Approximal caries progression in 13- to 15-year-old Danish children

Jette Bille and Kirsten Carstens
Department of Cariology and Endodontics, Royal Dental College, and Public Child Dental Health Service Ishøj, Copenhagen, Denmark

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A total of 278 children aged 13 years in 1980, who lived in an area where preventive programs and professional attitudes towards restorative treatment had changed over a 10-year period, were dentally examined in 1980, 1981, and 1982. Different preventive treatments were given to the children, to decrease the variation in dental caries. The development of new lesions and the rate of progression of existing lesions were studied by means of bitewing radiographs. Ninety-four per cent of the surfaces remained unchanged. Of the surfaces diagnosed as carious at 13 years of age no progression had occurred in 63%, and 86% of enamel lesions remained within the enamel. Although caries progression was slow in this population, the variation in dental caries was only slightly altered. □ *Clinical study; preventive programs; professional attitudes*

Jette Bille, Department of Cariology and Endodontics, Royal Dental College, Panum, Nørre Allé 20, DK-2200 Copenhagen N, Denmark

Data from Danish communities from the period 1972 to 1980 indicate that comprehensive dental care, together with widespread use of fluoridated dentifrice, has reduced dental caries to a level close to that in areas with fluoridated water (1). However, dental caries has not been eliminated in Danish children and, furthermore, the gradual change in caries prevalence is apparently occurring without a real change in the basic distribution pattern (1, 2). Even though attempts are made to change the caries progression pattern by means of a restrained attitude to restorative treatment in favor of preventive measures, the differences among the children are maintained (3). The authors of these studies found that a large proportion of enamel lesions were arrested, and they concluded that the use of more preventive resources on a relatively small group of children with deep lesions at an early age may result in large savings at a limited cost.

The present study was undertaken to examine the progression of approximal carious lesions in 13- to 15-year-old children in a child dental health service, in which preventive programs and attitudes towards restorative treatment have changed. The aim of this change in treatment was to eliminate the differences among the children and to obtain control of caries progression with non-operative treatment techniques.

Materials and methods

Community and public child dental health service

Ishøj is a suburban municipality in the southern part of Copenhagen with about 21,000 inhabitants. The population has expanded rapidly from 3000 in 1968, when the Child Dental Health Service was established. The contents of F^- in the drinking water ranges from 0.5 to 0.6 ppm, with the exception of a small area (pop. 1500) with 1.8 ppm. The Child Dental Health Service has included children of 7 to 15 years since 1975. The service comprises about 10 dentists and about 400 children in each age group. Dental health topics are included in classroom teaching during the school years, as in most Danish dental health services, and regular rinsings every 2 weeks with 0.2% NaF were performed routinely with children of 7 to 12 years until 1976. After that period the rinses were supplemented with biannual

applications of 2% NaF for children with smooth surface caries. Children aged 13 years or more have had biannual treatments with 2% NaF since the school year 1979/80, supplemented with additional preventive treatments in accordance with need and available resources. The additional preventive treatments are aimed at reducing the difference in caries. The treatment need was based on a clinical examination with emphasis on gingivitis and radiographically visible dental caries in approximal surfaces. In 1979 the dentists participated in a collection of data concerning clinical tissue changes in relation to operative treatment of approximal caries lesions (4).

Study population

All the children (371) in one school grade with an average age of 13 years and 5 months in 1980 were examined in 1980, 1981, and 1982 by the dentists in Ishøj. About 50 children of the same age who were either attending private schools outside the municipality or attending special classes for foreigners were not included in this material.

A total of 278 (75%) of the children were available for re-examination in 1982. Of the rest, 88 children had moved to other schools or had moved away from the area, and 5 children were excluded because radiographs had not been taken at the age of 15 years.

Data

The data originate from two sources: 1) clinical information from the treating dentists about the preventive program planned for the individual child immediately after the examination of 13-year-old children and about observable tissue changes in approximal carious lesions opened in the period 1980 to 1982 and immediately after the examination in 1982, and 2) information obtained from bitewing radiographs of the same children in 1980 and again in 1981 and 1982.

Clinical recording

It was possible to group the children in accordance with the dominant preventive treatments during the observation period: A) Routine biannual topical treatments performed with 2% NaF applied with cotton pellets and dental floss, but without a previous professional cleaning of the teeth; B) Chairside motivation for better hygiene, including use of dental floss and/or two additional applications of 2% NaF; C) Applications of 2% NaF several times for a period of 2 months; and D) Thorough professional plaque removal every 2 weeks and different combinations of the other treatments.

When restorative treatment was implemented, the clinical tissue changes visible in the opened approximal carious lesion were recorded at the maximal extent of the lesion as described previously (4). The enamel was recorded as normal or changed. The dentin was recorded as normal or changed in superficial, medium, or deep relation to the pulp. The pulp was recorded as clinically unexposed or exposed.

Radiographic recording

Two bitewing radiographs were taken annually in duplicate with a filmholder modified from the principle given by Dirks et al. (5). The modifications are in accordance with a recent description of filmholding, beam collimating, and aiming devices (6).

The radiographs taken in 1980 and 1982 were recorded by one of the authors (J. Bille), using a ×2 magnification. The first recording was made in 1980 and the second in 1982. At that time the radiographs were studied simultaneously, to use all information available from the total of three sets of radiographs taken in 1980, 1981, and 1982, respectively (3, 7).

Recordings were made of permanent approximal surfaces of molars and premolars with exception of distal surfaces of second molars and mesial surfaces of first premolars. A surface was excluded when the amelodentinal junction was invisible, usually because of overlapping and orthodontic banding. True approximal surfaces were defined as neighboring permanent surfaces separated from each other by not more than 0.5 mm. The radiographic changes in enamel and dentin were recorded as belonging to

one of four stages of penetration: Score 0 represents enamel with no radiographic changes or doubtful changes. Score 1 indicates a definite change in the outer half of enamel, and score 2 indicates that the radiolucency reaches over halfway through the enamel. Score 3 indicates a radiolucency over halfway through the enamel and a radiolucency in the outer one-third of dentin. Score 4 indicates a radiolucency more than one-third through dentin. Finally, score 5 was used to indicate a filling.

Results

Radiographic findings

The overall caries progression in a total of 5317 approximal surfaces is given in Table 1. Of these, 87% and 98% were true approximal surfaces at the age of 13 and 15 years, respectively. Of the total number of surfaces erupted at both examinations 94.3% remained radiographically unchanged during the 2-year study period. In addition, 394 surfaces, not shown in the table, which were unerupted at the age of 13 years, erupted and established normal contacts; they were all without visible radiographic changes at 15 years of age. It can be seen from Table 1 that in surfaces diagnosed as carious at the age of 13 years (186) no progressions had occurred in 118 (63.4%). Of the 148 enamel lesions diagnosed 2 years earlier 127 (86%) remained within the enamel at 15 years. Of the outer enamel lesions 90% were still found in the enamel, and of the inner enamel lesions, 79%. Of lesions in enamel and lesions in dentin 5% (7) and 45% (17), respectively, had been filled, and 0.1% of sound enamel had also been filled (6).

Clinical findings

Of the total number of lesions diagnosed as carious at 15 years (391) no lesions in enamel and 12 of the lesions in dentin were, according to the information from the dentists, scheduled to be filled immediately after the examination. The enamel and dentin in those and in the 30 lesions that had been filled during the period were clinically recorded as changed from normal at the time when restoration was performed. However, only approximately 30% of the lesions were in close relation to the pulp with one exposure where pulp capping was performed

Table 1. Distribution of radiographic scores on approximal surfaces of 278 children at age 15 years related to scores at age 13. Underlined figures indicate surfaces for which the same caries score was observed at the two examinations

	Radiographic score at age 15 years						
Radiographic score at age 13 years	Sound	Outer half of enamel	Inner half of enamel	Outer half of dentin	Inner two-thirds of dentin	Filled	Total
Sound (0)	4776 (95.3)	178 (3.5)	42 (0.8)	7 (0.1)	2 (0.0)	6 (0.1)	5011 (100)
Outer half of enamel (1)		57 (63.3)	24 (26.7)	6 (6.7)	0 (0)	3 (3.3)	90 (100)
Inner half of enamel (2)			46 (79.3)	5 (8.6)	3 (5.2)	4 (6.9)	58 (100)
Outer one-third of dentin (3)				15 (48.4)	6 (19.4)	10 (32.3)	31 (100)
Inner two-thirds of dentin (4)					0 (0)	7 (100)	7 (100)
Filled (5)						120 (100.0)	120 (100)
Total	4776	235	112	33	11	150	5317

Table 2. Distribution of children and surfaces with lesions in enamel at age 13 years and with new lesions in enamel in the period 13–15 years of age in accordance with treatment group

Treatment	*n*	Enamel lesions at age 13 years		New lesions in enamel	
		No. of children (%)	No. of (surfaces ($\bar{x}$ ± SE)	No. of children (%)	No. of surfaces ($\bar{x}$ ± SE)
A	170(100)	25(14.7)	39(0.2 ± 0.1)	37(21.8)	81(0.5 ± 0.1)
B	51(100)	9(17.6)	13(0.3 ± 0.1)	11(21.6)	20(0.4 ± 0.1)
C	31(100)	24(77.4)	56(1.8 ± 0.3)	20(64.5)	71(2.3 ± 0.5)
D	26(100)	17(65.4)	40(1.5 ± 0.4)	12(46.2)	48(1.8 ± 0.5)
Total	278(100)	75(27.0)	148(0.5 ± 0.1)	80(28.8)	220(0.8 ± 0.1)

before the filling was placed. This indicates that the observed slow caries progression was real and thus unaffected by the institution of early restorative treatment and that the restorative treatment was instituted at a time when caries progression had not yet penetrated to damage the pulp.

Caries progression in relation to treatment

The distribution of children and the number of surfaces with lesions in enamel and in dentin, including new fillings, in accordance with treatment group are shown in Tables 2 and 3. It can be seen from the tables that 170 (61%) of the children continued the routine biannual fluoride applications (A) after the age of 13, whereas the rest of the children were judged in need of additional preventive treatments. The children in groups C and D were in a state of faster caries progression at 13 years than the children in groups A and B. Thus in groups C and D 72% and 68% had enamel lesions and lesions into dentin, respectively, compared with groups A and B, in which the corresponding figures were 15% and 19%. This difference between the children continued during the 2-year study period: 56% and 30% of the children in groups C and D developed new lesions in enamel and lesions in dentin, respectively, compared with groups A and B, in which the corresponding figures for new lesions were 22% and 5%.

Of the total number of lesions and filled surfaces (306) diagnosed at the age of 13 years groups C and D, comprising 20% of the children, accounted for 57%; this proportion was only slightly reduced, to 55%, when looking at the number of new lesions and

Table 3. Distribution of children and surfaces with lesions in dentin or fillings at age 13 years and with new lesions in dentin or new fillings in the period 13–15 years of age in accordance with treatment group

Treatment	*n*	Lesions into dentin or filling at age 13 years		New lesions into dentin or filling	
		No. of children (%)	No. of (surfaces ($\bar{x}$ ± SE)	No. of children (%)	No. of surfaces ($\bar{x}$ ± SE)
A	170(100)	24(14.1)	41(0.2 ± 0.1)	9(5.3)	12(0.1 ± 0.0)
B	51(100)	17(33.3)	35(0.7 ± 0.2)	2(1.2)	2(0.0 ± 0.0)
C	31(100)	25(80.6)	51(1.6 ± 0.3)	11(35.5)	12(0.4 ± 0.1)
D	26(100)	14(53.8)	31(1.2 ± 0.3)	6(23.1)	10(0.4 ± 0.2)
Total	278(100)	80(28.8)	158(0.6 ± 0.1)	28(10.1)	36(0.1 ± 0.0)

Table 4. Distribution of surfaces with enamel lesions of age 13 years in treatment groups A + B and C + D related to radiographic scores at the age of 15

Treatment	Radiographic score at age 13 years	Radiographic score at age 15 years (%)					
		Outer half of enamel	Inner half of enamel	Outer one-third of dentin	Inner two-thirds of dentin	Filled	Total
A + B	Outer half of enamel	21 (61.8)	9 (26.5)	3 (8.8)	0 (0)	1 (2.9)	34 (100)
	Inner half of enamel		16 (88.9)	1 (5.6)	0 (0)	1 (5.6)	18 (100)
C + D	Outer half of enamel	36 (64.3)	15 (26.8)	3 (5.4)	0 (0)	2 (3.6)	56 (100)
	Inner half of enamel		30 (75.0)	4 (10.0)	3 (7.5)	3 (7.5)	40 (100)

enamel lesions, which had progressed into dentin (256). Thus the results in Tables 2 and 3 indicate that even though the children with rapid progression were identified in the clinic, the measures applied did not eliminate the overall differences in caries progression during the 2-year study period.

Table 4 gives the distribution of surfaces with enamel lesions at age 13 years in treatment groups A + B and C + D, so as to examine the extent to which the more intensive treatments (C + D) were able to arrest small lesions visible in radiographs. The absolute number of lesions that progressed was, however, small in both groups. Thirteen (38%) small enamel lesions in groups A + B and 20 (36%) in groups C + D had progressed (Table 4). The corresponding figures for larger enamel lesions were 2 (11%) and 10 (25%). These results indicate that the preventive treatments had contributed to eliminate a major part of the differences between the groups with regard to progression of carious lesions that were radiographically visible in the enamel at 13 years.

Discussion

The results showed that approximal caries progression in a Danish population of 13- to 15-year-old children was slow in the period 1980 to 1982 compared with other recent studies of children in Scandinavia. This is apparent in Table 5, which gives a summary of studies in the order of decreasing prevalence of radiographically visible enamel lesions at the first examination (3, 8–13). Although a direct comparison cannot be made because of the differences between the studies, it is nevertheless striking that in the present study 86% of the lesions in enamel remained in the enamel, and 55% of the lesions in dentin remained in the dentin without progressing into the pulp. Only about half of the latter were judged to be in immediate need of a filling, thus leaving 24% of the lesions unfilled for a total period of 3 years until the next examination in 1983. Very few lesions remained in dentin in the cited studies; however, results similar to ours were obtained in a study of dental students, in which 51% of the lesions in dentin remained after 2 years (14).

The high degree of overall 2-year arrest of clinically established carious lesions documented in the present study may be viewed as a result of the applied preventive treatments. However, a restrained attitude to restorative treatment, which has not in itself brought about an arrest of carious lesions, has undoubtedly contributed to make arresting lesions visible in the material by eliminating a major part of the variation in clinical tissue changes at the time of restoration, which has been found in previous studies (4, 15). Thus in Gröndahl et al.'s study (3), in which a large proportion of arrested enamel lesions was also found, it

Table 5. Summary of recent approximal caries progression studies among Scandinavian children in the order of decreasing prevalence of radiographically visible enamel lesions at the first examination

Authors	Age in years at exam.	No. of children	Period	Enamel lesions			Lesions in dentin	
				No. of lesions in first radiograph	Average no. of lesions per child	% Lesions still in enamel in second radiograph	No. of lesions in first radiograph (100%)	% Lesions still in dentin in second radiograph
Gröndahl et al. (1977)	16	158	1971–74	1239	7.8	47	315	11
Gröndahl & Hollander (1979)	16	100	1971–77	721	7.2	36	195	4
Modéer et al. (1984)	14	194	1979–82	614	3.2	61	—	—
Granath et al. (1980)	12–13	126	1975–77	374	3.0	60	—	—
Hugoson et al. (1985)	15	80	1973–78	232	2.9	31	30	17
Gröndahl et al. (1984)	13	110	3 years	276	2.5	69	34	0
Bruun et al. (1985)	9–12	251	1978–81	139	0.6	58	10	0
Bille & Carstens (1989) (present study)	13	278	1980–82	148	0.5	86	38	55*

* $n = 21$; 12 of these lesions were opened shortly after the examination in 1982, leaving 24% lesions still in dentin.

was determined that restorations should only be made when a lesion was radiographically seen in dentin, although the ultimate decision was left to the responsible dentist. It is possible that 2-year arrested lesions were even better elucidated in our material, as the clinical findings showed that restorative treatment was instituted at a time when caries progression in all cases had produced changes in dentin but had not yet penetrated to damage the pulp.

It is, however, interesting to analyze the results for reasons that could explain why fillings were performed at all and why it was not possible to eliminate the basic differences entirely between the children in the 2-year period. Several related factors may be responsible for this; however, in the professional clinical situation it should be considered that the preventive treatments were instituted in children with radiographic evidence of dental caries and/or gingivitis. This may be a rather late stage in the disease process for the identification of the children with rapid progression, as distinct clinical symptoms of disease caused by microbial deposits were present (16).

Another plausible reason in relation to the professional treatment, which could explain why fillings were necessary, is that the clinical examinations and the preventive treatments in essence were structured as programs for subgroups. This structure of programs versus highly individual procedures has been an integral part of most clinical measures in the Child Dental Health Service. In the 1950s and early 1960s, when the prevalence of dental caries to be treated with fillings was high (2) and when the drinking water had been fluoridated in many other countries, it was common practice in Denmark to organize children in groups for preventive purposes out of context with the systematic clinical examinations performed every 6 months. This organization of preventive measures is in accordance with the classical clinical trial, in which subgroups are 'blind' to the treating dentists (13). During the 1970s it became evident that the variation in caries progression persisted even though the prevalence of dental caries decreased. This phenomenon was in general termed polarization, in the sense that a group of children, most often termed the 'risk group', was in need of extensive operative treatment compared with the rest of the children (17–22). Even though such observations have contributed to a change in the clinical work from being entirely non-specific towards more differentiation, the concept of grouping according to standardized procedures for examinations and for preventive measures still exists. In the present study, planned in the mid-1970s, fluoride application and instruction for better oral hygiene were the dominating standard procedures. Thus only a small group of children (group D, $n=26$) received a clinical program with frequent professional cleaning.

It seems natural, therefore, to assume that with a better understanding among dentists of the necessity to perform specific preventive treatments at earlier subclinical stages of the carious lesions, it will be possible almost to eliminate treatments with fillings among Danish children.

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