Progression of posterior approximal carious lesions in Norwegian teenagers from 1982 to 1986

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The purpose of the present study was to assess the progression rate of approximal carious lesions in Norwegians aged 14–18 years. Sixty-five subjects whose average age at base line was 14.9 years had one pair of posterior bitewing radiographs taken annually from 1982 to 1986. One examiner assessed all radiographs in chronologic order, recording degree of approximal caries. When a surface changed from one state to another, it was assumed to have changed at the midpoint between the two examinations. A total of 590 lesions were observed. Uncensored lesions took on average nearly 3 years to penetrate the enamel. Inclusion of right censored lesions by the Kaplan–Meier approach increased the uncensored estimate by approximately 20%. The average for doubly censored lesions was about 6.5 years. Low average rate of caries progression coupled with wide variations between lesions and among subjects suggests a need for individually prescribed recall rountines. □ *Bitewing radiographs; clinical study; dental caries, activity*

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Knowledge about the rate of dental caries progression is fundamental to the planning of dental services. Approximal carious lesions in posterior teeth have been studied by bitewing radiography in different parts of the world (1) but so far not in Norway. Most available studies were undertaken some time ago. Their estimate of the time lesions remained in a carious state have tended to be biased because due allowance has rarely been made for censored lesions—that is, lesions for which it was unknown when they entered and/or left a particular carious state (2). Furthermore, it cannot be precluded that the recently observed decrease in caries incidence may be associated with a change in the caries progression rate (3).

The purpose of the present study was to monitor the progression of censored and uncensored posterior approximal carious lesions among 14- to 18-year-old patients in the Community Dental Service and to obtain information for evaluation of recall routines.

Materials and methods

As part of the regular dental examinations, 65 patients had posterior bitewing radiographs taken with an Eggen film-holding device (4). The subjects received dental examination and necessary treatment at least annually during the study period. In connection with the treatment they also received application of fluoride varnish once a year, and most of them used fluoride dentrifrice.

The age of the patients was 14.9 ± 0.8 years at base line. They were followed up from 1982 to 1986, with a mean observation period of 37.4 ± 8.6 months.

The radiographs were mounted on transparent foil and examined for approximal carious lesions. The following grading system was used: grade 0 = sound surface; grade 1 = lesion of outer half of enamel; grade 2 = lesion of both inner and outer half of enamel; grade 3 = lesion of dentin; grade 4 = lesion involving pulp; and grade 5 = filled surface.

The radiographs from each individual were read in succession; that is, information from previous radiographs was available at the time of examination. Lesions that appeared to return to a less advanced state on later radiographs (7.1% of the total number of lesions) were coded as being in a less advanced state throughout. Overlapped surfaces that made scoring impossible were recorded, and 17.8% of all examined surfaces were found to be unreadable.

The DMFT score of the patients in the study group at the last examination was abstracted from their dental records and found to be 11.0 (SD, 4.9), whereas the average DMFT for 84% ($n = 695$) of the same birth cohort (born in 1967) was 10.4 (SD, 4.9) at the age of 17–18 years. The difference was not significant ($p > 0.05$). One molar had been extracted, and 41 premolars in 16 individuals were missing as a result of hypodontia or orthodontic treatment.

When a surface changed from one state to another in the scoring system, it was assumed to have changed at the midpoint between the two examinations. The examination was repeated for every fifth patient to test intraexaminer variability, and Alman's consistency ratio and agreement ratio were calculated (5). Intraexaminer agreement in the detection of carious lesions was 79.5%. Agreement with regard to the extent of penetration of the lesions was 76.4%.

Results

A total of 590 lesions were observed, of which 281 (47.6%) were present at base line. Sixty-four per cent of the lesions noted when the study started were found in grade 1.

Of the lesions present at the beginning of the study 55 (19.5%) were in grade 1 or 2. Forty (14.2%) of the lesions diagnosed in grade 1 or 2 later progressed to grade 3. Most lesions present at base line (66.3%) were still confined to the enamel at the end of the observation period. Of 66 lesions that appeared at the second examination, 83% were still in the enamel after 2 years.

A total of 18.0% of the lesions observed in the study reached the dentin. These lesions were found in 70.8% of the patients, of whom 60.8% had one or two lesions in dentin, and no one had more than five. Thirty-nine lesions went from grade 0 to grade 3 during the study period, with an average time of 26.2 months (SD, 11.1). The range was 7 to 42 months. There was not any significant difference in penetration rate between carious lesions in molars and premolars ($t = 1.06$, $p > 0.05$).

Uncensored and censored carious lesions have been considered separately in Table 1. Uncensored lesions on average remained in grade 1 for 18.6 months and in grade 2 for 16.4 months. The corresponding estimates for doubly censored lesions were 35.3 months and 30.6 months. Inclusion of right censored lesions by the Kaplan–Meier approach (2) increased uncensored estimates by 15% for grade 1 and 28% for grade 2 (Table 1).

Chi-square analyses on two degrees of freedom showed statistically significant differences between the frequency distributions of censored and uncensored carious lesions

Table 1. The average number of months that posterior approximal carious lesions remained in the different states (SD); n = number of lesions

	Grade 1		Grade 2		Grade 3	
Observations	n	$\bar{x}$ (SD)	n	$\bar{x}$ (SD)	n	$\bar{x}$ (SD)
Uncensored	31	18.6 (9.2)	30	16.4 (7.2)	1	4.0 (0)
Right censored	54	24.3 (11.2)	68	21.7 (9.7)	9	12.9 (5.0)
Left censored	52	20.4 (11.2)	16	19.7 (13.2)	2	11.0 (0)
Double censored	37	35.3 (8.5)	23	30.6 (11.0)	2	11.0 (0)
Uncensored + right censored	85	21.4 (10.8)	98	21.0 (9.3)	—	

Table 2. Percentage distribution of censored and uncensored lesions in outer (1) or inner (2) half of the enamel in accordance with the number of months in each state

	Uncensored		Censored	
Months	1 ($n = 31$)	2 ($n = 30$)	1 ($n = 143$)	2 ($n = 107$)
5–	19	30	13	11
11–	23	20	8	15
16–	13	17	19	22
21–	23	27	12	13
>25	22	6	47	39

in accordance with the length of time they were observed in grade 1 and grade 2 ($p < 0.05$). Forty-four per cent of the censored lesions ($n = 250$) remained in grade 1 or 2 for more than 25 months. The same applied to only 14% of the 61 uncensored lesions (Table 2).

Discussion

Observer performance may influence the results of studies of progression of dental caries. Intraexaminer error in the present study was close to 20%, which is within the range of other studies of intraexaminer error for recording caries (6). Acceptable intraexaminer variability is, however, not a guarantee of the quality of the diagnosis, and recently a more objective computer-aided image analysis has been developed (7).

Lesions that changed to a less deep state were regarded as being in the less deep state throughout. Observed regression may be due to radiographic or examiner error, but true regression of approximal carious lesions has been reported. Thus Pitts & Renson (7) found that the depth of 4 of 100 lesions regressed.

Overlapping surfaces were recorded only if they made scoring impossible; that is, some overlaps were allowed for if previous or later radiographs made a diagnosis possible. The 17.8% of the surfaces found unreadable because of overlap could have affected the result if the study had been a clinical trial of a cariostatic agent, but with the present aim this is unlikely.

Ideally, a study of caries progression should cover the whole natural history of lesions from beginning to end. In studies over a limited time period this approach is usually not possible. If only uncensored observations are included in the estimate of the length of time a carious lesion stays in a particular carious state, then the slowly progressing lesions are omitted (Table 2) and the mean time a lesion remains in a carious state will be greatly underestimated (2).

Already in 1961 Backer Dirks (8) reported that carious lesions on average needed 3–4 years to penetrate the enamel. The average time lesions took to penetrate the outer half of the enamel in the present study was also similar to observations made by Marthaler & Wiesner (9) in a 7-year study of the mesial surface of the first permanent molar of children aged 7.5 years at base line. Zamir et al. (10) in a 4-year study of individuals from the age of 14–15 years found that the lesions took on average 26.4 months to penetrate the enamel. From the inner half of enamel and into dentin the average penetration time was 13.6 months in the study of Zamir et al. (10), whereas in the present study it was 21.0 months.

Apparently, all the lesions studied by Zamir et al. (10) were left censored and thus present at the first examination. Both Marthaler & Wiesner (9) and Zamir et al. (10) seem to have omitted lesions that remained of interest at the end of the study period (right censored lesions). In the present study the average time a lesion was in the enamel was increased by 7.4 months (21.1%) by including right censored data. If it had been possible also to include double-censored data, this figure would probably have increased even more (Table 1).

Numerous studies have calculated the number of lesions still present in the enamel a certain period of time after the first examination (1). In reports from studies of age groups similar to those in the present study, the percentage of lesions in the enamel when the study started which were still present in enamel after 3–4 years seems to be approximately 50% (1), but the percentage is increased when considering only lesions in the outer half of the enamel at the beginning

of the study (11). The percentage of the lesions confined to enamel at the start of the present study which had not progressed into dentin by the end of the study was calculated to be approximately 60–70%. Unless a study starts shortly after tooth eruption, lesions that have been in a carious state for a long time before the study starts may be registered as quickly progressing if they change carious state. On the other hand, lesions that enter the carious state of interest after the first examination are not registered at all. This may result in an overrepresentation of lesions that progress in the study period. It has therefore been recommended to include only surfaces that are not carious at a preliminary examination before the study starts (12). This is usually not taken into consideration in the studies reported in the literature, but when it was done in the present study, 83% of the increment in enamel lesions at the second examination were still confined to enamel after 2 years.

If operative intervention were undertaken only when the radiolucency had entered the dentin, this would in the present material have resulted in an increment of 1.6 filled approximal surfaces per individual during the study period. If all radiolucencies were filled, then the number of fillings would have increased five- to six-fold. This clearly demonstrates the major effect of operative treatment strategy on dental health. Since it is now commonly accepted that the enamel may remineralize in the presence of fluoride (13) and that lesions have been found to reverse (7), restrictive use of operative therapy and implementation of preventive measures seem to have a lasting positive effect. From the present study it is also worth noting that the lesions used on average 3–4 years to penetrate the enamel and that there was ample time to initiate preventive therapy in an attempt to arrest or remineralize the carious lesions.

Annual recall for dental examination and treatment has been regarded as a major contributor to dental health and has for many years been practiced by the Community Dental Service in Norway.

The recent decrease in caries incidence and prevalence in children together with observations of a long average rate of caries progression have been used as arguments when the actual benefits of annual recall have been questioned.

The present study reconfirms observations in previous studies on the average progression rate of carious lesions. There were, however, highly variable progression rates of the carious lesions both between and within the different patients, which calls for individual recall routines on the basis of future predicted caries activity. In addition, it must be emphasized that the purpose of regular recalls and the use of periodic bitewing radiography is not only to detect carious lesions in need of operative treatment but is also the only aid to monitor success or failure of preventive therapy of initial lesions on approximal surfaces (14).

References

1. Pitts NB. Monitoring of caries progression in permanent and primary posterior approximal enamel by bitewing radiography. A review. Community Dent Oral Epidemiol 1983;11:228–35.
2. Shwartz M, Pliskin JS, Grøndahl H-G, Boffa J. Use of the Kaplan-Meier estimate to reduce biases in estimating the rate of caries progression. Community Dent Oral Epidemiol 1984;12:103–8.
3. Granath L, Kahlmeter A, Matsson LL, Schrøder U. Progression of proximal enamel caries in early teens related to caries activity. Acta Odontol Scand 1980;38:247–51.
4. Beyer-Olsen EM, Eggen S. Evaluation of the reproducibility of two bitewing techniques by means of a microdensitometric recording method. *Oral Surg* 1983;55:103–7.
5. Pliskin JS, Shwartz M, Grøndahl H-G, Boffa J. Reliability of coding depth of approximal carious lesions from non-independent interpretation of serial bitewing radiographs. Community Dent Oral Epidemiol 1984;12:366–70.
6. Haugejorden O, Slack GL. A study of intra-examiner error associated with recording of radiographic caries at different diagnostic levels. Acta Odontol Scand 1975;33:169–81.
7. Pitts NB, Renson CE. Monitoring the behaviour of posterior carious lesions by image analysis of serial standardised bitewing radiographs. Br Dent J 1987;162:15–21.
8. Backer Dirks O. Longitudinal dental caries study in children 9–15 years of age. Arch Oral Biol 1961;6:94–108.
9. Marthaler TM, Wiesner V. Rapidity of penetration of radiolucent areas through mesial enamel of first

permanent molars. Helv Odont Acta 1973;17:19–26.
10. Zamir T, Fisher D, Fishel D, Sharav Y. A longitudinal radiographic study of the rate of spread of human approximal dental caries. Arch Oral Biol 1976;21:523–6.
11. Grøndahl H-G, Andersson B, Torstensson T. Caries increment and progression in teenagers when using a prevention- rather than restoration-oriented treatment strategy. Swed Dent J 1984;8:237–42.
12. Shwartz M, Pliskin JS, Grøndahl H-G, Boffa J. Study design to reduce biases in estimating the percentage of carious lesions that do not progress within a time period. Community Dent Oral Epidemiol 1984;12:109–13.
13. Thylstrup A, Birkeland JM. Prognosis of caries. In: Thylstrup A, Fejerskov O, ed. Textbook of cariology. Copenhagen: Munksgaard, 1986:358–68.
14. Pitts NB. The bitewing examination as a preventive aid to the control of approximal caries. Clin Prev Dent 1984;6:12–5.

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