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Bitewing Examination to Detect Caries in Children and Adolescents – When and How Often?

Abstract: It is generally agreed that the decision to take bitewing radiographs for detecting caries should be based on the benefit to the individual patient in relation to the risks associated with low dose radiation exposure and the costs. There is incomplete knowledge about the effectiveness of various methods for selecting individuals who will benefit from bitewing examination. Available knowledge suggests, however, that our ability to identify correctly those who will benefit is limited. It may, therefore, be more effective to combine population- and individual-based selection criteria. For this purpose, four key ages and individual-based criteria between the key ages are suggested.
Clinical Relevance: The purpose of the presented selection criteria are to improve the dental practioner's effectiveness in selecting patients who will benefit from bitewing examination, thereby reducing the number of arbitrary and 'just in case' radiographs and the radiation dose.
Dent Update 2005; 32: 588-597

Although far from perfect, bitewing radiography is still the most commonly used diagnostic aid for:

- Detecting approximal enamel lesions that can be treated for remineralization;
- Deciding if or when to restore approximal caries lesions by monitoring lesion progression;
- Detecting occlusal dentine lesions;
- Identifying individuals at risk for new caries lesions or progression of existing lesions.

Unlike Great Britain,[1] there are no official guidelines in the Nordic countries for when and how often bitewing radiography should be considered. However, in the UK and Nordic countries, the general policy is that bitewing examination should be based on individual caries risk assessment, taking into account the benefits for the individual patient, particularly in relation to the risk associated with low-dose radiation exposure and the costs to society. The effectiveness resulting from this rather unspecific recommendation may, however, be questioned, and the difficulties in putting it into practice have been demonstrated.[2,3]

The expected benefits of bitewing examination depend on several factors such as:

- The caries prevalence in the population;
- The extent to which caries lesions can be detected from visual/tactile examination or by other means;
- At what stage of lesion development we want to detect lesions;
- The expected rate of lesion progression;
- At what stage the lesions are restored; and
- The amount of risk that we are willing to take.

Furthermore, the quality of the radiographs and the diagnosis play a decisive role. Considering the complexity of many of these factors, it is not surprising that practising dentists may have difficulties in finding and applying decision rules allowing them to individualize the time and frequency of bitewing examinations in an effective way. The main aim of suggesting the present selection criteria was therefore to increase the effectiveness of the use of bitewing examinations and thereby minimize arbitrary and 'just-in case' radiographs, reducing the radiation dosage to the population and, consequently, the costs.

It should be appreciated that the following is not meant to replace the dentist's individual-based caries risk assessment. Rather, the purpose is to assist the dental practitioner in his/her decision when to take bitewing radiographs.

Population- and individual-based selection criteria

Along with the decline in caries prevalence – sometimes combined with economic incentives – the intervals between dental examinations have gradually increased; 1.5–2 years between examinations is now advocated for low caries risk

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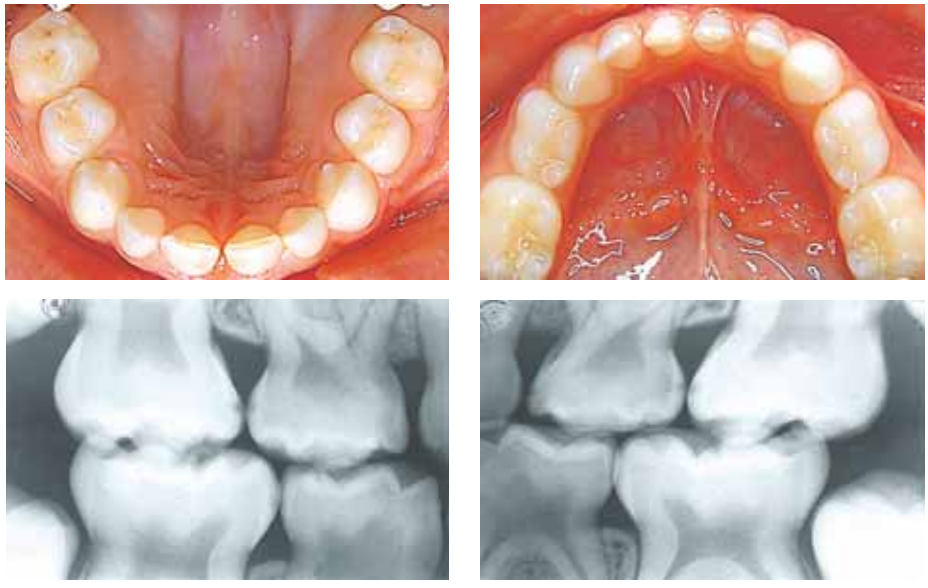

Figure 1. Clinical and radiographic appearance of a 5-year-old. Clinical examination alone showed no signs of approximal caries while bitewing radiography revealed a number of enamel and dentine lesions.

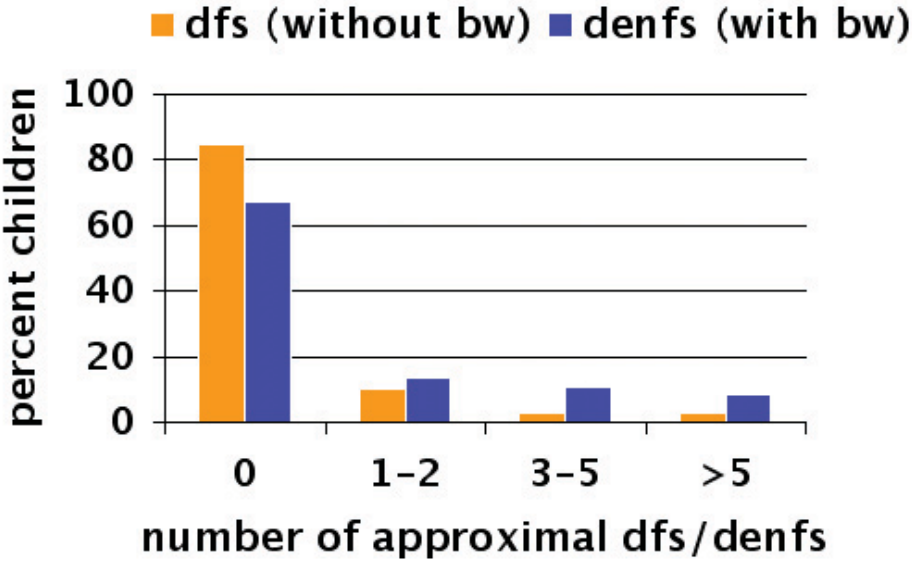

Figure 2. Percentage distribution of approximal caries lesions (distal surface of the canines to the mesial surface of the second primary molars) without and with bitewing radiography in a group of 5-year-old Swedish children in 2002 (n = 267); dfs = dentine lesions, denfs = enamel and dentine lesions. From Anderson *et al*.[9]

individuals in the Nordic countries and the adult population in the UK, whereas the recall interval for children remains between 6 months and 1 year in Britain. Prolonged intervals of up to 2.5–3 years between bitewing examinations for populations with generally low caries prevalence were suggested in 1986,[4] and more recent reports have confirmed that the intervals can be prolonged without jeopardizing the dental health of populations.

The selection criteria presented here are primarily designed for populations with generally low caries prevalence where the distribution is skewed, that is the caries burden is unevenly spread among the individuals. They include both population-based and individual-based caries risk assessments concerning new caries lesions and progression of existing lesions. Two main questions arise:

- Are there certain ages when bitewing radiography should be considered?
- At what intervals should the examinations be performed?

In general, repeated caries risk assessments at regular intervals are necessary for all, and the risk of developing new caries lesions is highest during the first years after eruption.[5-8] From this reasoning, four key ages can be identified: 5, 8–9, 12–13 and 15–16 years. Individual caries risk assessments are made from the information gathered at these key ages until the next key age.

The first key age – 5 years

At age five, the approximal surfaces of primary molars have been in contact for 2–3 years and, according to recent studies from the Nordic countries, between one-third and a half of all 5-year-olds have at least one approximal caries lesion.[9,10] The vast majority of these lesions could not be detected without bitewing examination. Figure 1 shows a 5-year-old who, from the visual/tactile examination, showed no signs of approximal caries, whereas the bitewing radiographs reveal a number of approximal lesions. The percentage distribution of approximal lesions in a group of Swedish 5-year-olds in 2002 is given in Figure 2. The diagnostic yield from bitewing examination compared with visual/tactile inspection was, on average, 1.2–1.8 lesions.[9,11] Therefore, there are reasons to consider bitewing examination at the age of five even in so-called low caries prevalence populations.

The value of identifying caries-free 5-year-olds (including radiographically sound approximal surfaces) should also be appreciated. Unless other relevant risk factors have been identified, these children run a comparatively small risk of developing new approximal lesions during the next 3–4 years. Likewise, the risk of developing caries on occlusal surfaces of permanent first molars is relatively small.[12]

Individual risk assessment

Factors known to be associated

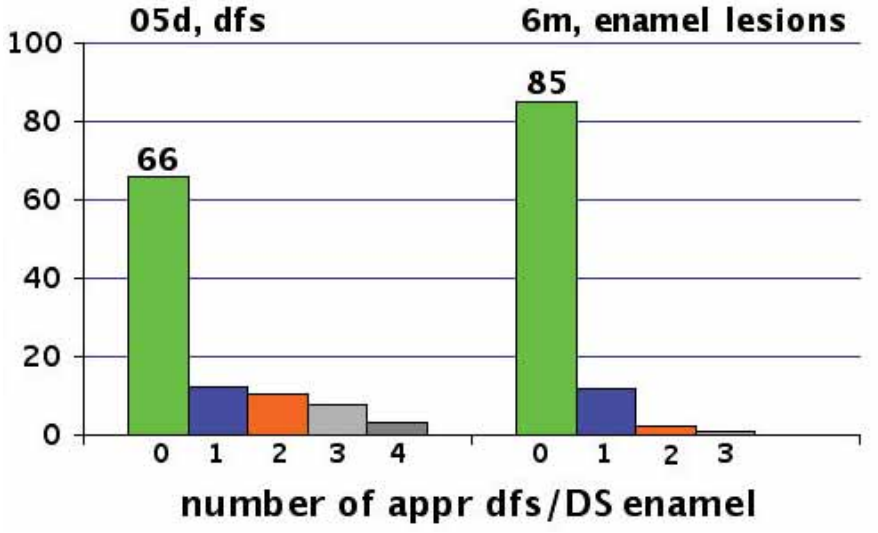

Figure 3. Percentage distribution of approximal caries lesions in the second primary and the permanent first molars at age 9 in a group of Swedish children (n = 260); 05d = distal surface of the primary second molar; 6m = mesial surface of the permanent first molar. From Mejàre *et al*.[14]

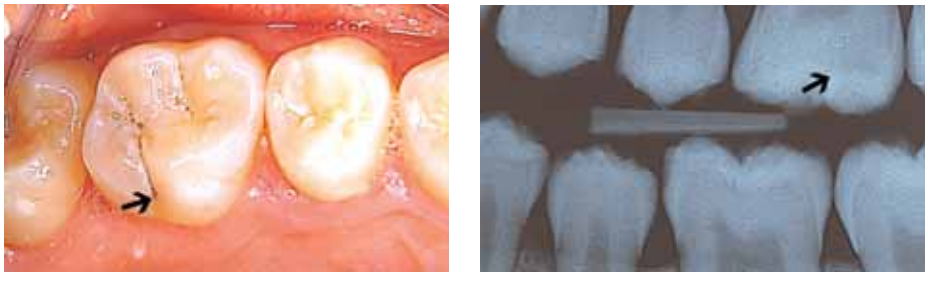

Figure 4. Clinical and radiographic appearance of the occlusal surface of a permanent upper left first molar in an 11-year-old. The clinical photo shows that the normal translucency of the enamel is lost in the distal-palatal fissure, with a shadow in the enamel and possibly also a small cavity, as judged visually with arrow indicating dentine caries. Most probably, these pathological changes had been overlooked at previous examinations. At age 11, the radiograph reveals rather extensive occlusal dentine caries (arrow).

with future caries, such as social background, previous caries experience, visible plaque, inappropriate diet – and oral hygiene habits and the 'overall judgement' of the dentist are also used to 'predict' the presence of approximal caries in bitewing radiographs. However, knowledge about how well the risk indicators/risk factors can predict the presence of approximal lesions as seen in the bitewing radiographs of an individual is scarce. In two studies on Norwegian and Swedish 5-year-olds, respectively, the prediction was rather limited.[9,10] In the Swedish study, the 'overall judgement' by the dentist (the dentist's qualified guess about the probability of the presence of approximal lesions seen only radiographically after collecting clinical information about the child) was the best parameter to predict which children had/had not approximal caries at the following bitewing examination. But only about half of the children with approximal lesions were correctly identified from the dentist's 'overall judgement'. The presence of mutans streptococci has also been investigated as a 'predictor' for the presence of approximal caries in 5-year-olds.[13] However, this is no better than the dentist's 'overall judgement'. This illustrates the difficulty in correctly identifying children with approximal caries from different background factors and clinical parameters in a contemporary so-called low caries prevalence population.

The second key age – 8–9 years

At this age, a new risk assessment for the next 3–4 years should be considered. For the majority of children, the mesial surfaces of the permanent first molars have been in contact with the primary second molars for about 2–3 years. As for all the key ages, the benefit of bitewing examination is dependent on the caries prevalence in the population. Knowledge about the prevalence of approximal caries on the mesial surface of the permanent first molars in today's 8–9-year-olds is scarce. Fifteen percent of Swedish 9-year-olds born in 1972–73 had at least one approximal enamel lesion on this tooth surface, and every third child had at least one approximal caries lesion on the distal surface of the primary second molars[14] (Figure 3). The risk of developing caries on the mesial surface of permanent first molar increases considerably if the distal surface of the primary second molar has developed caries or is restored.[14] Assuming that non-operative, preventive measures are effective, it is therefore especially important to detect caries in the primary second molar as early as possible. About 20% of Swedish 12-year-olds have at least one approximal dentine lesion on the mesial surface of the permanent first molar. The conditions for successful non-operative treatment should increase if they are detected early. Just like the 5-year-olds, caries-free 8–9-year-olds can be looked upon as low-risk children for new caries lesions during the next 3–4 years. Thus, information that a child of 8–9 years has no lesions on a bitewing is also valuable. This child would not normally require another radiograph until the next key stage, 12–13 years.

Bitewing radiographs may also be used to detect occlusal dentine caries. According to experienced general practitioners in Sweden, extensive occlusal restorations in molars are not uncommon in adolescents, indicating that occlusal dentine lesions have been overlooked (Figure 4). This assumption is supported by results from Kidd *et al*.,[15] showing that about half of a group of 15-year-olds had at least one molar with radiographically detected untreated occlusal dentine caries.

The third key age – 12–13 years

At this age, most individuals have several contacting approximal

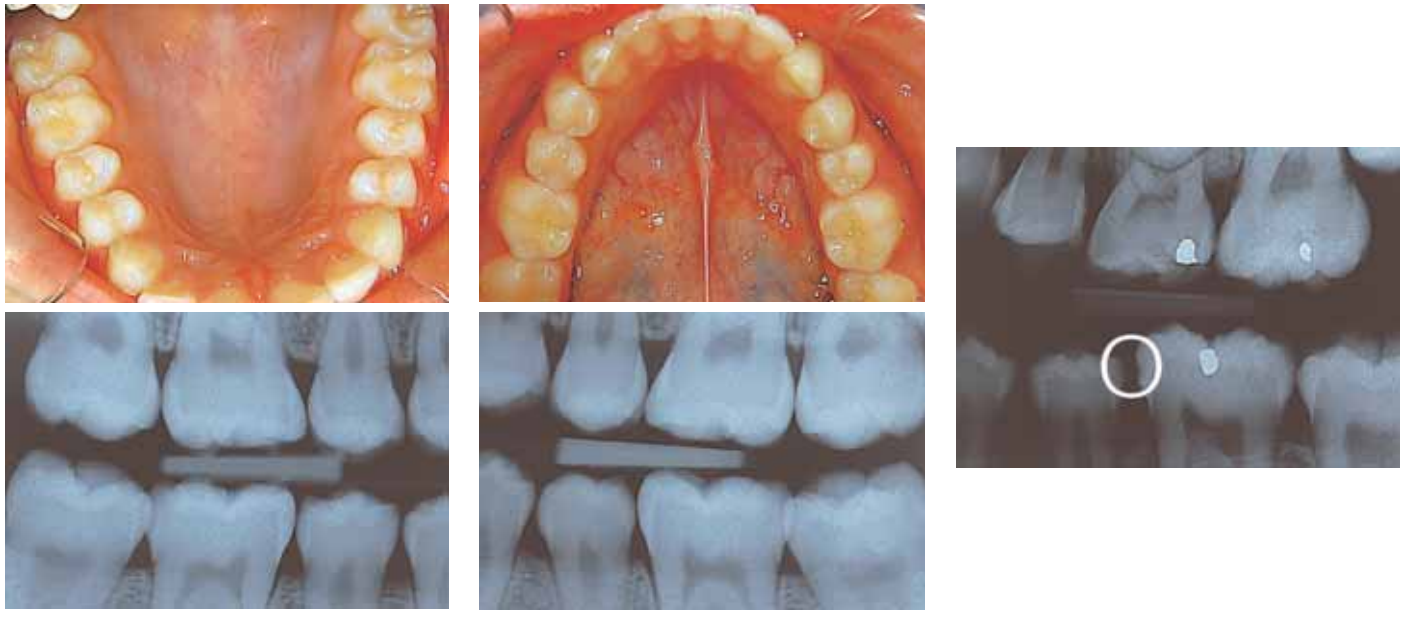

Figure 5. Clinical and radiographic appearance of a caries-free 13-year-old. The radiograph to the right shows another 13-year-old with an approximal enamel lesion on the mesial surface of the lower left permanent first molar.

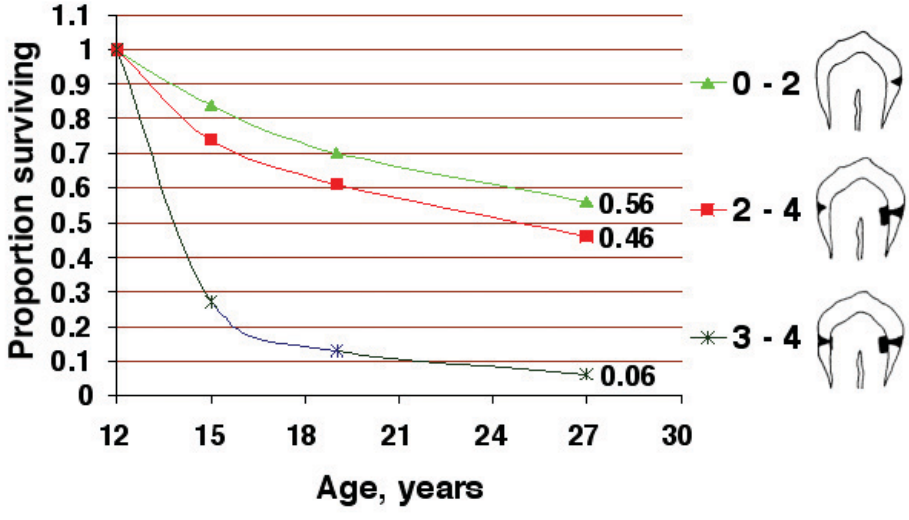

Figure 6. Survival curves of approximal surfaces from 12 to 27 years of age; from radiographically sound to the inner half of the enamel (0–2), from inner enamel to outer dentine (2–4) and from the enamel-dentine border to outer dentine (3–4). From Mejàre *et al*.[5]

Number of approximal lesions at age 12–13	Incidence*	Relative risk
0	3.1	1.0
1–2	5.0	1.5
3	7.7	1.9
4–8	10.8	2.3
>8	21.1	3.2

*Interpretation of incidence: If we follow 100 surfaces for one year we can expect 3.1 new caries lesions.

Table 1. Caries incidences and relative risks up to age 22 of approximal surfaces in relation to caries prevalence at age 12–13. From Stenlund *et al*.[19]

surfaces (Figure 5). A recently published Swedish multicentre study showed that, on average, 20% of 12–13-year-olds had at least one approximal dentine lesion.[16] There are differing opinions about the benefit of bitewing examinations at the ages of 12–14. The average additional diagnostic yield from the bitewing for 14-year-old Dutch adolescents, compared with only clinical inspection, was 2.8 approximal enamel and 0.4 dentine lesions.[17] Another study, using a refined and detailed visual examination by a single and specially trained examiner, reported less benefit.[18] The risk of false positive diagnoses has also been pointed out. However, the significance of misclassifications from a population perspective is not clear. It is obvious that more knowledge is needed, both regarding the effectiveness of selecting individuals that will benefit from bitewing examination, and the ability to diagnose approximal caries by a means other than bitewing radiography. Nevertheless, the age of 12–13 constitutes a key age for caries risk assessment.

As with the previous key ages, it is also beneficial to identify individuals without approximal caries lesions. Unless other relevant risk factors are identified, these individuals run a considerably lower risk of developing caries during adolescence compared with those who have approximal caries at the age of 12–13[19] (Table 1).

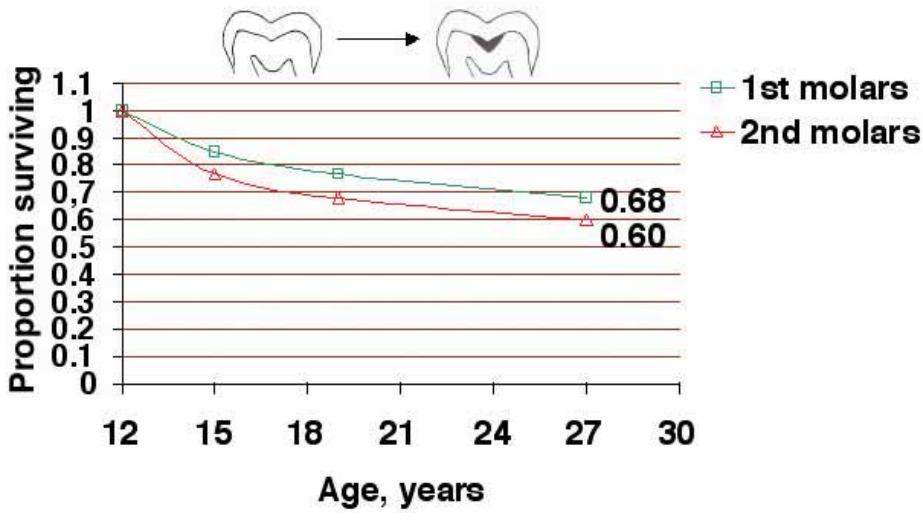

Figure 7. Survival curves of occlusal surfaces of permanent first and second molars from 12 to 27 years of age, from no visible radiolucency to an obvious radiolucency in the outer half of the dentine. From Mejàre *et al*.[5]

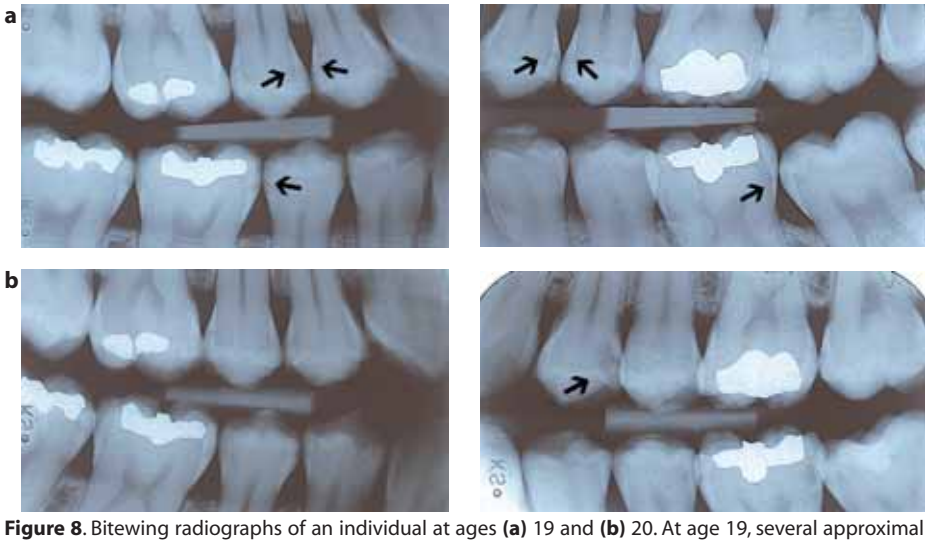

Figure 8. Bitewing radiographs of an individual at ages **(a)** 19 and **(b)** 20. At age 19, several approximal dentine lesions are present (arrows). None of them was restored at that time. Within one year, one of these lesions (the distal surface of the upper left first premolar) has progressed to a deep dentine lesion (arrow). A six-month interval between the two examinations could have prevented this development by instituting restorative treatment.

The fourth key age – 15–16 years

In general, both the risk of new approximal caries lesions and progression of existing lesions are highest during the first 3-4 years after establishment of approximal contacts[5] (Figure 6). The same applies to the occlusal surfaces of permanent second molars[5,8] (Figure 7). It is therefore recommended to consider bitewing examination at the age of 15–16. Individuals that are caries-free in their approximal surfaces at this age run a relatively small risk of developing new lesions. Since the rate of lesion progression is also slower after the age of 15-16, the interval to the next bitewing examination for caries-free individuals can be extended to three years.

Intervals between key ages

Intervals between the key ages should be based on individual risk assessment. Annual examinations should be considered in the following situations:

- Ages 5–7: ≥1 approximal dentine lesions or several approximal enamel lesions in primary molars.
- Ages 7–12 (mixed dentition): a permanent first molar with approximal caries ≥ half through the enamel or several approximal lesions in primary molars.
- From age 12–13:
  - ≥1 approximal dentine lesion or restored approximal surface;
  - ≥3 approximal enamel lesions;
  - any unrestored approximal dentine lesion;
  - a recently restored approximal neighbouring surface.

The degree of caries risk should be re-assessed individually every year by considering the number of new lesions and progression of existing lesions, as well as other relevant risk factors. The interval to the next bitewing examination is adjusted accordingly.

Intervals shorter than one year are seldom indicated. A six-month interval is, however, advocated if several approximal dentine lesions are left unrestored.

Reasons for annual intervals between bitewing examinations

- Ages 5–7: children with approximal dentine lesions or restored surfaces in molars run a relatively high risk of developing caries on the occlusal and mesial surfaces of the permanent first molar during the first few years after its eruption.[12,14] The rate of lesion progression of primary molars is also considerably higher than for permanent teeth.[20,21]
- Ages 7–12: the rate of lesion progression from enamel to dentine is considerably faster during this period compared with later.[21]
- From age 12-13:
  - the caries risk of newly erupted surfaces is clearly related to previous caries experience. The rate of lesion progression is also highest during the first 3-4 years after eruption.[5,19]
  - The rationale behind this can be seen in Table 1, where the risk of new approximal lesions increases as the number of lesions at age 12–13

Interval to next bitewing exam (years)	Low risk	High risk
5	3–4	1
8–9	3–4	1
12–13	2	1*
15–16	3	1*

*Six-month interval if several dentine lesions are left unrestored.

Table 2. Key ages for bitewing examination and intervals between examinations.

increases.
- The rate of lesion progression is considerably higher for approximal lesions that have reached the dentine as judged radiographically, compared with lesions confined to the enamel; in age group 12–15, every third such lesion progressed in the dentine within one year.[5]
- The prevalence of preparation damage is high. Any neighbouring damaged surface runs a relatively high risk of lesion progression (4 times as high as the corresponding undamaged surface).[22]

Reasons for six-month interval between bitewing examinations

The more approximal lesions there are, the higher is the risk that at least one of them will progress rapidly. This is particularly important to consider if several approximal dentine lesions are left unrestored, since the risk that at least one of them will progress fast to a deep dentine lesion is high, Figure 8.

The key ages and intervals between examinations have been summarized in Table 2.

Conclusions

It is generally agreed that the decision to take bitewing radiographs should be based on the benefit to the individual patient in relation to the risks and costs. However, there is incomplete knowledge about the effectiveness of various methods for selecting individuals that benefit from bitewing examination. Considering the reported difficulties in doing this effectively, it might be more appropriate to combine population- and individual-based selection criteria. Four key ages and individual-based criteria for intervals between the key ages are suggested. It should be remembered that bitewing examination is an aid and it must not replace clinical examination and judgement. In addition, it should be pointed out that good quality radiographs and the diagnostic procedure are far more important than short intervals between examinations.

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BOOK REVIEW

The Art of the Smile. Integrating Prosthodontics, Orthodontics, Periodontics, Dental Technology and Plastic Surgery in Esthetic Dental Treatment. Rafi Romano, ed (Nitzan Bichacho and Bernard Touati, associate eds). New Malden: Quintessence Publishing Co., 2005 (446pp. h/b, £152) ISBN 1-85097-096-3.

This new book draws together the knowledge and experience of almost 30 leading clinicians and dental technicians. Each uses patient cases to demonstrate 'the state of the art', in how they improve their patients' smiles.

This is a large book, with 446 pages and over 1,100 colour illustrations. There are five sections, including 20 chapters, covering Prosthodontics, Orthodontics, Periodontics, Dental Technology and Plastic Surgery. As we have come to expect from any Quintessence Books, publication, the production standard, clarity and quality of the printing and illustrations are to a very high standard.

The Prosthodontics section covers treatment with composite resin, all-ceramic and metal-ceramic restorations, bleaching and then concludes with four further patient cases that allow the reader to consider the psychology of aesthetics and understand that an appreciation of dental appearance is predominantly an emotional response. Considering the widespread use of dental bleaching, composite 'artistry' and laminate veneers in modern clinical practice, this section would have been enhanced further by more examples of these techniques.

The Orthodontics section covers 'dynamic smile visualization' with various techniques for treating cases with missing upper central or lateral incisors. It discusses general and specific considerations when creating a beautiful smile and, finally, there are two chapters on lingual orthodontics. A large number of the techniques described are used for treating adult orthodontic patients. However, with an increasing number of adults having orthodontic treatment, this section would probably benefit from a chapter on more recent techniques, such as 'Invisalign'.

The Periodontics section commences with a chapter that considers each element of the smile and then covers preservation of the inter-implant papilla, the periodontal-restorative interface and microsurgical soft tissue management around teeth and implants. The quality of the cases presented is inspiring, although, such is the detail involved, that these chapters would have benefited from much larger illustrations.

The Dental Technology section discusses new approaches to shade communication, correct prosthetic material selection and how the dental technician combines illusion and reality when providing aesthetic prostheses. This section could have been expanded further to give more credit to the critical role of the dental technician in the management of many aesthetic cases.

The Plastic Surgery section covers face-lifts and nose-jobs. This is a much smaller section and serves as both an introduction to these techniques and as a reminder that our patients may also benefit from treatment concepts that exist beyond dentistry. As some members of the dental profession have broadened their horizons by offering treatment such as dermal fillers and Botox, this section would have benefited from including examples of these methods.

Considering the number of disciplines involved in this book, there are surprisingly few examples of truly 'multi-disciplinary care', with several colleagues working together for one patient. However, this does not detract from what is an inspiring, enjoyable and useful book and it will certainly be popular amongst all those in the profession who care for their patients in this way.

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