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Citation for final published version:

Timms, Laura, Deery, Chris, Chadwick, Barbara and Drage, Nicholas 2020. Bitewing radiography for caries diagnosis in children: when and why? *Dental Update* 47 (4) , pp. 334-341. 10.12968/denu.2020.47.4.334

Publishers page: <http://dx.doi.org/10.12968/denu.2020.47.4.334>

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a) Paediatric Dentistry

Bitewing Radiography for Caries Diagnosis in Children: When and Why

Abstract: Untreated dental caries affects children in the UK, with significant burden to the child, family and health service. High quality bitewing radiography is more effective than clinical observation alone at detecting proximal caries in children. Accurate diagnosis before cavitation allows preventive rather than operative management. Research has demonstrated that most children find bitewing radiography acceptable. It is therefore vital that bitewing radiographs of children are taken as per national guidance in general practice.

Clinical Relevance: Timely and high quality bitewing radiography is required for accurate diagnosis and treatment planning in children.

Objectives: The reader should know the indications for bitewing radiography in children, and appreciate the importance of using it in clinical practice for caries detection and subsequently appropriate prevention and treatment.

Background

The 2013 Children's Dental Health Survey found that 31% of 5-year-olds had obvious caries in the primary dentition. (1) The average number of decayed teeth was 0.9 but for those with caries it was 3.0. (1) Thirteen per cent of 5-year-olds suffer from severe and extensive decay, and 54% of 8-year-olds had a mean of 1.1 primary teeth affected by untreated caries into dentine, with 28% of 5-year-olds and 38% of 8-year-olds having decay into dentine. (1, 2) The Care Index indicates the proportion of carious teeth that are restored was 11.8% in England for 5-year-olds in 2016-2017, meaning only around 1 in 8 carious primary teeth were treated. (3)

Caries is a burden for patients affecting confidence, sleeping and eating. (4) When not treated, severe decay can lead to pain and sepsis, and treatment under general anaesthetic with associated morbidity and mortality risks. It is also a significant public health problem, in 2015/2016 there were 43,700 hospital admissions of children under 16 with a primary diagnosis of dental caries, mostly requiring extractions. (5) Detection of caries before cavitation allows use of preventive measures such as oral hygiene instruction, dietary advice and fluoride use to arrest lesions. In both primary and permanent teeth, between 33-100% of caries lesions in the outer dentine are cavitated and the deeper the lesion has penetrated dentine, the more likely it is to have cavitated. (6) If cavitation exists the efficiency of preventive treatment is reduced as removal of bacteria from the cavity is difficult. In consequence more invasive treatment requiring local or general anaesthesia may be necessary. Further, in primary molars with proximal caries, teeth are often pulpally involved at an early stage, therefore early diagnosis to allow restoration to avoid infection is necessary. (7)

Diagnostic Yield of Bitewings

Kidd and Pitts's 1990 literature review concluded that bitewing radiography is essential to ensure proximal caries is not missed in the primary or permanent dentition. (8) Most studies included in the review found that 50% more lesions were detected compared to those identified clinically and that in some cases 250% more lesions could be detected from bitewings. A more recent systematic literature review also confirmed that for proximal surfaces the radiographic prevalence of carious lesions was considerably higher than clinical prevalence. (9) Further, Newman et al found 48% more proximal carious lesions were diagnosed with bitewing radiography than without. Bitewing radiography is considered particularly important in diagnosing early proximal lesions, allowing the possibility for preventive intervention (10, 11). Figures 1a and 1b shows an apparently caries free lower arch. However, radiographs reveal distal dentine caries in the lower first primary molars and enamel caries in the mesial surface of the lower right second primary molar. There is a slight shadow visible through the marginal ridge of the lower left first primary molar, this is a result of the camera flash and was not seen clinically.

Figure 1a and 1b

As well as providing information regarding proximal surfaces bitewing radiography will also demonstrate occlusal caries once it has reached dentine. Weerheijm et al in two separate studies found that in the permanent dentition in children 15-37.5% more occlusal lesions were detected where bitewing radiography was employed. (12, 13) Similar findings were found by Newman et al where 12% more occlusal lesions were detected with the use of bitewing radiography. (10) However several other studies have shown that bitewing radiography adds little in the detection of occlusal lesions. (14,15) In a review by Braga et al it was suggested that if a thorough clinical examination was carried out on cleaned dry teeth then occlusal

lesions will not be missed. That being said whenever a bitewing radiograph has been obtained it should always be examined for occlusal caries in dentine. (16)

A study involving 126 children in the primary dentition looked at the effect on treatment planning of the additional information provided by bitewing radiograph by comparing treatment plans based on clinical assessment alone with a treatment plan on the same patient after assessment was supplemented with bitewing radiography (18). The examiners used a meticulous caries diagnostic system (ICDAS). After use of bitewing radiography the number of surfaces that changed from no treatment to non-operative management and to operative management increased. While the overall percentage increase was small, this has to be taken in context as the authors considered all surfaces including occlusal ones, when caries in the primary dentition is centred on the approximal surfaces, particularly the distal surface of the first primary molar and the mesial surface of the second primary molar. Therefore the percentage increase for clinically important (approximal) surfaces may well have been greater. This is reflected in the fact that a greater effect was seen for proximal surfaces. Fifty-two (3.2%) surfaces believed sound moved into requiring non-operative treatment and 96 surfaces (9%) deemed to be sound or with surfaces amenable to prevention moved to requiring operative care. Therefore the additional diagnostic information available following bitewing radiographic examination altered a significant number of treatment plans. Specificity of bitewing radiography has been found to be high at over 90%, therefore the rate of false positives and over treatment would be low. (10)

Caries Risk

A patient's caries risk should be determined following thorough history taking (including medical, social and dental) and examination thus requiring accurate caries diagnosis. In children, caries experience is the single best predictor for future caries development but the

findings of a recent systematic review and a review of longitudinal studies have shown that other factors may be useful including sociodemographic /socioeconomic level, dietary habits, oral hygiene, fluoride use, presence of lactobacilli /Streptococci mutans, salivary flow rate and the post eruptive age. (19-21) Using these risk factors patients can be categorised into very high, high and low caries risk, with preventive treatment tailored appropriately . (22) The additional diagnostic yield from bitewing radiography is higher in the high-risk groups and lower in the low risk groups. (17)

Bitewing Interval Guidelines

The Faculty of General Dental Practice UK (FGDP) have recommended appropriate time intervals between bitewing investigations. (17) Summarised in Table 1 they are informed by risk assessment but reassessment of caries risk should be undertaken at each recall appointment. It is recognised that for the low risk group longer radiographic recall intervals may be more appropriate.

Table 1 – FGDP UK Guidelines on Bitewing Radiography in Children (17)

The European Academy of Paediatric Dentistry (EAPD) has also produced guidelines regarding the timing and frequency of bitewings in children. (23) Patients are categorised as either 'high risk' or 'low risk'. Baseline bitewings are suggested at age 5, but this may be too late to diagnose lesions that may potentially be reversed before cavitation if detected earlier, particularly considering the proportion of 5 year olds in the UK with caries experience. (3)

There is evidence to suggest that despite the publication of evidence-based guidelines many dentists do not carry out caries-risk assessments for their patients with an underuse of

bitewings in the diagnosis of dental caries. (24, 25) A study found that less than half of GDPs regularly carried out risk assessments in all children, the same study looked at use of bitewing radiography in children and 24% of GDPs considered bitewing radiography for caries diagnosis in primary teeth to be of little value for preventive care, with only 15% considering it to be very valuable. (11) Regarding restoration of proximal dentinal lesions 19% thought bitewings were of little value, with only 12% saying they were very valuable and only 9% thought that bitewings were very valuable for assessing caries progression, 21% assigning them little value. (11) Factors considered to be very important in influencing the decision to take bitewing radiographs were child co-operation and past caries, with these being very important to 42% and 52% of respondents, respectively. (11) Past caries experience is indeed an important indicator for radiographic examination by informing risk status and therefore interval between examinations. Co-operation is a relevant factor, research at a UK dental school found that 75% of children aged 5-10 found radiographic examination easy or very easy, with only 10% finding it hard or very hard. (26) (Table 2) Further only 7% would be unhappy or very unhappy to have a radiograph taken again. Therefore co-operation would not seem to be the limiting factor that explains the gap between clinical practice and national standard.

Table 2 Children's Acceptability of Different Diagnostic Methods. Reproduced with kind permission from Dr S Subka LF Pen: Laser fluorescence device, TTS: Temporary tooth separation

Radiographic diagnosis of caries using bitewings

Ideally bitewings require an image receptor holder and beam-aiming device but associated discomfort can make this difficult in young children. Image receptor holders result in less beam angulation error in comparison to traditional bitewing tabs which is important as false

proximal lesion progression can be suggested due to small changes in horizontal beam angulation. (27-29).

Examples of bitewings taken using holders and tabs are shown in Figure 2. Both sets of images are grade 1 quality.

Figure 2a and 2b Examples of bitewings taken using a) an image receptor holder and beam aiming device, and b) traditional 'tabs'.

For conventional film radiography a size 0 (22mm x35mm) film packet should generally be used, but when the permanent second molars have erupted a size 2 film packet (30.5mm x40.5mm) ensures adequate coverage of the teeth. It is important that the bitewing radiographs are of a consistently high quality in order to maximise diagnostic outcomes and reduce radiation dose. Summarised below are the European Commission quality standards for bitewing radiography. (30)

1. Optimum image geometry

- No bending of the image of the teeth
- No foreshortening or elongation of the teeth
- No horizontal overlap

2. Correct anatomical coverage

- The image should include the distal surfaces of the canine teeth and the mesial surface of the most posterior erupted teeth
- The periodontal bone level should be visible and equally imaged in the mandible and maxilla

3. Good density and contrast

- There should be good density and adequate contrast between the enamel and the dentine.

These standards refer to conventional radiography but similar standards would also be applied to radiographs acquired using digital systems.

Radiation dose and risk

The effective dose from 2 bitewing radiographs is low and ranges from 0.6-43 μ Sv. (17) However, bitewing radiography risk in young children is 2-3 times that of an adult making it vital that radiographic exposures are fully optimised. (30) Modern x-ray equipment should be used with correct exposure factors and rectangular collimation used routinely. Alone the latter may reduce the effective dose 5 fold.(31) F-speed film should be used as it requires significantly lower radiation exposure with no differences in diagnostic accuracy in terms of caries detection compared to slower film speeds (32, 33).

Digital Radiography

Conventional radiography is being steadily replaced with digital systems in the UK, with more digital systems in use than conventional. (34) Most of these units used solid state detectors (SSDs) with the remainder using photostimulable phosphor plates (PSPs). Digital radiography has many advantages including the elimination of chemical processing, image enhancement, and dose reduction. Interestingly however this dose reduction has not been realised in practice. This has been attributed to a lack of knowledge of appropriate exposure settings and because it may not be possible to reduce the exposure times sufficiently on older x-ray sets. (34)

Generally there is a higher retake rate using solid state detectors in comparison to film. (35) Bitewing SSDs are more difficult to position than PSPs with first premolar and canine teeth often missed. (36) SSD bulk can make them particularly uncomfortable for the patient but this can also be so for PSPs as some have sharp edges on their outer envelopes. (36)

The image enhancement available on digital systems may help improve caries detection. (37, 38) The main adjustments clinicians make to digital images are to the brightness and contrast. High brightness, low contrast images are associated with higher number of true negative cases and a decrease in caries. (39) In addition, high contrast images may overestimate the presence and extent of caries lesions. (39) The perception of 'Mach bands' which can mimic caries are also influenced by image adjustments of the image. Examples of image enhancements are shown in Figure 3.

Figure 3a-d

Examples of enhanced digital images. 3a) original image, 3b) inverted image, 3c) Edge-enhanced image and 3d) high contrast image.

Most studies have shown that the diagnostic accuracy of digital systems is similar to conventional radiography. (33, 40-44) Examples of PSP and SSD detectors set up for bitewing radiography are shown in Figure 4.

Figure 4a and 4b

Image automated analysis

An early in vitro study on digitised conventional films showed automated image analysis, where software extracts data from digital radiographs, for example to aid diagnosis, was

accurate and reproducible. (45) While Wenzel's early testing of the only commercially available system (Logicon caries detector) showed inconsistency more recent studies show that software improvements make it more reliable. (46, 47) More research is required before these systems can be used routinely in dental practice. Subtraction radiology involves the superimposition of two images taken at different times. The software compares the images and shows areas of lesion progression or regression visually as dark or light respectively.(46) Currently no commercial systems are available but this technique offers great potential for monitoring lesions.

Conclusion

Caries diagnosis is important as it can allow prevention and treatment, potentially resulting in disease reduction and treatment with beneficial outcomes for children, families, practitioners and the health service. Bitewing radiographs reveal superior diagnostic yield of caries to clinical assessment alone, and are recommended in national and international guidelines for children. Bitewing radiography is best practice for diagnosis for proximal caries in children, and therefore must be carried out in primary care to provide the best standard of care.

Acknowledgements:

Dr S Shukba – use of Table 2.

Dr J Lawson – use of Figures 1a and 1b

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Figure Captions

Figure 1a and 1b: Clinical photograph showing an apparently caries free lower dentition (1a) , radiographs of the same child showing distal dentine caries in both lower first primary molars and enamel caries lower right second primary molar(1b).

Figure 2a and 2b Examples of bitewings taken using a) an image receptor holder and beam aiming device, and b) traditional 'tabs'.

Figure 3a-d Examples of enhanced digital images. 3a) original image, 3b) inverted image, 3c) Edge-enhanced image and 3d) high contrast image.

Figure 4a and 4b: photograph of a) PSP and b) SSD set up for bitewings using holders and beam aiming devices. Note the cross infection sleeve has been removed from the SSD for photographic purposes.






Tables

Table 1: FGDP UK Guidelines on Bitewing Radiography in Children (17)

Risk Category	Recommendation
High Risk	6-monthly posterior bitewings until no active lesions are apparent and the individual has entered another risk category

Moderate Risk	Annual bitewings until no active lesions are apparent and the individual has entered another risk category
Low Risk	12-18 monthly bitewings in the primary dentition and at 2-year intervals in the permanent dentition.

Table 2: Children’s Acceptability of Different Diagnostic Methods. Reproduced with kind permission from Dr S Subka. LF Pen: Laser fluorescence device, TTS: Temporary tooth separation

Examination method	Acceptability category				
	<i>Respondents N (%)</i>				
	Very easy 	Easy 	Didn't mind it 	Hard 	Very hard 
Mirror	43 (52)	31 (38)	8 (10)	0 (0)	0 (0)
X-ray	42 (51)	20 (24)	12 (15)	4 (5)	4 (5)
LF pen	34 (42)	24 (29)	11 (13)	9 (11)	4 (5)
TTS	17 (21)	11 (13)	19 (23)	21 (26)	14 (17)