

A 13-year follow-up of a comprehensive program of fissure sealing and resealing in Varkaus, Finland

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The objective of the study was to examine the coverage of the sealing program on first permanent molars (FPMs) and second permanent molars (SPMs) and first and second premolars (FSPMs), as well as to monitor the fate of the sealed teeth over time. All patients born in 1977 who had had regular check-ups in the Varkaus Health Center, Finland ($n = 166$) were included in the 1996 study. Data on the annual state of each tooth had been collected retrospectively since 1983. The coverage for the sealant program was 95%, 92%, and 6% of the FPMs, SPMs, and FSPMs, respectively. Out of the FPMs sealed at age 6 years, 28% were subjected to resealing, 13% developed occlusal, and 15% proximal caries during a 13-year follow-up period. From the SPMs sealed at age 11 years, 24% were subjected to resealing, 4% developed occlusal caries, and less than 2% proximal caries during the 9-year follow-up. None of the sealed FSPMs and only 1% of the non-sealed ones developed occlusal caries during the 9-year period. The mean DMF in the study population ($n = 160$) at age 12 years was 0.8 ($n = 124$), compared to a nation-wide mean value of 1.2. A large percentage of the FPMs and SPMs were sealed and then resealed during the study period. Although the study design lacked a control group for comparison, the lower caries rates of this study compared to the results of other studies with only a single application of sealants suggest a major role for resealing. □ *Community; occlusal caries; resealing*

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In Finland, as well as in the other Nordic countries, prevention of occlusal caries takes up a substantial amount of resources in public oral healthcare. Several studies have demonstrated that sealants, as long as they are intact, are highly effective in preventing occlusal caries (1–5). Hence, in most Finnish municipal dental clinics, occlusal sealants have been used routinely as part of free public oral health service for more than 20 years (6).

Carlos & Gittelsohn (7) stated that if the occlusal surface of a posterior tooth survives sound 2 years after eruption, it is unlikely later to decay. However, in the 1980s, several authors clearly demonstrated a relatively constant rate of occlusal caries in posterior teeth over time. Ripa et al. (8) reported that first molar occlusal caries in schoolchildren exhibited an unchanging caries incidence rate for as long as 10 years after eruption. Likewise, in an 8-year retrospective follow-up of first permanent molars (FPMs) in the Finnish population, Vehkalahti et al. (9) pointed out that even though occlusal caries incidence in FPMs was highest from 7 to 9 years of age, new lesions developed every year regardless of being initially sealed or not. Therefore these investigators have recommended continued resealing after this risk period. Moreover, several other articles introduced maintenance resealing as a solution to occlusal caries (1, 10, 11). However, maintenance resealing requires frequent check-ups and thus causes further expense for the public health system, although its actual effect has not been documented.

The objectives of this study were to determine the coverage and outcome of the sealing program, as well as the frequency and timing of resealing, and to monitor the procedures performed on patients born in 1977 and receiving regular check-ups in the Finnish municipal health center of Varkaus during 1983–1996.

Materials and methods

This retrospective follow-up study was carried out in the Varkaus Municipal Health Centre. Varkaus is an industrial city of around 25,000 inhabitants in eastern Finland, which has a non-fluoridated water supply containing 0.2 ppm fluoride. The municipal health center is responsible for providing free public dental services for all inhabitants younger than 19 years living in the area. In the Varkaus Health Center, occlusal resin sealants have been used routinely in caries prevention since the late 1970s. Before 1986, mainly chemically curable Delton (Johnson & Johnson, East Windsor, NJ, US) was used. After 1986, when light curable Delton (Dentsply, York, PA, USA) came on to the market, it became the most frequently used brand in the health center. Dentists were advised to seal all FPMs and second permanent molars (SPMs), but no first and second premolars (FSPMs) or primary molars. The dentists were advised to use (bitewing) radiographs only for the diagnosis of proximal

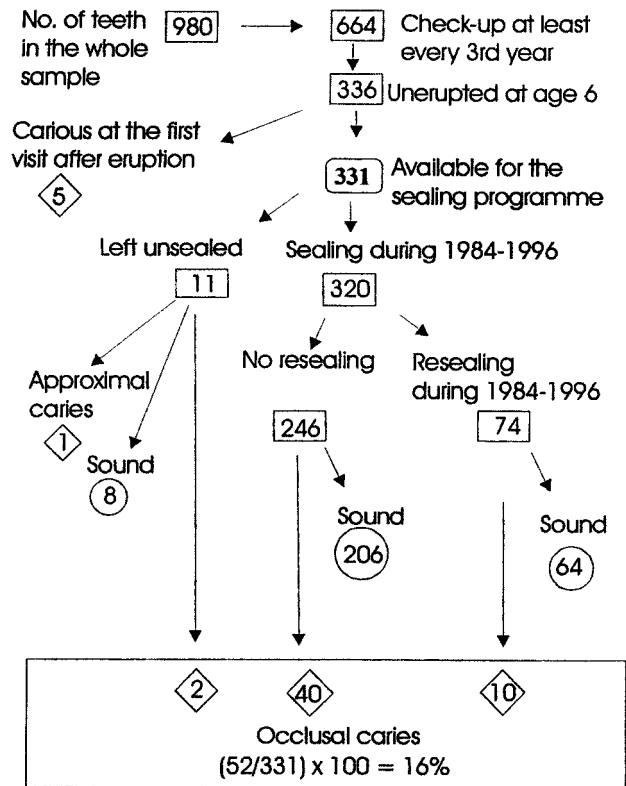


Fig. 1. Fate of first molars during 13-year follow-up.

caries. The occlusal restorative decisions of 10 dentists were calibrated in 1993 according to a feedback method comprising 4 different examinations with an interval of 1 week between these examinations (12). In 1993–1996, only these calibrated dentists performed clinical dental examinations, but in years prior to 1993 the treatment of this cohort had been performed in a pragmatic, non-calibrated environment. Though dental hygienists also placed sealants, the dentist was ultimately responsible for the treatment provided. The sealants were placed following the manufacturer’s instructions with one exception: the applicator provided was replaced with an explorer, as this instrument was considered to carry the material better into the fissures and avoid undesired excess. No rubber-dam was used during the sealing procedure, but special emphasis was put on maintaining the operation field dry by means of cotton rolls and saliva ejector. No general recommendation for preventive preparation of the tooth prior to sealing was given, but occasionally some of the dentists used tapered fine diamond fissure to remove enamel caries/stain and to ensure that the lesion did not reach dentin prior to sealing. However, this procedure was not noted in the records and thus could not be included as a variable in the analysis. Other caries-preventive measures routinely used in the health center included dietary and home-care instructions, and cleaning with prophylaxis-paste and fluoride varnish application. These were usually performed in connection with check-ups.

Sampling. According to the population records of 1996, altogether 322 inhabitants, born in 1977, lived in the city of Varkaus. During 1994–1996, 245 of them had received dental care in the Varkaus Health Center. Oral health records of these patients were requested from municipal dental clinics.

From the beginning of the 1990s, the Varkaus Health Center dental care system has followed a policy of individualized check-up intervals. Thus, patients estimated as having a low risk for dental caries were recalled for a check-up only every other year. In order to also include these non-risk patients, as well as any others not reporting yearly, all patients subjected to check-ups at a minimum of 3-year intervals were included in the analysis.

Assembly of information. In Finland, standardized charts are used throughout public dental services, and include information on dental check-ups, oral health status, and treatment given. The present study collected data on either the state of the tooth or the treatment provided during any given year.

A tooth was regarded as occlusally filled even if a partial sealant was present. Similarly, a tooth was regarded as being proximally decayed despite occlusal sealants or fillings. DMF indexes were calculated and recorded on the basis of oral health records.

In all, 664 FPMs (68% of the whole sample) that were subjected to dental check-ups at least every third year during 1983–96 were available for analysis. To examine the coverage of the sealing program, we first identified a cohort of FPMs that were unerupted at age 6 years ($n = 336$). To monitor the fate of the sealants and to maximize the length of the observation period, we also identified all sealants placed on the FPMs at age 6 years ($n = 238$). The remaining 90 teeth were relevant neither to the coverage nor to the fate analysis, as they were erupted (but not receiving a sealant that year), already sealed, carious, or filled.

Likewise, 720 SPMs (73% of the sample) and 1440 FSPMs (73% of the sample) meeting the same criteria during 1987–96 were available for the analysis.

To examine the coverage of the sealing program for SPMs, we identified a cohort of teeth that were unerupted at age 10 years ($n = 666$). The remaining 54 teeth were not relevant to the analysis, as they were erupted, already sealed, carious, or filled. To monitor the fate of the sealants, we also identified all sealants placed on the SPMs at age 11 years ($n = 127$).

To examine the coverage of the sealing program for FSPMs, we identified a cohort of teeth that were unerupted at age 10 years ($n = 1148$).

Results

Coverage for FPMs

To examine the coverage of the sealing program, we first identified a cohort of FPMs that were unerupted at

Table 1. Number and annual distribution (%) of treatment procedures performed on first permanent molars sealed at age 6 years ($n = 238$)

Procedure	Age (years)											Total no. of procedures (% of 238)				
	6	7	8	9	10	11	12	13	14	15	16		17	18	19	
Initial sealing	n (%) 238 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	238 (100)
None	n (%) 0 (0)	222 (93)	197 (95)	196 (92)	228 (97)	208 (95)	161 (90)	91 (92)	209 (92)	57 (93)	199 (93)	93 (94)	175 (94)	99 (97)	0 (0)	N.A.* N.A.*
First resealing	n (%) 0 (0)	12 (5)	8 (4)	12 (6)	2 (1)	6 (3)	9 (5)	4 (4)	8 (4)	0 (0)	5 (2)	1 (1)	0 (0)	0 (0)	0 (0)	67 (28)
Second resealing	n (%) 0 (0)	0 (0)	0 (0)	0 (0)	1 (<1)	1 (<1)	6 (2)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	8 (3)
Third resealing	n (%) 0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (<1)	0 (0)	1 (<1)	0 (0)	1 (<1)	0 (0)	0 (0)	0 (0)	0 (0)	3 (1)
Occlusal filling	n (%) 0 (0)	4 (2)	2 (1)	3 (2)	2 (1)	3 (1)	2 (1)	1 (1)	1 (<1)	2 (3)	3 (1)	1 (1)	4 (2)	3 (3)	0 (0)	31 (13)
Approximal filling	n (%) 0 (0)	0 (0)	1 (<1)	1 (<1)	2 (1)	2 (1)	3 (2)	1 (1)	8 (4)	2 (3)	4 (2)	4 (4)	7 (4)	0 (0)	0 (0)	35 (15)
Total no. of teeth checked each year	n (%) 238 (100)	238 (100)	208 (100)	212 (100)	235 (100)	220 (100)	179 (100)	99 (100)	227 (100)	61 (100)	213 (100)	99 (100)	186 (100)	102 (100)	0 (0)	

* N.A., Not applicable.

age 6 years. Out of these 336 teeth, 320 (95%) were sealed during the 13-year follow-up period (Fig. 1). Sixteen teeth (5%) were left unsealed, 5 of these because they had been diagnosed carious at the first check-up after eruption. Of the remaining 11 teeth, two subsequently developed occlusal caries. Approximately 1.2 sealing procedures were performed per FPM in this cohort.

Altogether 16% of the FPMs available in the sealing program developed occlusal caries during the follow-up. Among the teeth resealed once or twice ($n = 74$), the caries rate was 14% (Fig. 1).

Fate of FPMs sealed at age 6 years

To monitor the fate of the sealants and to maximize the length of the observation period, we identified all sealants placed on the FPMs at age 6 years and followed them retrospectively over the 13-year period. Out of these 238 FPMs, 67 (28%) were subjected to resealing at least once. During the first 6 years of the follow-up, 49 (21%) were resealed once and 5 (2%) twice. In comparison, only 15 (6%) were resealed during the final 6 years of the follow-up, and practically no resealings were done in the final 3 years. In all, 316 sealing procedures were performed, on average 1.3 procedures per FPM. Thirty-one (13%) of the FPMs sealed at age 6 developed occlusal and 35 (15%) proximal caries during the 13-year period. The corresponding figures for the first 10 years were 10% and 10%, respectively. A small number of occlusal caries were restored every year (Table 1).

Coverage for SPMs

To examine the coverage of the sealing program, we identified a cohort of SPMs that were unerupted at age 10 years. Out of these 666 teeth, 612 (92%) were sealed during the 9-year follow-up (Fig. 2). Fifty-four teeth (8%) were left unsealed, 13 of these because they had been diagnosed carious at the first check-up after eruption. Of the remaining 41 teeth, only 3 subsequently developed occlusal caries. Approximately 1.1 sealing procedures were performed per SPM. Altogether 31 (5%) of the SPMs available for the sealing program developed occlusal caries during the follow-up. Among the teeth resealed once or twice ($n = 120$), the caries rate was 8% (Fig. 2).

Fate of SPMs sealed at age 11 years

To monitor the fate of the sealants, we identified all sealants placed at age 11 years (Table 2). The total number of sealant procedures for 127 SPMs was 158, or on average 1.2 procedures per tooth. From these 127 SPMs, 27 (21%) were subjected to resealing during the first 4 years, and only 3 (2%) were resealed during the last 4 years of follow-up. In total, 23% of SPMs were resealed during the 9-year follow-up. Out of the SPMs sealed at age 11 years, 5 (4%) developed occlusal and 2 (less than 2%) proximal caries.

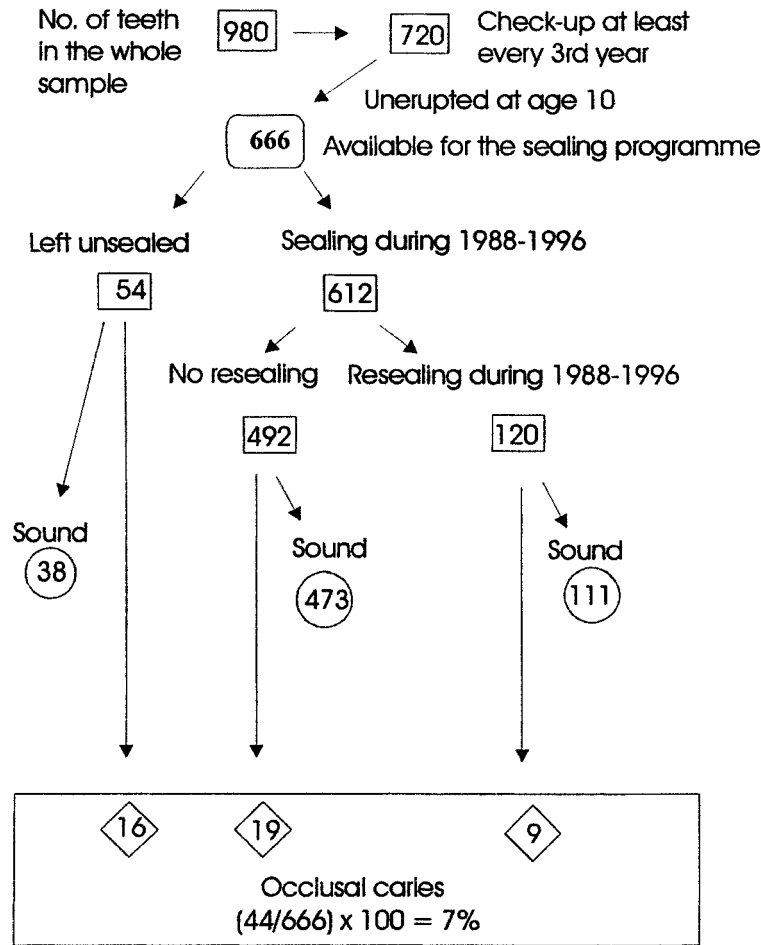


Fig. 2. Fate of second molars during 9-year follow-up.

Table 2. Number and annual distribution (%) of treatment procedures performed on second molars sealed at age 11 years ($n = 127$)

Procedure		Age (years)									Total no. of procedures (% of 127)
		11	12	13	14	15	16	17	18	19	
Initial sealing	<i>n</i>	127	0	0	0	0	0	0	0	0	N.A.*
	(%)	100	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	
None	<i>n</i>	0	87	40	117	31	105	63	89	59	N.A.*
	(%)	(0)	(87)	(95)	(94)	(77)	(97)	(97)	(99)	(98)	
First resealing	<i>n</i>	0	13	2	7	5	3	0	0	0	30
	(%)	(0)	(13)	(5)	(6)	(12)	(3)	(0)	(0)	(0)	
Second resealing	<i>n</i>	0	0	0	0	1	0	0	0	0	1
	(%)	(0)	(0)	(0)	(0)	(3)	(0)	(0)	(0)	(0)	
Occlusal filling	<i>n</i>	0	0	0	0	3	0	1	0	1	5
	(%)	(0)	(0)	(0)	(0)	(8)	(0)	(2)	(0)	(2)	
Approximal filling	<i>n</i>	0	0	0	0	0	0	1	1	0	2
	(%)	(0)	(0)	(0)	(0)	(0)	(0)	(1)	(1)	(0)	
Total no. of teeth checked each year	<i>n</i>	127	102	42	124	40	108	65	90	60	(<2)
	(%)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	

* N.A. = Not applicable.

Coverage for FSPMs

To examine the coverage of the sealing program for FSPMs, we identified a cohort of teeth that were unerupted at age 10 years. Out of these 1148 teeth, 64 (6%) were sealed during the 9-year follow-up period. None of the sealed FSPMs developed occlusal caries during follow-up. Only 1% of the erupted, non-sealed FSPMs ($n = 1058$) developed occlusal caries during follow-up.

Average check-up interval and mean DMF

The average check-up interval was 1.4 years. The mean DMF scores at the ages 6 and 12 were 0.08 ($n = 160$) and 0.8 ($n = 124$), respectively.

Discussion

This study was a retrospective follow-up of an age cohort born in 1977 and living in the city of Varkaus in 1996, where 76% had received dental care during the period 1994 to 1996. Owing to the retrospective nature of the study, the exact number of children born in Varkaus in 1977 and entering the dental clinic at the age of 6 years could not be traced. However, the overall change in population in the town of Varkaus during those years was negligible, and it is unlikely that the migration out of town would in any way have been associated with the dental health. Neither the dentists nor the hygienists placing the sealants were aware that they would be subsequently monitored. Thus, the sample can be regarded as representative of the routine procedures and outcomes of the dental healthcare system in Varkaus for those who had regular check-ups. The population in Finland is homogeneous in its habits, customs, religion, and ethnic background (over 95% white Finnish ancestry); thus it is likely that the results from our study can be generalized to other Finnish towns where the dental healthcare is similarly organized.

If proximal caries was diagnosed at the same or an earlier check-up than occlusal caries, the tooth was recorded as proximally decayed. Thus, some occlusal lesions may have been recorded as proximal lesions. However, it was impossible to determine from the record whether only proximal or both proximal and occlusal fillings were present. Furthermore, since only the teeth that had been subjected to check-up once every 3 years were included in the study, some FPMs were followed for 12 and some for 13 years. Similarly, some SPMs and FSPMs were followed for 8 or 9 years. These limitations may have led to a slight underestimation of actual occlusal caries rates.

The overall sealing and resealing rates were high for both FPMs and SPMs. In practice, very few permanent molars were intentionally left unsealed. Romcke et al. (10) reported that 6% of FPMs required resealing after 1 year, and thereafter 2% to 4% each year. After 20 years of

follow-up, Wendt et al. (13) found 22% of the FPMs with partial retention or a missing sealant, which would have indicated resealing. In the same study, 30% of the sealants in the SPMs were found totally or partially lost after 15 years of follow-up. Our study was consistent with these results, except for the surprisingly high percentages of FPMs that were resealed, once or twice, during the ages from 12 to 14 years. At 12 years 7% were resealed and 6% to 4% were resealed at 13 and 14 years, respectively. On the other hand, much lower percentages for resealing have also been reported. Jones (14) found that only 3.3% of the teeth were in need of resealing after a follow-up varying between 6 months and 6 years. In our study, as erupting SPMs were sealed during that age period, it might be that the resealing of the FPM was easy to perform at the same time—whether resealing was needed or not. Resealing of SPMs was frequent during the first 4 years. This might have been due to technical problems when initially sealing partly erupted SPMs.

This study demonstrated that comparatively low occlusal caries rates of permanent molars can be achieved with a non-targeted sealant policy in a community health program. Before onset of the sealant program in 1975, the DMFT values for the 12-year-olds in Varkaus were higher than those for Finland as a whole, 8.9 versus 6.9, respectively (6, 15). The sealing program was started at the end of the 1970s, gradually progressing, and in 1985 the DMFT values for 12-year-olds in Varkaus were already lower compared to the rest of the country (2.3 versus 2.8, respectively). The same trend then continued and thus this cohort constantly had lower values compared to the rest of the country: at 12 years of age only 0.8, compared to 1.2, respectively.

Although the study design lacked a control group, these results strongly suggest the beneficial nature of the sealants. Other preventive measures for this cohort were consistent with national standards; it is therefore unlikely that any other preventive care was responsible for this remarkably low DMFT value. In follow-up studies of a single application of resin sealants, Simonsen (5, 16) reported 39% of FPMs occlusally or buccally carious after 15 years. In our study, the occlusal caries rates were considerably lower, 10% after 10 years and 13% after 13 years, respectively. The high percentage of resealing of FPMs in our study (28 %) may have contributed to this difference. Moreover, some dentists may have incorporated preventive preparation of fissures prior to sealing, although this procedure cannot be verified from patient records.

Since only 1% of the premolars developed occlusal caries during the 9-year period, this study suggests that routine sealing of premolars was unnecessary for the study population. Even though it is assumed that the low occlusal caries rates in this population were due to the intensive use of occlusal sealant, it is not known what will happen in the future when some of the sealants are inevitably lost. Do the sealants provide a life-long protection against occlusal caries, or is caries perhaps only

delayed or hidden beyond the age when the patient is entitled to free dental care services (17)? In light of the present findings, where new carious lesions occurred throughout the follow-up, life-long protection seems improbable. However, it seems equally implausible that the new carious lesions in this study would have been merely 'hidden caries', because non-cavitation stages of caries were also included in the restoration criteria (12, 18). To elucidate this further, patterns of occlusal caries should be studied not only in children and adolescents, but also in adults.

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