**Comparison of diagnostic yields of clinical and radiographic caries examinations in children of different age**

V. MACHIULSKIENE*, B. NYVAD**, V. BAEOLUM**

**ABSTRACT. Aim** This was to investigate if the pattern of distribution of caries lesions detected by clinical and radiographic examinations at different diagnostic thresholds changed over a 3-year period during the course of eruption of the permanent dentition. It has been hypothesized that the contribution of bitewing radiography to caries detection in posterior teeth may increase when approximal contacts are established during maturation of the dentition.

**Methods** Clinical and radiographic caries recordings were made using the non-cavitated/enamel and cavity/dentine thresholds for caries detection among a group of 12-year-old Lithuanian children with a high caries experience. Examinations were repeated in the same children after 3 years. The bitewing radiographs from both examination sessions were coded to ensure unbiased recordings and were read by a single examiner.

**Results** The diagnostic yields of the clinical and radiographic examination methods did not change after the permanent teeth had fully erupted. At both examination sessions the clinical examination resulted in the detection of significantly more lesions than did the radiographic method at the non-cavitated level (43-47% lesions detected by clinical means only and 2-26% by radiographic means only). Only for approximal surfaces at the cavity/dentine diagnostic threshold did radiographs contribute to more lesions (15-16% lesions detected by clinical means only and 38-41% by radiographic means only). Establishment of approximal contacts in the permanent dentition did not increase the relative diagnostic yields of bitewing radiography in this study group.

**Conclusion** The contribution of the two methods to caries diagnosis depends more on the diagnostic threshold selected than on the stage of maturation of the dentition.

**Keywords**: Bitewing radiographs, Caries diagnosis, Non-cavitated caries, Children.

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**Introduction**

During the last two decades it has become apparent that selection of appropriate diagnostic criteria plays a key role in clinical caries diagnosis. In modern populations featuring a decrease of dental caries, crude clinical diagnostic criteria based on counts of cavitated lesions only are no longer a reliable measure of fast and ongoing disease [Pitts and Fyffe, 1988; Amarante et al., 1998; Ismail et al., 1992]. Hence, it has been advocated to include initial, non-cavitated lesions among the caries scores in order to allow for the possibility to monitor disease progression as well as to predict caries activity and to revise treatment strategies [Ismail, 1997]. In this context, the diagnostic performance by other supplementary diagnostic tools, particularly radiographic methods of caries detection, should also be addressed. It has been shown that radiography has low sensitivity in detecting early caries lesions [Gröndahl, 1994; Hintze et al., 1994], and is associated with large variations in perception of the lesion depth as seen on the radiographs [Mileman et al., 1992; Lewis et al., 1996]. Nevertheless, this method is sometimes still considered as an accepted standard when estimating the caries prevalence in populations, or when determining the treatment for patients [Kay et al., 1992; Poorterman et al., 1999]. Therefore, re-evaluation of the contribution of bitewing radiography to present day caries diagnosis is needed, in order to alter a common tradition among dentists in many Western European countries to take radiographs in a routine manner [Espelid et al., 1985; Gröndahl et al., 1992].

A few years ago we were able to demonstrate that the additional diagnostic yield of bitewing radiography in a
high caries prevalence population of 12-year-old children was very limited when the clinical diagnosis included the non-cavitated lesions [Machiulskiene et al., 1999]. It may be argued that the relatively few approximal contacts in the dentition of children at the age of 12 would make it easier to perform a reliable clinical caries diagnosis of early lesions. Therefore, it is possible that the conclusions drawn in the above mentioned study could not be generalized to populations of older age. On the other hand, studies on the surface morphology of caries lesions have shown that approximal caries lesions are usually initiated beneath the contact facet close to the marginal gingiva where the tooth surface is well protected from mechanical forces [Thylstrup and Fejerskov, 1994]. Black noted, as early as 1914, that “...the most prominent tendency to wide spreading of decay on the surface of the enamel is a direction that encircles the tooth following close to free margin of the gum”. Indeed, clinical experience shows that non-cavitated lesions usually spread as a thin white or brown line along the proximal surface and often extend onto the buccal or lingual surfaces. Therefore, even if direct access to the approximal surface is limited, a careful clinical inspection of the approximal embrasure may provide certain information about the caries status of the surface.

The aim of the present study was to follow a population of 12-year-old children over 3 years, and to investigate if the pattern of distribution of carious lesions detected by clinical and radiographic examination of posterior teeth at different diagnostic thresholds changed over the course of this period during eruption of the permanent dentition.

Materials and methods
The study was performed in a high caries prevalence population of Lithuanian children [Machiulskiene et al., 1998] who had taken part in two clinical trials testing different caries preventive measures over a period of 3 years (1995-1998) [Machiulskiene et al., 2001; Machiulskiene et al., 2002]. The design of the trials and the interventions employed have been described in detail previously [Machiulskiene et al., 2001; Machiulskiene et al., 2002]. Briefly, a total of 872 children with a mean age of 11.7 (SD±0.63) from the city of Kaunas entered the study after parental written informed consent had been obtained and the protocol approved by the Ethical Committee of the University of Kaunas. At the outset of the study the children had a careful clinical (visual/tactile) and radiographic caries examination. After 3 years the 535 children still remaining in the study were re-examined by the same two methods. All examinations were performed under standardized conditions by the same examiner (VM). Clinical caries diagnoses reflected the disease activity at different diagnostic thresholds (non-cavitated as well as cavitated) [Nyvad et al., 1999] (Table 1). Caries was recorded at the surface level, using plane mouth mirrors and standard explorers after application of cotton rolls and drying with a blast of air for 3-5 seconds. Two posterior bitewing radiographs (Kodak Ectaspeed Plus films) were taken of each participant using a beam aiming device and a portable X-ray equipment (Oralix 65 S, Dentronic A/S, Denmark, 1994), followed by processing in an automatic processor (Dürr Dental, Bietigheim-Bissingen, Germany). Assessment of the radiographs from both examination sessions was performed as

<table>
<thead>
<tr>
<th>Clinical diagnostic criteria</th>
<th>Radiographical diagnostic criteria</th>
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<tbody>
<tr>
<td><strong>Original</strong></td>
<td><strong>Re-coded</strong></td>
</tr>
<tr>
<td>Sound</td>
<td>Sound</td>
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<tr>
<td>Surface intact (active/inactive)</td>
<td>Non-cavitated</td>
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<td></td>
<td>Radiolucency in inner 1/2 of enamel</td>
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<td>Surface discontinuity (active/inactive)</td>
<td>Cavitated</td>
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<td></td>
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<tr>
<td>Cavity (active/inactive)</td>
<td>Radiolucency in inner 2/3 of dentine</td>
</tr>
<tr>
<td>Filled + caries (active/inactive)</td>
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<td>Filled</td>
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**Table 1** - Diagnostic criteria used in the present study for assessment of the diagnostic yields of clinical and radiographic examinations of Lithuanian children.
described previously [Machiulskiene et al., 1999], without knowledge of clinical scorings and of the examination date. For this purpose, all the bitewing radiographs from 1995 and 1998 were re-coded and read in a “blind” manner under standardized conditions, using x2 magnification.

The relative diagnostic yields of the clinical and radiographic examinations were estimated based on a total of 29,878 and 22,821 occlusal and approximal surfaces of permanent teeth, in 1995 and 1998, respectively. The number of surfaces available for caries diagnoses at the four different examination sessions is presented in Table 2.

**Data analysis.** Assessment of the contribution of the clinical and radiographic examination methods to the total number of caries diagnoses was performed at two diagnostic levels: the non-cavitated/enamel level (including all caries diagnoses) and the cavity/dentine level (including cavitated/dentine diagnoses, only). Evaluation of the impact of increased approximal contacts over the study period on the relative diagnostic yields of the methods was performed by comparing the pattern of distribution of caries lesions detected by either method as well as the actual numbers of site-specific diagnoses at both examination sessions.

**Results**

**Intraexaminer reliability.** The kappa value for the intraexaminer reliability (VM) of the clinical caries recordings on posterior approximal and occlusal surfaces was 0.82-0.88, and the proportion of disagreement of the clinical diagnoses ranged from 0.54% to 2.40% at the cavity and non-cavitated levels, respectively [Machiulskiene et al., 1999]. The corresponding figures for radiographic intraexaminer reliability were as follows: kappa values ranging from 0.89 to 0.94 for approximal and occlusal surfaces, and the proportion of disagreement ranging from 0.28% to 1.03% at the dentine and enamel levels, respectively [Machiulskiene et al., 1999]. Furthermore, when comparing the scores of the baseline radiographs performed in 1995 [Machiulskiene et al., 1999] with the scores of the repeated readings of the same radiographs, the calculated intraexaminer agreement for erupted and recordable surfaces between the two different examinations of baseline x-rays was 92%.

**Caries data.** Analysis of the data obtained by examining occlusal and approximal surfaces of posterior teeth by both methods showed that there were significantly more carious lesions detected at the non-cavitated/enamel level than at the cavity/dentine level of diagnosis (Table 3). Thus, in 12-year-olds, 48% of all occlusal and 21% of all approximal surfaces examined by both methods were positive for caries as judged from a positive diagnosis by at least one of the two recording methods. However, when the non-cavitated/enamel diagnoses were omitted and only cavities or dentine lesions were considered, the total number of caries lesions decreased, while 1,519 occlusal surfaces and 2,704 approximal surfaces were regarded as sound. The same tendency was observed in the 15-year-olds, although the percentage of surfaces affected by caries increased slightly with age (51% of all occlusal surfaces and 27% of all approximal surfaces examined had any type of the lesion) (Table 3).

In both age groups the clinical visual/tactile method performed much better than did the radiographic examination at the non-cavitated/enamel level. Thus, in 12-year-olds, almost half of the 4,851 and 4,049 lesions detected in occlusal and approximal surfaces, respectively, could be detected clinically. Similarly, in 15-year-olds, of about 4,000 carious sites 44-46% showed only clinical evidence of the disease (Table 3). However, the contribution of radiographs to caries diagnosis increased significantly when the non-cavitated/enamel lesions were omitted and the diagnostic threshold was set at the cavity/dentine level: from 2% to

<table>
<thead>
<tr>
<th>Number of surfaces</th>
<th>Occlusal</th>
<th>Approximal</th>
<th>Total</th>
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<tr>
<td>1995</td>
<td>10,110</td>
<td>19,768</td>
<td>29,878</td>
</tr>
<tr>
<td>1998</td>
<td>7,747</td>
<td>15,074</td>
<td>22,821</td>
</tr>
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**Table 2 - The distribution of surfaces potentially available for clinical and radiographical caries diagnoses in 1995 and 1998.**
10% in occlusal surfaces of 12-year-olds (from 2% to 9% in 15-year-olds), and from 26% to 41% in approximal surfaces of 12-year-olds (from 24% to 38% in 15-year-olds) (Table 3).

Diagnostic yield. Comparison of the relative diagnostic yields of the two examination methods applied in different age groups showed that the pattern of distribution of the lesions detected by either method remained essentially the same after 3 years (Fig. 1).

A site-specific comparison of the clinical and radiographic diagnoses obtained in approximal and occlusal surfaces showed that the percentage of ‘hidden’ caries (i.e. clinically sound surfaces with radiographic diagnosis of dentine lesion/filled) ranged between 2.0-2.4% in 12- and 15-year-olds, when non-cavitated diagnoses were included in the clinical examination.
When considering clinical non-cavitated diagnoses as sound, the percentage of “hidden” lesions in approximal surfaces was 2.9% in 12-year-olds and increased to 3.7% in 15-year-olds. The corresponding figures for the occlusal surfaces were 4.9% and 4.2%, respectively (Table 4).

Discussion

The ultimate goal of the caries diagnostic process in clinical practice is to form the basis for subsequent treatment decisions. When considering the current concept about dental caries as a lifelong dynamic process that can be controlled by non-operative procedures [Fejerskov, 1997], modern treatment strategies should aim at preserving the integrity of the tooth as long as possible. Therefore, early diagnosis of lesions becomes of prime importance.

The present study compared the diagnostic yields of independent clinical and radiographic examinations as seen from an epidemiological perspective. It should be appreciated that recordings made by clinical and radiographic methods reflect lesion characteristics that are qualitatively different. While clinical recordings are mainly concerned with the surface properties of lesions (texture, colour, cavity formation etc.) radiographic recordings reflect the depth of mineral loss in the dental hard tissue. To establish the true diagnosis would require an independent standard that encompasses key characteristics of both clinical and radiographic caries. As such a universal ‘gold standard’, with which the individual diagnoses can be compared, does not exist [Hintze and Wenzel, 2003], it is not legitimate to merely sum up the diagnostic yields of both examinations. The purpose of our study was, therefore, not to identify a priority method for clinical caries diagnosis, but rather to demonstrate the diagnostic potential of the two most commonly used methods for detection of caries, depending on the diagnostic threshold selected.

Even though we did not apply supplementary diagnostic tools likely to increase the diagnostic yields of clinical examination, such as Temporary Tooth Separation [Pitts and Rimmer, 1992; Deery et al., 2000], our data clearly demonstrated that it is possible to detect the signs of caries clinically at a much earlier stage than by the use of radiographs, with no influence of patients’ age. Thus, in both 12- and 15-year-olds the clinical visio-tactile examination of approximal surfaces was able to detect nearly twice as many lesions as did the radiographic method when using the non-cavitated/enamel level of diagnosis. Furthermore, in occlusal surfaces, the contribution of bitewing radiographs to the detection of early lesions was negligible. This observation is not new, but rather confirms the inherent problem associated with dental radiography, that a certain amount of mineral must be lost from the tooth before a lesion can be detected radiographically [Gröndahl, 1994]. Indeed, in agreement with many other studies [for review, see Pitts, 1996], our data confirm that bitewing examination is a valuable supplementary diagnostic tool for the detection of cavitated stages of lesion formation or lesions with dentine involvement. Hence, in approximal surfaces the ability of radiographs to detect a carious lesion at the cavitated/dentine level was four times higher than at the non-cavitated enamel level.

Contrary to common beliefs, a carefully conducted clinical examination of approximal surfaces performed at least as well as radiographic examination in the fully erupted dentition as compared with the younger immature dentition. Unfortunately, many dentists have been brought up with the idea that clinical examination is rather ineffective in difficult to reach areas such as approximal surfaces and therefore they rely mainly on radiography [Mileman et al., 1992; Lewis et al., 1996]. It should be appreciated, however, that a radiolucency detected on a radiograph does not always reflect the true caries status of a surface [Mejare and Malmgren, 1986; Pitts and Rimmer, 1992; Akpata et al., 1996; Lunder and der Fehr, 1996; Machiulskiene et al., 1999], nor does it say anything about the activity status of the surface. As a result Woodward and Leake [1996] have suggested that dentists should estimate the probability of a clinically diagnosed cavitated lesion to be at least 30% before they prescribe radiographs for regularly attending patients, in order to avoid frequent false-positive diagnoses. In contemporary low caries populations characterized by a large number of non-cavitated lesions a considerable part of the caries treatment is likely to entail non-operative preventive procedures, the effect of which needs to be monitored over time. Till now, only clinical caries diagnostic criteria have proved to be capable of recording changes in the activity of lesions in response to preventive treatments [Nyvad et al., 2003]. Therefore, the dental profession should be aware that unless a thorough clinical caries examination is performed, important information about the behaviour of caries lesions could be lost, even in approximal surfaces.

Conclusion

The data of the present study support our previous findings [Machiulskiene et al., 1999] that the contribution of the clinical and radiographic methods to caries diagnosis in a high caries population strongly depends on the diagnostic threshold selected. If the
diagnostic priority is set to detect early caries lesions in need of preventive treatment, the additional value of bitewing radiography is minor. Furthermore, as demonstrated in the current high caries prevalence population of Lithuanian children, establishment of approximal contacts does not in and off itself increase the relative diagnostic yield of bitewing radiography. Consequently, the widespread recommendation of regular use bitewing examinations for caries diagnosis is not justified by the results of this study.

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References


