Effect of Caries Experience in Primary Molars on Cavity Formation in the Adjacent Permanent First Molar

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Key Words

Caries incidence · Deciduous molars · Permanent first molars · Survival analysis

Abstract

This study sought to address the influence of a sound versus affected first and/or second deciduous molar on the incidence of visible caries experience in the adjacent permanent first molar. Clinical and questionnaire data were obtained from a 6-year prospective oral health screening project in Flanders, Belgium (Signal-Tandmobiel[®] project), where 4,468 children (born in 1989) were examined annually during their primary school time. A multiple survival model allowing for dependent data with possible censoring was applied. The impact of timing of tooth emergence (determining the period at risk), gender, presence of sealants and reported oral hygiene habits was also considered. Cavity formation in permanent first molars was clearly influenced by the status of the adjacent primary molars; the effect of the second deciduous molar was most pronounced. Moreover, if both deciduous molars experienced caries and the child presented with poor oral hygiene, a peak in cavity formation of the permanent first molar 1–2 years after emergence was noticed. On the other hand, if a child presented with good oral hygiene, no peak was observed; caries risk increased slightly over time. No significant benefit from restoring primary molars could be demonstrated, possibly because of methodological limitations.

The relationship between caries experience in the primary and permanent dentition has been pointed out in many publications [Honkala et al., 1984; Heidmann and Poulsen, 1986; Greenwell et al., 1990; Raadal and Espelid, 1992; Arrow, 1997; Powell, 1998; Mejare et al., 2001; Vanobbergen et al., 2001; Li and Wang, 2002]. Gray et al. [1991] concluded that caries experience in three or more deciduous molars at the age of 5 was the best predictor of caries experience in the permanent first molars at the age of 7. In a previous study in Flemish children multiple survival analyses confirmed the major impact of the status of the deciduous dentition in addition to occlusal plaque accumulation, reported brushing frequency and gender on the incidence of visible caries experience in permanent first molars [Leroy et al., 2005]. In these analyses, caries experience in the deciduous dentition was assessed at baseline (mean age: 7.1 years) and added to the model as a dichotomous covariate.

In the knowledge that caries is an infectious disease [Caufield and Griffen, 2000] and that the bulk of caries experience in the deciduous dentition of schoolchildren is situated in the primary molars – teeth that are adjacent to the permanent first molars for about 5–6 years – the question arises what the effect of an affected first and/or second primary molar is on the incidence of visible caries experience in the adjacent permanent first molar. Therefore, the purpose of the present study was to analyze the effect of sound versus decayed and/or restored deciduous molar(s) on the survival of the permanent first molars in the same quadrant. In the analyses the impact of timing of

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Table 1. Sample characteristics of the Signal-Tandmobiel® project

	Survey					
	1996	1997	1998	1999	2000	2001
Children examined	4,351	3,899	3,677	3,540	3,239	3,291
Girls, %	48.13	48.19	48.55	48.56	49.46	49.13
Boys, %	51.87	51.81	51.45	51.44	50.54	50.87
Mean age (SD)	7.08 (0.41)	8.08 (0.39)	8.96 (0.39)	9.80 (0.39)	10.71 (0.40)	11.58 (0.36)
Median number of deciduous teeth (Q1–Q3)	15 (13–18)	12 (12–14)	12 (10–12)	10 (7–12)	6 (2–10)	2 (0–6)
Median number of permanent teeth (Q1–Q3)	8 (6–10)	11 (10–12)	12 (12–13)	13 (12–16)	17 (14–22)	22 (18–26)
Caries-free (permanent and deciduous dentition), %	41.69	34.19	29.08	28.14	33.40	42.05

SD = Standard deviation; Q1 = first quartile; Q3 = third quartile.

tooth emergence (determining the period at risk), gender and reported oral hygiene habits was also considered.

Materials and Methods

Data Set

The data used in this study were obtained in the Signal-Tandmobiel® project, a longitudinal prospective (1996–2001) oral health screening project in Flanders, Belgium. For this project 2,315 boys and 2,153 girls were examined on a yearly basis during their primary school time by trained dentist-examiners; at baseline the mean age of the children was 7.1 years (table 1). Data on oral hygiene and dietary habits were obtained through structured questionnaires, completed by the parents. The details of the study design and research methods have been described in detail [Vanobbergen et al., 2000].

The presence of caries was scored visually and recorded (at cavitation level) according to the diagnostic criteria published by the BASCD [Pine et al., 1997]. The interobserver kappa coefficient indicated an acceptable agreement between the 16 examiners and the benchmark examiner (κ ranged between 0.72 and 0.91) [Landis and Koch, 1977]. The presence of plaque on the occlusal surfaces of permanent first molars was assessed using a simplified version of the index described by Carvalho et al. [1989]. At each examination the emergence status of all permanent teeth was recorded. Every individual permanent tooth was scored according to its clinical eruption stage [adapted from Carvalho et al., 1989]. The grades were: P0 = tooth not visible in the mouth; P1 = occlusal surface only partially erupted; P2 = occlusal surface fully erupted, but less than half of the buccal surface erupted; P3 = more than half of the buccal surface erupted, no antagonistic contact; P4 = fully erupted and full occlusion.

Clinical and questionnaire data were entered directly in a database using the Dental Survey Plus® Program, version 4.50 b (Providence Software) and converted into SAS® files (version 8.2) for statistical analyses [SAS, 2002].

Data Analysis

Outcome Variable

The survival time of a permanent first molar was defined as the time from tooth emergence to the time when a permanent first molar was recorded as decayed, restored or extracted because of caries. These data are doubly censored: neither the exact date of tooth emergence nor the moment at which a caries lesion fulfilled the clinical criteria for being diagnosed as caries is exactly known. As it has been demonstrated that in case of censored data a midpoint approach may lead to invalid inferences [Parner et al., 2001], we opted not to compute point estimates, but to enter timing of emergence and caries experience as interval-censored data in the analyses. Based on the clinical eruption stage at the moment of examination, the left side of the time interval during which the permanent first molar had pierced the gums was approximated for every permanent first molar:

- P1: [age at examination minus 0.25 year; age at examination];
- P2: [age at examination minus 0.50 year; age at examination];
- P3: [age at examination minus 1.00 year; age at examination];
- P4: [5 years old; age at examination].

The rationale for the lower limit of the last interval was based on data from other European countries where it was observed that permanent first molars hardly ever emerged before the age of 5 [Kochhar and Richardson, 1998; Ekstrand et al., 2003]. About 85% of permanent first molars had emerged at the first examination, these data are called left censored data. For the present study, a permanent first molar was excluded from further analyses if it had experienced caries before the first examination, because then it was impossible to assess its survival time. Moreover, as it was intended to evaluate how the state of the primary molars affected cavity formation in the adjacent permanent first molar and one cannot rule out the concurrent initiation of any caries process on a primary and permanent molar, this exclusion criterion prevented any 'chicken-and-egg problem'.

From the obtained survival curves, hazard functions were deduced; they express the 'instantaneous risk' for a permanent first molar to be diagnosed with cavity formation.

Explanatory Variables

The choice of explanatory variables was based on the results of a previous study in the same sample [Leroy et al., 2004] where multiple survival analyses revealed that the state of the deciduous dentition, occlusal plaque accumulation, reported brushing frequency and gender had a significant effect on cavity formation in permanent first molars. At the examination where the presence of the permanent first molar was first recorded, the state of the adjacent primary molars was assessed; this score was used as explanatory variable. The presence of sealants on the occlusal surfaces of the permanent first molars was also taken into account.

In order to correct for the emergence interval, this covariate was kept in the model (although possibly no longer significant). Since information on this parameter was obtained through censored data, it was adjusted before being added as covariate to the model. The data were categorized into three emergence intervals: [...–6], [6–7] and [7–...] years. The emergence of each permanent tooth was randomly assigned to one of the three intervals with probabilities proportional to the length of the overlap between the time interval (between the two consecutive examinations) in which the emergence had taken place and the predefined emergence intervals. Let us assume a child whose tooth 16 emerged between the examination performed at the age of 6.3 years and the exam performed at the age of 7.2 years. Hence, for that specific tooth the emergence interval is [6.3, 7.2], with a total length of 0.9 years. Applying the multiple imputation technique, the child was randomly assigned to the interval [6, 7] with a probability $(7 - 6.3)/0.9 = 0.78$ and with a probability $(7.2 - 7)/0.9 = 0.22$ to the interval [7–...]. This procedure was repeated 5 times and summarized according to multiple imputation techniques [Little and Rubin, 1987]. For each imputation, the same model has been fitted. The final (summarized) estimate of a covariate is the average of the corresponding estimates for the different imputations. The corresponding variance is a combination of the within and between imputation variance.

Statistical Model

As within an individual, teeth are not independent from each other, standard statistical software (e.g. LIFEREG procedure in SAS) cannot be used. If the dependence of clustered observations is overlooked, point estimates may be similar, but variance estimates may be drastically different. Hence, the 95% confidence intervals for the naïve model are narrower, resulting in an increased risk for type I error and erroneous rejection of the null hypothesis [Chuang et al., 2002]. Hence, a statistical model applicable for dependent interval-censored survival data was developed [Bogaerts et al., 2002]. Briefly, a Generalized Estimation Equations model for bivariate right-censored data proposed by Huster et al. [1989] was extended to the multivariate setting with interval-censored data. While a bivariate model allows for the simultaneous analysis of only two teeth, a multivariate model combines the marginal fits of several teeth into one model and correctly takes the correlation between the teeth into account. It allows making inferences about the marginal distributions while treating the dependence between the teeth as a nuisance.

Moreover, as in a multivariate analysis the effect of covariates is jointly measured over all permanent first molars at the same time, a joint conclusion can be drawn as it reduces the number of statistical tests performed and hence the problem of multiple testing.

An SAS® macro was written to fit a multivariate log-logistic survival model with possibly different scale parameters for each

tooth. Covariates can be added easily to the model that produces median survival estimates, confidence intervals and p values. (The macro for the multivariate log-logistic case can be downloaded from <http://www.kuleuven.ac.be/biostat/research/software.htm>).

A fully parametric survival model was preferred as parametric models provide confidence intervals for parameters of interest and allow for the convenient inclusion of interval-censored data. On the other hand, parametric models rely on assumptions that need to be checked. Since the logistic survival curve on the log (age) scale provided a good fit, log-logistic survival analyses were performed.

As the applied model is not a logistic regression or proportional hazards model, model coefficients cannot be converted into odds ratios or hazard ratios. The applied model is an accelerated failure time model; this is a kind of survival model where $y = \log T$ is expressed as a linear function of the covariates (as in linear regression, but here the extra complication is that the response is censored). While in a Cox proportional hazards model $e^{\text{regression coefficient}}$ provides a hazard ratio, in an accelerated failure time model $e^{\text{regression coefficient}}$ represents an acceleration factor. An acceleration factor (corresponding to a binary covariate x) that is greater than 1 implies that when the binary covariate $x = 1$, a permanent first molar experiences visible caries AF times quicker than when $x = 0$ and vice versa if $AF < 1$.

For a better understanding of the results survival curves were plotted based on the regression coefficients. From the survival curves hazard plots were derived: they illustrate in which period of time permanent first molars are most at risk for cavity formation. Survival curves and hazard functions were plotted in S-plus 2000® [S-Plus 2000 Guide to Statistics].

Relationship between the Length of Time between Caries Occurrence and Restoration in Deciduous Molars and Caries Development in the Adjacent Permanent First Molar

In order to evaluate whether restoring primary molars has a beneficial effect on the prevention of cavity formation in permanent first molars, additional analyses were performed. Briefly, a smoothing procedure based on an extension of the method described by Komárek et al. [2003] explored the bivariate distribution of both survival functions (i.e. the time from emergence to caries on the permanent first molar and the time from caries to filling of the adjacent primary molar). The procedure is based on placing a fixed fine grid with at each gridpoint a bivariate normal distribution with some weight; the weights are determined by a penalized maximum likelihood method [Bogaerts and Lesaffre, 2003]. While Kendall's Tau, a popular measure that expresses the dependency between the two censored outcome variables [Joe, 1997], is hard to calculate for interval-censored data, the method described above made it possible to calculate it in an efficient way from the smoothed fit.

Results

Figure 1 illustrates the state of the primary molars ($n = 2,252$ boys and 2,111 girls) as observed at the examination where the presence of the permanent first molars was first recorded. The percentage sound primary molars ranged between 66 and 80; 11–17% were decayed whereas 8–14% had been restored. Only 1–4% of prima-

Fig. 1. Proportions of sound, decayed, filled and extracted primary molars.

ry molars were recorded as extracted because of (extensive) caries. A statistically significant gender difference in caries experience was recorded for both mandibular first primary molars; these teeth were more frequently scored as cavity-free in girls than in boys.

Permanent first molars with a caries history at the first examination – i.e. 3–6% of the sample – were excluded from the present study. The proportion of sound permanent first molars dropped in the final survey year to 76% in girls and 79% in boys. Girls tended to have more affected permanent first molars than boys, the gender difference being statistically significant for the mandibular molars. On the other hand, the proportion of sealed permanent first molars was slightly higher in girls (i.e. 23%) than in boys (i.e. 21%).

Table 2 summarizes the acceleration factors corrected for all other included covariates. Multiple survival analyses revealed that caries experience in deciduous molars as well as occlusal plaque accumulation on permanent first molars and reported brushing frequency had a sig-

Table 2. Acceleration factors and statistical significance obtained in a multiple survival model

Covariates	Overall p value ^a	Tooth 16		Tooth 26		Tooth 36		Tooth 46	
		acceleration factor ^b	95% CI	acceleration factor ^b	95% CI	acceleration factor ^b	95% CI	acceleration factor ^b	95% CI
Gender	0.060								
Male (reference)									
Female		0.92	0.84–1.01	0.94	0.86–1.03	0.87	0.79–0.96	0.87	0.78–0.96
Brushing frequency	<0.001								
Not daily (reference)									
Daily		1.29	1.14–1.45	1.31	1.15–1.49	1.42	1.25–1.60	1.36	1.19–1.54
Occlusal plaque	<0.001								
None (reference)									
In pits and fissures		0.93	0.84–1.03	0.85	0.77–0.95	0.82	0.73–0.91	0.84	0.75–0.95
On total occlusal surface		0.58	0.46–0.73	0.50	0.36–0.68	0.62	0.43–0.88	0.54	0.41–0.71
Pit and fissure sealing	<0.001								
None (reference)									
Present		1.39	1.25–1.56	1.41	1.25–1.59	1.23	1.10–1.38	1.14	1.02–1.28
Emergence interval	0.784								
[...–6] years (reference)									
[6–7] years		1.02	0.88–1.17	1.01	0.79–1.29	1.02	0.84–1.24	0.98	0.79–1.20
[7–...] years		1.00	0.82–1.20	1.01	0.84–1.22	0.93	0.77–1.12	0.86	0.71–1.05
Status first primary molar	<0.001								
Sound (reference)									
Decayed		0.81	0.70–0.94	0.77	0.65–0.91	0.86	0.75–0.99	0.80	0.69–0.93
Filled		0.79	0.68–0.93	0.88	0.73–1.05	0.72	0.62–0.84	0.73	0.63–0.86
Extracted		0.75	0.57–1.00	0.89	0.57–1.37	0.78	0.60–1.02	0.75	0.59–0.95
Status second primary molar	<0.001								
Sound (reference)									
Decayed		0.63	0.55–0.73	0.62	0.52–0.73	0.54	0.46–0.63	0.58	0.49–0.68
Filled		0.55	0.48–0.64	0.55	0.47–0.65	0.65	0.56–0.75	0.59	0.51–0.69
Extracted		0.66	0.43–1.00	0.55	0.32–0.94	0.37	0.28–0.51	0.44	0.31–0.61

^a p value for the overall impact of each (multicategorical) covariate over the first permanent molars.

^b An acceleration factor >1 indicates later visible caries experience. Italicized acceleration factors indicate statistically significant results.

Fig. 2. Survival curves for girls. Full line: Frequent brushing, no visible plaque on occlusal surfaces of permanent first molars, sealed. Dotted line: Infrequent brushing, visible plaque on occlusal surfaces of permanent first molars, not sealed. Line A represents sound primary molars, line B decayed first primary molar, line C filled first primary molar, line D decayed second primary molar, line E filled second primary molar, line F decayed first and second primary molar, line G filled first and second primary molar. Comparable results were obtained for the other teeth and for boys.

nificant impact on the incidence of visible caries experience in permanent first molars. An affected second primary molar had more effect than a first primary molar. In this sample only 1–3% of sealed permanent first molars developed caries (results not presented); the preventive effect of pit and fissure sealants – even after controlling for the other influencing factors – was statistically significant. The analyses revealed also that girls were more susceptible to caries development; this gender effect was only significant for mandibular molars. The effect of the

Fig. 3. Hazard functions for girls. Full line: Frequent brushing, no visible plaque on occlusal surfaces of permanent first molars, sealed. Dotted line: Infrequent brushing, visible plaque on occlusal surfaces of permanent first molars, not sealed. Line A represents sound primary molars, line B decayed first primary molar, line C filled first primary molar, line D decayed second primary molar, line E filled second primary molar, line F decayed first and second primary molar, line G filled first and second primary molar. Comparable results were obtained for the other teeth and for boys.

emergence interval was not significant, indicating that – after controlling for the other evaluated covariates – the effect of early versus late emergence is negligible when tooth emergence was taken as the zero-point of the survival analysis.

The survival curves (fig. 2) illustrate the significant effect of caries experience in adjacent primary molars (i.e. line A versus other lines), occlusal plaque accumulation and reported brushing frequency (i.e. full versus dotted lines). On the other hand, the effect of restoring primary

molars on the incidence of visible caries experience in permanent first molars (i.e. lines B, D and F versus lines C, E and G, respectively) was small and not consistent. Additional analyses evaluating the relationship between the period of time from caries occurrence to restoration in a deciduous molar and cavity formation in the adjacent permanent first molar revealed a possible but very weak correlation between both survival curves; Kendall's Tau ranged between -0.08 and 0.14.

The hazard functions (fig. 3) represent the instantaneous risk for a permanent first molar to develop visible caries. Roughly two subgroups can be distinguished. In children who reported frequent brushing, had their permanent first molars sealed and presented without occlusal plaque, a slightly increasing instantaneous risk over time is recorded. For infrequent brushers who did present with visible plaque accumulation and no sealant on the occlusal surface of the permanent first molar (i.e. dotted lines) and who experienced caries in both primary molars (i.e. lines F and G) or on the second primary molar alone (i.e. lines D and E), a peak is observed the first 2 years after emergence. Thereafter, the instantaneous risk decreases over time.

Discussion

In previous reports dealing with the correlation between caries prevalence in the primary and caries development in the permanent dentition [Poulsen and Holm, 1980; ter Pelkwijk et al., 1990; Gray et al., 1991; Raadal and Espelid, 1992; Li and Wang, 2002] the relationship was expressed by sensitivity, specificity, positive and negative predictive values. Based on high positive predictive values and sensitivity individuals can be selected who will benefit from preventive strategies (e.g. pit and fissure sealants), while high negative predictive values and specificity will help select those children where extra preventive efforts are redundant. However, one must realize that positive and negative predictive values are dependent on the prevalence of the predictor (i.e. caries experience in the primary dentition). In a population with low caries prevalence in the deciduous dentition, the positive predictive values are low and the negative predictive values high, while the opposite is observed in populations with a high dmft [Raadal and Espelid, 1992]. In the present study survival analysis was applied to estimate the incidence of visible caries experience of the permanent first molars; the caries state of the primary molars was – among other factors – added as covariate to the model. The ad-

vantages of survival analysis for the analysis of longitudinal caries data have been emphasized in recent reports [Hannigan et al., 2000; Baelum et al., 2003]: it can estimate the time at risk for each individual tooth, even in case of censoring, and it allows for the altered number of teeth at risk, which is a result of the natural exfoliation and emergence process in 6- to 12-year-old children.

In line with previous studies [Heidmann and Poulsen, 1986; Greenwell et al., 1990; Mejre et al., 2001] the analyses revealed that permanent molars adjacent to sound primary molars were less susceptible to caries development. As common risk factors such as dietary and oral hygiene habits are responsible for caries lesions in the primary as well as in the permanent dentition, these results were anticipated. On the other hand, even after controlling for common risk factors (i.e. occlusal plaque accumulation, reported brushing frequency, gender and presence of dental sealants), the effect of caries experience in the deciduous molars was significant, indicating a direct effect on cavity formation in the permanent first molars. Moreover, the greater impact of a carious second deciduous molar than of a carious first deciduous molar may indicate that the closer location of the former may have an additional effect on the caries development in the permanent first molar. Since only 1–4% of primary molars in this sample had been extracted because of caries, no useful conclusions could be drawn from this subgroup.

Unexpectedly, only a small and nonconsistent advantage of restoring an affected deciduous primary molar on the incidence of visible caries experience in the adjacent permanent first molar was observed. Mejre et al. [2001] similarly found no benefit from restoring the lesion in the deciduous molar with amalgam as opposed to leaving the lesion unrestored. They suggested that the outcome might have been different if a fluoride-releasing filling material had been used. As in the present survey clinical examinations were not performed in connection with routine dental treatment appointments, no information was available regarding the applied restorative material. Hence, the influence of the nature of the filling material could not be evaluated.

Mejre et al. [2001] indicated also that the lack of effectiveness of restoring the deciduous molar may be ascribed to possible preparation damage during cavity preparation. In the present sample – as in reports from other industrialized countries [Ripa et al., 1985] – the majority of caries experience in the permanent first molars was limited to the occlusal surfaces, so this hypothesis can explain the results only in part. Since the exami-

nations in the present survey were performed on a yearly basis and not in connection with dental treatment appointments, no detailed information on the occurrence of the carious lesion or on the length of time between caries occurrence and restoration was available. Hence, a primary molar could have been decayed for only a couple of months when the tooth was scored or affected for a long time and filled just before the examination. Additional analyses revealed a possible but very weak correlation between the period of time from caries occurrence to restoration in a deciduous molar and the incidence of visible caries experience in the adjacent permanent first molar. A strong negative correlation would have indicated that when a primary molar was decayed for a long time before being restored the adjacent permanent first molar had a higher chance of being affected by caries whereas a permanent first molar adjacent to a primary molar that had been restored shortly after caries experience would be less susceptible to caries experience. Although Levine et al. [2002] reported that 74% of unrestored carious deciduous teeth were exfoliated without causing pain, further follow-up studies are indicated to fully evaluate the benefits from restoring primary teeth since untreated carious lesions may act as a source of pathogenic flora for erupting permanent teeth.

The influence of fissure sealants was also evaluated. In spite of their technique-dependent durability, fissure sealants had – even after controlling for other influencing factors – a statistically significant caries-preventive effect [Ahovuo-Saloranta et al., 2004].

In earlier longitudinal caries studies it was reported that caries risk of permanent first molars was highest 1–4 years after emergence and decreased thereafter [Carlos and Gittelsohn, 1965; Abernathy et al., 1986], while more recently the absence of a peak in caries susceptibility was recorded [Ripa et al., 1988; Suni et al., 1998; Harkanen et al., 2002; Seppä et al., 2002; Leroy et al., 2004]. The hazard plots (fig. 3), however, give evidence for both – seemingly contradictory – results. They illustrate a peak in (instantaneous) caries risk 1–2 years after emergence in infrequent brushers who did present with dental plaque on the occlusal surface and who had experienced caries in the adjacent primary molars, while children who reported frequent brushing and presented without occlusal plaque, experienced a slightly increasing instantaneous risk over time. The curves confirm that cavity formation in permanent molars is dependent on oral hygiene, the application of dental sealants and visible caries experience of the adjacent primary molars. Although ‘statistical risk’ should not be confused with ‘clinical risk’, the results indicate

that there is no maximum age for preventive efforts. The results are in line with a longitudinal Dutch study where it was concluded that at the age of 17 occlusal surfaces of permanent molars are still highly susceptible to new dentine caries and further progression of dentinal radiolucencies already present [Poorterman et al., 2003].

In conclusion, cavity formation in permanent first molars is influenced by the status of the adjacent primary molars, especially the second deciduous molar. If both deciduous molars had experienced caries and the child presented with poor oral hygiene, a peak in caries susceptibility 1–2 years after emergence of the permanent first molar was noticed. On the other hand, if a child reported good oral hygiene, caries risk increased slightly over time.

Further research is indicated to explore the impact of reported brushing frequency, presence of occlusal sealants, presence of occlusal plaque and caries experience in the primary dentition on caries development at surface level. Dental sealants for instance have most likely no caries-preventive effect on approximal surfaces; the presence of occlusal plaque may only have a cariogenic effect on the occlusal surfaces, although regarded as a parameter of oral hygiene efficiency, it may well be associated with caries susceptibility of the proximal surfaces.

No significant benefit from restoring primary molars could be demonstrated, possibly because of the methodological limitations of this study; therefore further research is indicated to fully explore this issue.

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