Progression rate of approximal carious lesions in Swedish teenagers and the correlation between caries experience and radiographic behavior. An analysis of the survival rate of approximal caries lesions

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The objectives were to study the progression rate of approximal caries in 14 to 19-year-old adolescents and to assess the influence of experience of previous caries as a predictor of caries progression during the following years. The study population comprised 100 adolescents, all 19 years old, randomly selected. In all, there were 93 adolescents included in the study, for whom all sets of bitewing radiographs from 14 up to and including the age of 19 were assessed with respect to approximal caries. It could be noted that 32% of the adolescents had had at least one bitewing examination every year from 14 to 19 years of age. At the age of 14, 38% of the males and 24% of the females were radiographically without any sign of caries lesions (caries-free). The median survival time of initial caries in the present study was >5 years, while for manifest caries it was 3.2 years. It was found that 37% of the surfaces with manifest caries in males and 18% of the corresponding surfaces in females were restored within a year. The results show that experience of previous caries does not seem to be a significant indicator and does not influence when the next radiographic examination should be performed. It is thus concluded that individualized bitewing examination is the exception rather than the rule. □ *Caries dental; examination radiography; progression*

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Caries progression through the enamel of approximal surfaces is a slow process, as has been shown in a number of studies (1, 2). The mean time for a lesion radiographically confined to the enamel to progress through the amelodentinal junction has been in the order of 3–4 years in children (3). In a recently performed study, it was shown that 75% of the lesions confined to the enamel survived 4.8 years without reaching the outer half of the dentin (4), and it has been reported that the prevalence of caries among young people in most industrialized countries has decreased dramatically during the last couple of decades (5). Swedish data from 1973 and 1983 demonstrate a considerable decline in prevalence of approximal caries among people below 20 years of age (6). However, it has recently been shown that there is an increasing prevalence of caries among young people (7).

The bitewing examination has become one of the most frequent examinations of all, and, compared to non-radiographic methods, shows a substantial increase in the number of detected lesions (8–10). Bitewing examination therefore has an important role to play in diagnosis and treatment planning and has become an essential part of everyday clinical work (11). Considering the number of intraoral radiographs taken annually, dental radiography presents a significant source of radiation exposure. Every radiographic examination has to be justified and can only be performed on individual grounds owing to the potential risk of exposure to low-dose radiation pointed out in several contexts (12, 13). In a couple of studies in the early 1980s, it was shown that dentists tended to take radiographs at the same frequency and interval for a majority of patients (14). As the prevalence of caries has decreased, a corresponding decrease in the number of bitewing radiographs taken should be expected. Recent studies have shown, however, that information from previous radiographic examinations has had only a limited influence on the decision to perform subsequent examinations (15–17). Between 9 and 18 years of age, more than 75% of patients were subjected to at least one bitewing examination annually (15, 17). The mean number of bitewing examinations per patient up to and including the age of 18 was shown to be 10.4, with a range of 6–15; the average interval between bitewing examinations was 11.6 months (15).

One objective was to study the progression rate of approximal caries in 14 to 19-year-old adolescents. Another was to study the influence of number of manifest caries lesions at age 14 on the development of manifest caries lesions during the age period 15–19 years.

Materials and methods

The study population comprised 100 randomly selected 19-year-old patients from the files of the Public Dental Service and was recently described elsewhere (17). The selected individuals had all lived in the same county in which the public dental clinic was located and had

received annual dental care from ages 3 to 19 years. The patients came from 22 different public dental clinics. Altogether, 93 dental records were examined and all sets of bitewing radiographs up to and including the age of 19 were assessed. In 7 cases no radiographs could be obtained owing to missing or unavailable radiographs. There were 44 boys and 49 girls. The dates of the examinations were noted and the identity of the patients concealed.

The sets of bitewing radiographs were assessed by 2 of the authors (EE and AG) for approximal caries using the same viewing box with constant light intensity. The observers were provided with a viewer with 2× magnification (X-produkter, Malmö, Sweden) that could be used to screen off light from the room. They were instructed to diagnose caries in the approximal surfaces and gave their statements on a premade form. The observers evaluated half the number of patient files each with associated bitewing radiographs and independently classified the approximal surfaces of all posterior permanent teeth as sound, carious, filled, unreadable or missing. The carious surfaces were classified into initial caries—a lesion confined to the enamel—and manifest caries—a lesion extending into the dentin. The surfaces assessed ranged from the approximal distal surface of the first premolar to the approximal distal surface of the second molar in all quadrants. The mesial surfaces of the first premolars were not recorded. The reason for not including the mesial surfaces of the premolars was that in most cases this surface is rarely imaged on the bitewing radiographs. From the patient records no information was obtained concerning the caries status of the other tooth surfaces. A calibration trial was conducted before the start. Interobserver and intraobserver variability was measured by rereading every tenth case after 2 months.

Statistical methods

All statistical calculations were made with a computerized statistical package (SPSS PS + 4.0, SPSS Inc., Chicago, IL, USA). Inter- and intra-examiner reproducibility was calculated using Cohen's kappa (18). Statistical techniques for survival analysis (19) were used to analyse the progression rate of initial and manifest caries and to test if progression rates were the same for subgroups (20). Survival of initial caries is defined as the number of years between the first registration of the lesion and the radiographic investigation when the surface has been registered as having a manifest caries lesion or an approximal restoration. Survival of manifest caries on an approximal surface is defined as the number of years between the first registration of manifest caries and the year when an approximal restoration has been registered on the same approximal surface. In order to compare prediction of caries development with observed outcomes, a logistic regression model was used (21). The statistical analyses were performed with the patient as the computational unit. Differences were considered significant at $P < 0.05$.

Results

Inter- and intra-examiner reproducibility of all radiographic assessments was calculated based on repeated evaluations of 672 sites in 9 individuals and was found to be significant ($P < 0.0001$). The overall agreement between examiners and Cohen's kappa was found to be 86.9% and 0.68, respectively. The corresponding figures for examiner I were 98.2% and 0.76 and for examiner II 98.8% and 0.77.

The mean number of bitewing examinations was 0.74 per individual per year and the mean time interval between each was 12 months. Thirty-two percent of the adolescents had had at least one bitewing examination every year from 14 to 19 years of age. At the age of 14, 38% of the males and 24% of the females were radiographically without any sign of approximal caries lesions (Fig. 1). The corresponding figures for 19-year-olds were 6% and 9%, respectively. The frequencies of initial and manifest caries, as well as proximal restorations, are presented according to age and sex in Table 1. It is shown in Fig. 2 that there is a positive correlation between number of proximal surfaces with initial caries and age between the ages 14 and 17, and also that there is a linear relationship between number of proximal surfaces with manifest caries and age over the age interval 14–19.

Initial caries

The proportion of surviving initial caries on proximal surfaces on premolars and molars over time is illustrated in Fig. 3. The five-year survival of initial caries was found to be 62%. Thus, median survival time of initial caries in the present study was >5 years. The progression rate was higher during the first 2 years than in the following 3 years.

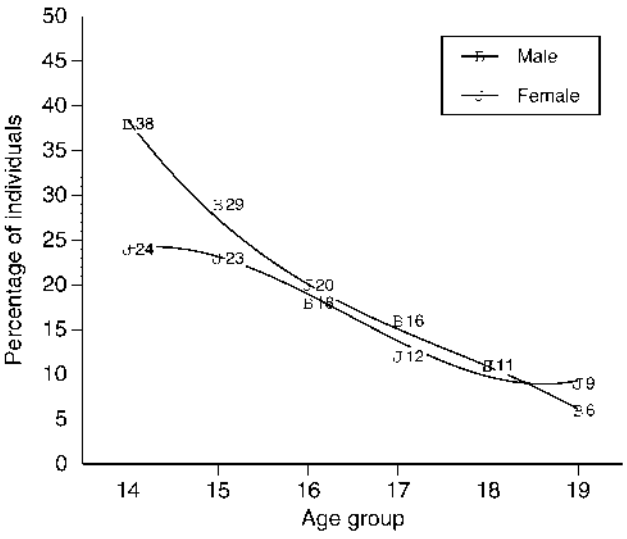

Fig. 1. Percentage of individuals with no initial and/or manifest caries in various age groups.

Table 1. Mean (standard deviation) number of initial caries, manifest caries and restorations on proximal surfaces in premolars and molars according to age group and sex

Age group	Sex	*n*	Initial caries	Manifest caries	Proximally restored surfaces
14	Male	33	2.9 (3.9)	0.42 (0.79)	0.30 (0.64)
	Female	34	4.2 (5.5)	0.24 (0.70)	0.38 (0.92)
15	Male	35	4.9 (4.6)	0.57 (1.2)	0.29 (0.79)
	Female	38	5.2 (5.2)	1.0 (2.0)	0.84 (1.5)
16	Male	35	5.3 (4.2)	1.1 (1.8)	0.74 (1.5)
	Female	33	6.6 (5.5)	0.88 (1.3)	0.91 (1.8)
17	Male	33	6.5 (4.9)	1.3 (2.1)	1.3 (2.8)
	Female	32	6.7 (5.3)	1.2 (2.2)	1.2 (2.0)
18	Male	36	5.8 (4.6)	1.5 (2.1)	1.6 (3.4)
	Female	38	7.0 (4.8)	1.5 (2.2)	1.3 (2.0)
19	Male	33	6.1 (4.7)	2.3 (3.1)	2.2 (3.8)
	Female	33	7.0 (4.7)	1.4 (2.1)	1.3 (2.0)

Age, sex and tooth surface were found not to have any significant influence on the progression rate.

Manifest caries

The median survival time of manifest caries was 3.2 years, with a 5-year survival of 33% (Fig. 3). The progression rate was approximately constant during the observation period. It was noted that 37% of the surfaces with manifest caries in males and 18% of the corresponding surfaces in females were restored within a year (Fig. 4). The median survival time of manifest caries was found to be 1.7 years in males and 4.4 years in females. After 5 years, 26% of the surfaces with manifest caries in males and 42% of the corresponding surfaces in females remained unrestored. The progression rate of manifest caries was significantly higher for males ($P < 0.01$). None of the other registered variables was found to be significantly correlated to survival of manifest caries.

In order to estimate the accuracy in predicting at least one new approximal dentinal caries lesion during the age period 15–19, the number of approximal surfaces in molars and premolars with manifest caries or restorations at age 14 was used (Table 2, Fig. 5). If the diagnostic criterion ≥ 1 approximal restoration and/or carious lesion was chosen, 95% of individuals with at least 1 approximal dentin lesion from the age of 15 to the age of 19 were correctly classified with the logistic regression model, while the corresponding relative frequency was 70% if the diagnostic criterion was =3 approximal restorations and/

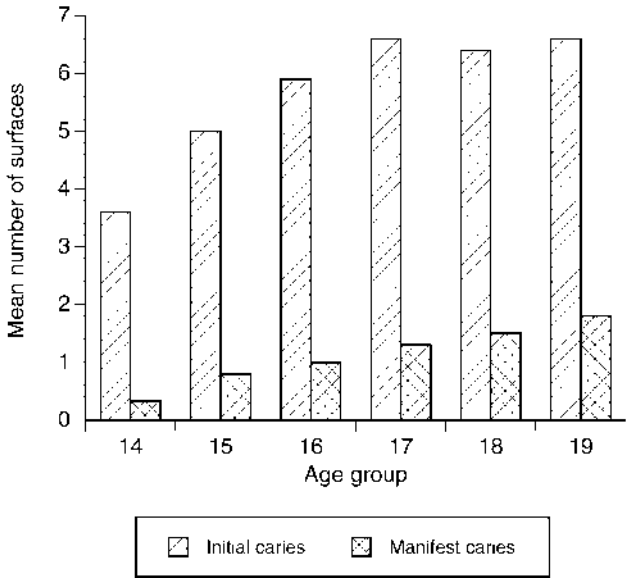

Fig. 2. Number of proximal surfaces with initial and or manifest caries in premolars and molars. Means in the different age groups.

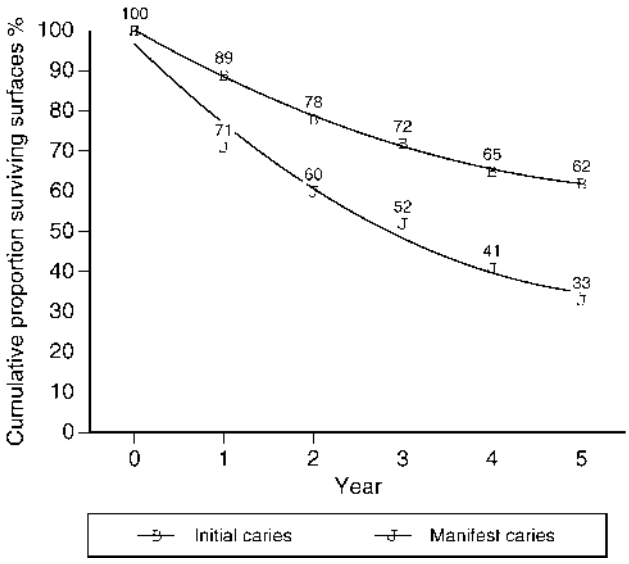

Fig. 3. Progression rate of initial and or manifest caries from 14 to 19 years of age.

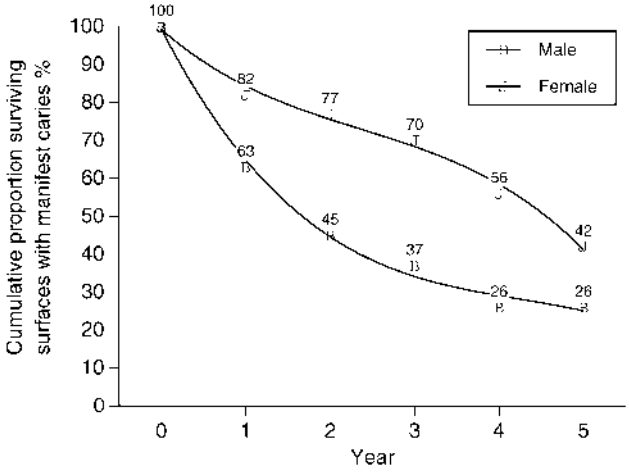

Fig. 4. Progression rate of manifest caries from 14 to 19 years of age according to sex.

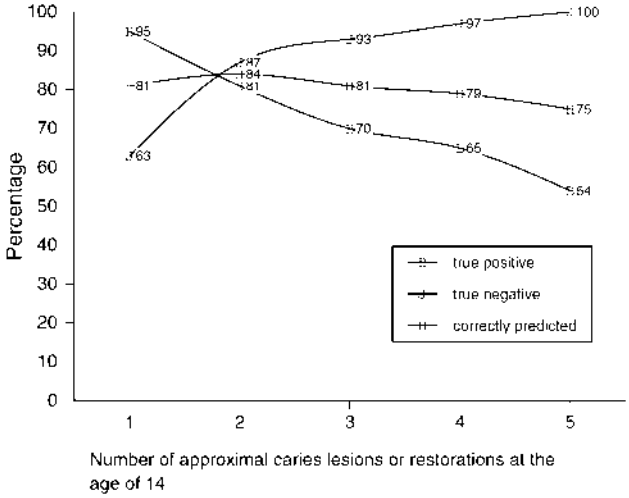

Fig. 5. Relative probability (%) of true positive, true negative and correctly predicted patients developing at least one approximal dentinal lesion from the age of 15 to the age of 19.

or carious lesions (true positive cases). In the group of patients without development of approximal caries lesions or restorations from 15 to 19 years of age, 63% were correctly classified with the diagnostic criterion = 1 approximal restoration and/or carious lesion (true negative cases). The highest relative frequency of correctly predicted classifications (84%) was found if the diagnostic criterion = 2 approximal restorations and/or carious lesions was chosen. Including sex in the logistic regression analyses did not significantly improve the model.

Missing data: 10.4% of the surfaces could not be registered. The most common reason was that it was not possible to evaluate the second molar distal surface and the corresponding figure was 31.1%.

Discussion

The present longitudinal study, a retrospective or historical cohort study, can be performed with reduced costs and in a more limited time period than a cohort study. However, reliability is increased in cohort studies, since all measurements can be standardized during planning of the design of the study.

In the present study, survival analysis of initial and manifest caries lesions was used as an approximate model for caries progression. We could show that the median survival time of initial caries was >5 years and that the progression rate was higher during the first 2 years compared to the following 3 years. We also showed that the median survival time of manifest caries was 3.2 years, with a 5-year survival of 33%, and that the progression rate was approximately constant during the observation period. Recently, it has been shown that the majority of lesions confined to the enamel do not reach the outer half of the dentin within 4.8 years (4)—a finding in good agreement with our study.

X-ray examinations should only be performed using strict criteria to minimize the number of radiographs taken, and hence the radiation dose, consistent with obtaining a diagnostically useful image. Bitewing examinations must not be prescribed or repeated as an automatic routine (22), or inconsistently (23). The reasons for prescribing bitewing radiographic examinations depend on a number of factors (24), one of which, i.e. earlier experience of approximal caries, may influence the decision to perform an X-ray examination the following year. It was observed that for 15-year-old adolescents the experience of caries at the age of 14 led to a reduced number of radiographs taken, but not for the older ones (17). The result of a recent study (Lith, 1992, p. 267) suggest that it should be possible to determine when next

Table 2. Frequency distribution of development of approximal manifest caries during the age period 15–19 after stratification according to number of approximal manifest caries lesions or restorations at age 14

	No. of approximal manifest caries lesions or restorations at age 14					
No. of new manifest caries lesions during the age period 15–19	0	≥1	≥2	≥3	≥4	≥5
0	19	11	4	2	1	0
≥1	2	35	30	26	24	20

to perform a radiographic examination using radiographic data collected at one point of time. However, the results showed that experience of previous caries did not seem to be a significant indicator of when to perform the next radiographic examination. Thus, individualized use of bitewing examinations seems to be the exception rather than the rule, as observed here and in another study (15). It has been suggested that it ought to be possible to prolong the interval between bitewing examinations, based on results obtained in other studies showing that the number of approximal restorations and/or radiographically observed carious lesions at the age of 13 could be used as a relatively good predictor of the development of lesions extending into the dentin over the next 2- and 5-year period (25). Thus, information from baseline radiographs, alone or along with additional information, may be used to assign dental care to those patients in greatest need of it (25). However, as found in this and in another study (15), the mean interval between bitewing examinations was approximately 12 months and it was only to a limited extent correlated to earlier developing caries over the years.

In industrialized countries, the number of X-ray examinations per year averages one per individual if oral radiology and mass radiography are included (26). As the bitewing examination is the most frequent radiographic examination of all, its contribution to the total radiation dose is not insignificant and accounts for approximately half of the collective dose from dental practice in Britain (27). All radiographic examinations should be performed according to individual needs and every radiographic examination in Sweden should be justified in relation to the regulatory requirements of the Swedish Radiation Protection Institute. In a recently published study, it was found that 75% of patients ranging in age from 9 to 18 years were subjected to at least one bitewing examination every year (15), which corroborates our findings, where the mean frequency of bitewing examinations per individual per year is 74%.

The number of approximal dentinal caries lesions and approximal restorations at the age of 14 was used in a prediction model estimating the probability of developing approximal dentinal caries during the age period 15 to 19 years. If the diagnostic criterion is changed, by increasing the number of caries lesions, the frequency of true positives was reduced. However, the frequency of true negative decisions increased with increasing number of caries lesions at the age of 14. The diagnostic threshold = 2 caries lesions at the age of 14 was found to be the diagnostic cut-off point with the highest frequency of correct decisions. This is in agreement with an earlier study (25), where caries lesions and approximal restorations at the age of 13 were used as a predictor for caries development between the ages of 13 and 18.

Overall agreement between examiners was 0.68 (Cohen's kappa), which is in accordance with other studies on diagnosis of carious lesions (28, 29). It was also noticed that there was a high level of agreement within the same observer. Thus, the corresponding figure for examiner I was 0.76 and for examiner II 0.77.

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