needs to be studied further.

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