

**THE USE OF DENTAL RADIOGRAPHS
IN THE NORTH YORK PUBLIC DENTAL PROGRAM**

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Radiographs are a valuable tool for the diagnosis and treatment of dental diseases and developmental anomalies. As a result of this, dentists now own over 50% of the diagnostic radiograph generators and dental radiographs account for 30% of all diagnostic films (Stephens *et al.* 1985). Dental practitioners have commonly taken routine radiographs of the patient at every appointment, before the patient had received a clinical examination. Over the past two decades however, the dental profession has become more concerned about the misuse and overuse of radiographs. The uncertainty surrounding the use of dental radiographs makes it appropriate to examine the North York Public Health Department's guidelines for prescribing dental radiographs.

Background

Concern about the deleterious effects of ionizing radiation has increased over the past decade. Diagnostic radiographs usually involve "repeated exposures of less than 20 rads of absorbed radiation" and dental radiographs usually involve only about 200-300 millirads per film. Generally, it is believed that there is a direct linear relationship between the radiation dose and the incidence of a variety of cancers, and that most of the damage produced by a dental radiograph can be repaired. However, it is also believed that a lower threshold, below which carcinogenic effects will not occur, does not exist. Therefore, some of the damage from each radiograph is probably permanent and may accumulate over repeated exposures. For this reason, a more conservative use of radiographs, minimizing exposure, is recommended until

more evidence is obtained (Valachovic & Lurie 1980; Stephens *et al* 1985).

Awareness of the risks involved in using diagnostic radiographs has resulted in much discussion around reducing the amount of radiation that each patient is exposed to (Kidd & Pitts 1990). Prescription of dental radiographs is now based on a risk-benefit concept, so that the probability of obtaining information benefitting the patient must outweigh the radiation risk involved. Numerous articles in the literature have examined the efficacy of dental radiographs for diagnostic purposes, along with how many, how frequently and what type of radiographs should be taken. The result has been the development of guidelines for prescribing dental radiographs based on clinical and historical evidence, the effectiveness of the radiograph itself, and the prevalence of the disease it is being used to diagnose (Valachovic & Lurie 1980; Barret *et al.* 1984; Stephens *et al.* 1985; Ignelzi *et al.* 1989; Kantor *et al.* 1989; Packota & Kolbinson 1989; Stephens & Kogon 1990).

Guidelines for prescribing radiographs in the Dental Division of the North York Public Health Department are fairly conservative and are summarized in Table 1. North York's procedural guidelines for radiographs are listed in Table 2.

TABLE 1. Indications for Radiographs (North York Public Health Department, Dental Division Policy and Procedure Manual, 1990, p.10.3.66,67)

- (1) Diagnosis and Treatment Planning
Following Clinical Examination:
 - a) If suspicion of caries is present (e.g. discolouration/shadow) in interproximal areas;
 - b) If caries is present interproximally in one or more quadrants;
 - c) If primary molars are carious and non-mobile in children of 8-11 years, to assess longevity;
 - d) If permanent molars have extensive caries to assess the correct treatment.

- (2) Developmental Anomalies
If suspected:
 - a) Supernumerary teeth, "suppressed molars", ectopic eruptions, and missing teeth;
 - b) Swellings of unknown or apparently unknown cause, e.g. cyst;
 - c) Crowding, crossbite cases if additional information is required.

- (3) Pathological Conditions
 - a) Endodontics:
 - i) Root canal therapy or pulpotomies on permanent teeth
 - ii) Cysts, abscesses, etc.
 - b) As above in (2)

- (4) Trauma
 - a) Following accident if:
 - i) part of a tooth is apparently lost
 - ii) tooth is fractured close to the pulp;
 - b) after emergency phase, to assess the outcome of accident and emergency therapy, and to plan for further treatment.

Remember: If no visible caries exists, no radiographs should be taken, unless other determinants exist.

TABLE 2. Procedural Guidelines for Radiographs. (North York Public Health Department, Dental Division Policy and Procedure Manual, 1990, p.10.3.65,67,71)

- (1) The hygienists should only take radiographs at the express instructions of a dentist.
- (2) The x-ray policy for dentists is as follows:
 - a) Routine radiographs will not be taken;
 - b) All children will be examined by a dentist, who will then determine if dental radiographs are indicated;
 - c) If radiographs are required, the exact type of view and number of films will be determined by the dentist;
 - d) Under radiographing is an error of omission. Use professional judgement to ensure the minimum of radiographs are taken to give sufficient information for an adequate diagnosis.
- (3) The ALARA principle should be observed at all times.
ALARA = as low as reasonably achievable.
 - a) SIZE OF FILM should be the largest that can be easily tolerated by patient. For the child patient this should be size 2 (DF58) rather than size 0 (DF54), since the same exposure yields more information.
 - b) Strict attention to technique to minimize retakes and to produce good quality radiographs.
 - c) Proper developing and fixing technique to produce sharp images.
- (4) When radiographs are required by the examining dentist for patients who have teeth in the buccal segment, the following are suggested if necessary:
 - a) For new patients who are 6 years of age take either,
2 bite wings - use size 0 film, or
1 maxillary occlusal anterior - use size 2 film.
 - b) For new patients who are 5 or younger take
2 bite wings - use size 0 film.
 - c) For new patients who are 7 or older take
2 bite wings - use size 2 film if possible.
 - d) For children who are 6 or younger, use size 0 film;
for children who are 7 or older, use size 2 film.
 - e) For patients with anomalies or definite pathology take radiographs as prescribed by dentist.

Purpose

The purpose of this critical review of the literature is to investigate the scientific basis of North York's radiograph guidelines. After reviewing the literature on dental radiographs, recommendations for the prescription of dental radiographs will be made based on the available scientific evidence. These recommendations must also be kept within the context of the North York Public Health Department's resources.

Methods

The literature reviewed in this paper is not intended to represent an exhaustive search of the literature. The intention of this paper is to review the current standards and opinions found in the literature, but not to review all the published articles and studies who support or oppose these standards and opinions. Therefore, reference is not made to all recent publications on this topic.

To identify references pertaining to dental radiographs and indications for their use, a computer-aided literature search was performed. Using MEDLINE and various Medical Subject Headings (MeSH), the dental literature was searched from 1988 through 1991. The following four independent searches were performed using a number of restrictions and limitations, such as articles that dealt with standards and that were written in english.

<u>MeSH</u>	<u>Restrictions</u>	<u>Limitations</u>
Bitewing Radiography	none	human, english, review
Dental Radiography	none	human, english, review
Dental Radiography	standards	human, english
Dental Radiography and Dental Caries	diagnosis	human, english

The four searches yielded a total of 36 citations, including citations that were listed by more than one search. Relevant papers that were available from the University of Toronto's Dental Faculty Library were obtained and reviewed to locate additional references.

Articles presenting standards for prescribing dental radiographs, or opinions concerning the use of radiographs in dentistry, were included in this paper if they were based on scientific evidence. In most cases, scientific evidence was deemed to be findings from at least one clinical trial or an appropriate survey. Studies were excluded if they involved individual cases, personal opinions, or procedures that were untested scientifically.

Guidelines from the University of Toronto and the University of Western Ontario were also examined. Information on paediatric dentistry, restorative dentistry, preventive dentistry, radiology, and clinics was gathered using teaching manuals and interviews. Further mention of these guidelines was made only when they were found to present opposing views to the findings of the current literature. It should be noted that the University of Western Ontario's Paediatric Dental Clinic follows 1992 Guidelines proposed of the American Academy of Pediatric Dentistry.

Using the available scientific evidence practice guidelines for the use of dental radiographs were drafted. When scientific evidence was lacking, expert opinion and other existing guidelines were considered.

After drafting the revised guidelines, this critical review of the literature and its guidelines were reviewed by two panels. An Internal Staff Panel consisting of three dentists and one hygienist, all of whom work in North York's school-based dental program, initially assessed this report. Concerns and recommendations of the panel were discussed with members of the Community Dental Health Services Research Unit (CDHSRU) and necessary changes were made to accommodate those providing the dental services. The document was then reviewed by an External Panel of experts consisting of the President of the Royal College of Dental Surgeons, the President of the Ontario Dental Association, an Epidemiologist, an Ethicist, a Paedodontist, a General Practitioner, and a member of the Internal Panel. Concerns and recommendations of the External Panel were discussed with members of the CDHSRU and recommended changes were made. The critical review and the recommended guidelines were then finalized after approval by both the Internal and External Panels.

Findings

The 1987 Healing Arts Radiation Protection Guidelines (HARP, Ontario Ministry of Health 1987) state that the use of radiographs should be aimed at optimizing the risk/benefit ratio, where the benefit of receiving a radiograph

outweighs the radiation risk involved. Specific to dentistry, the guidelines state that every x-ray must be justified and produce a positive net benefit. Exposures should be kept As Low As Reasonably Achievable (ALARA) to reduce the hazard to the patient. "Since exposure to x-rays carries with it an attendant risk, **A RADIOGRAPH SHOULD ONLY BE TAKEN WHEN A DIAGNOSTIC NEED FOR IT HAS BEEN ESTABLISHED BY PRIOR CLINICAL EXAMINATION BY A DENTIST.**" Routine radiographs prior to a clinical exam are unacceptable. The North York Guidelines conform to these guidelines.

A common dental practice in the past, and one that may still be practised today by some dentists, is radiographic screening. Funk and Wagnalls Dictionary (1982) defines screening as an action "to determine the competence or eligibility of (an individual) for a specified task." Valachovic and Lurie (1980) described a medically oriented definition of a screening examination as "one in which specific diagnostic procedures are performed in a population specifically at risk with a view towards discovering occult disease of a life-threatening nature which would be otherwise undetected...For a screening procedure to be effective, positive findings must be followed by appropriate treatment." Kogon and Stephens' (1982) description of radiographic screening, "x-ray examinations conducted to detect abnormalities in asymptomatic persons", includes taking bitewing x-rays of recall patients before a clinical examination has been performed. A routine survey of a pre-determined number of radiographs could also be described as radiographic screening (Stephens *et al.* 1985). In this paper, we have defined radiographic screening as the practice of

routinely radiographing patients before a clinical examination and radiographing patients without signs or symptoms of dental or oral disease i.e. asymptomatic patients.

In general, the current dental literature reiterates the recently adopted U.S. Guidelines for Prescribing Radiographs (ADA Council on Dental Materials, Instruments, and Equipment 1989; Packota & Kolbinson 1989; Stephens & Kogon 1990). The U.S. Guidelines state that radiographs should only be prescribed after a clinical exam, should be based on the risk/benefit concept, and should only be prescribed if they will aid in diagnosis or treatment. Prescription should be based on dental history or clinical indicators, and routine radiographic screening is not recommended.

Some disagreement appears to exist however, between the U.S. Guidelines and the HARP Guidelines concerning the detection of interproximal caries. According to the HARP Guidelines, radiographic screening is not justified for any dental diseases or developmental anomalies. The U.S. Guidelines and the dental literature also do not support screening for developmental anomalies and occult diseases, but do support regularly scheduled radiographs to detect interproximal caries (Stephens *et al.* 1985, 1987; ADA Council on Dental Materials, Instruments, and Equipment 1989; Packota & Kolbinson 1989; Stephens & Kogon 1990). The interval of time between a patient's regularly scheduled radiographic examinations varies based on their caries experience, but x-rays may still be prescribed without clinical evidence of interproximal caries being present. This appears to constitute radiographic screening

and the efficacy of this procedure should be examined.

It is now widely accepted that using radiographs to screen for developmental anomalies or occult diseases is not justified. The prevalence of these conditions, such as missing and supernumerary teeth, is in the neighbourhood of 4-7% (Stephens *et al.* 1985; Stephens & Kogon 1990), and is too low to justify the radiation risk. Many cases do not require treatment and will exhibit clinical symptoms indicating whether or not a radiograph is necessary (Stephens *et al.* 1985; ADA Council on Dental Materials, Instruments and Equipment 1989; Kantor *et al.* 1989; Packota 1989; Stephens & Kogon 1990). For example, "there are many soft tissue lesions where radiography is most unlikely to provide any useful information" (Stephens *et al.* 1985).

In cases of developmental anomalies and occult diseases, x-rays should only be prescribed if there is clinical evidence and if the x-ray will aid the dentist in diagnosis or treatment. These general guidelines also apply to cases of trauma, where radiographs are often recommended. Because of the complications that may result from an untreated or undiagnosed traumatic injury, the benefits of radiographic examination often outweigh the radiation risk (Valachovic & Lurie 1980; Stephens *et al.* 1985).

The major issue in most of the recent articles regarding dental radiographs is the use of dental x-rays for diagnosing interproximal caries of posterior teeth (e.g. Stephens *et al.* 1981, 1985; ADA Council on Dental Materials, Instruments, and Equipment 1989; Grondahl 1989; de Vries *et al.* 1990; Kidd & Pitts 1990; Stephens

& Kogon 1990;). It is generally agreed that dental radiographs are still a valuable tool for diagnosing caries. Compared to a clinical exam, the bitewing radiograph has been shown to significantly increase the number of interproximal caries found by dentists, especially early, non-cavitated lesions (Kogon & Stephens 1982; Pitts 1983; Stephens *et al.* 1987; Grondahl 1989; Kidd & Pitts 1990). A cavitated lesion may be defined as a clinically detectable hole in the tooth surface (Stephens *et al.* 1987). The probability of cavitation is high when the radiolucency extends to or past dentin-enamel junction (Pitts 1983; Espelid 1986; Espelid & Tveit 1985; Verdonshot *et al.* 1991).

Many investigators believe that using x-rays to screen for interproximal caries should be continued but that each individuals screening schedule should be tailored around his or her caries experience (Stephens *et al.* 1981, 1985; ADA Council on Dental Materials, Instruments, and Equipment 1989; Kidd & Pitts 1990; Stephens & Kogon 1990). The frequency of the x-rays should vary according to the patient's dental history and the results of a clinical exam. Individualizing each patients x-ray schedule will result in high risk patients receiving radiographs more frequently than low risk patients; if a high risk patient remains caries free between examinations, the frequency of x-rays should be reduced (Stephens & Kogon 1990).

A summary of three recent articles that recommended screening frequencies for interproximal caries is shown in Table 3. These frequencies are partially based on estimated rates of tooth decay. The rate of tooth decay can vary considerably between patients, but the average carious lesion progresses slowly, requiring

approximately 3-4 years to progress through the enamel to the dentin (Pitts 1983; Shwartz *et al.* 1986; Grondahl 1989). Although high risk individuals may experience quite rapid rates of decay, at least 50% of lesions do not progress after initiation (Elderton 1985; Stephens *et al.* 1987).

TABLE 3. Frequency of caries screening radiographs according to patient type.

STUDY	PATIENT TYPE	PERIOD BETWEEN RADIOGRAPHS
Shwartz <i>et al.</i> 1986	low risk	30-36 months
	high risk	6-12 months
ADA Council on Dental Materials, Instruments, and Equipment 1989	low risk child	12-24 months
	adolescent	18-36 months
	high risk child	6 months
	adolescent	6-12 months
Stephens & Kogon 1990	low risk child	12-24 months
	adolescent	24-36 months
	high risk child	6-12 months
	adolescent	12-24 months

high risk = presence of caries or high risk factors such as caries being present in the previous exam(s) or low fluoride exposure.

low risk = no caries present, no caries present in the previous exam, adequate fluoride exposure.

The conventional justification for screening rests mainly on three general concepts:

- (1) failing to use radiographs will result in a substantial underestimation of the number of interproximal caries;
- (2) detection of interproximal lesions, regardless of their severity, is beneficial as it allows the dentists to intervene with either prevention or restorative treatment;
- (3) the prevalence of interproximal caries is high enough that it warrants screening.

All of these concepts should also be addressed with respect to the service that can and will be provided by the examiner. Using radiographic screening to detect early, non-cavitated carious lesions may be of little benefit if the patient will not receive any preventive or restorative care.

Over the past two decades the incidence of dental caries, particularly smooth surface caries, has decreased significantly. Ripa *et al.* (1988) estimated that only about 10% of molars in children and adolescents that are not sound will have proximal caries. The decrease in proximal caries has been attributed mainly to increased public awareness, better oral hygiene, and the increased use of fluorides. Exposure to fluorides through vehicles such as fluoridated toothpastes and fluoridated water, has increased to the point that professionally applied **topical fluorides are often not recommended except for individuals who are high caries risk** (e.g. Ripa 1988, 1989, 1990, 1991). This recommendation is especially applicable to public dental programs where the limited resources can now be directed to other areas.

Direct and histological examinations of extracted teeth have shown that 50% or more of proximal surfaces may have a carious lesion, but few of the lesions are

cavitated (Ruiken *et al.* 1982, 1986; Pitts 1983; Mejare *et al.* 1985; Grondahl 1989; Neilson & Pitts 1991). Radiographic examination will reveal about 50% or less of these non-cavitated lesions (Mejare *et al.* 1985; Grondahl 1989), but conventionally this is deemed beneficial because preventive methods, such as professionally applied topical fluoride, may then be used to arrest or reverse the decay process in such lesions (Pitts 1983; Grondahl 1989; Kidd & Pitts 1990). However, it is difficult to determine if a lesion has already arrested, and since, by definition, arrested lesions will not progress (Elderton 1985; Stephens *et al.* 1987), a preventive program for these cases is unnecessary. Therefore, public programs with limited resources must determine if they can provide preventive services to patients testing positive before they begin radiographic screening for interproximal caries. If individuals with early carious lesions detected on an x-ray will not receive preventive intervention based solely on this diagnosis, can screening for interproximal caries be justified?

If preventive care will not be offered after radiographic detection of early non-cavitated lesions, screening should be evaluated according to the prevalence of interproximal caries that will require treatment, as was the case for developmental anomalies. Restoration of a carious lesion is usually believed necessary when it reaches a stage of cavitation. The majority of radiolucencies confined to the enamel, especially the outer half of the enamel, are not cavitated and so no restoration is needed (Pitts 1983; Espelid 1986; Espelid & Tveit 1985; Verdonschot *et al.* 1991). Recent studies indicate that the prevalence of cavitated interproximal lesions may be as low as the 4-7% prevalence of developmental anomalies (Mejare *et al.* 1985; de

Vries *et al.* 1990; Ruiken *et al.* 1982, 1986).

Histological examination of 598 proximal surfaces of extracted premolars by Mejare *et al.* (1985) found that 56% of the surfaces were carious, but only 28 (4.7%) of the surfaces were cavitated. Clinical examination detected 8 of the 28 cavities (28.6%). Radiographs showed radiolucencies for 23 of the 28 cavities (82.1%), but only 10 of the teeth on x-rays showed a radiolucency extending 2/3 or more into the enamel i.e. representing cavitation. Therefore, over a total of 598 surfaces, radiographs only identified 2 more cavitated surfaces than clinical exams; this difference represents 0.3% of the surfaces examined. Radiographs also showed radiolucencies extending 2/3 or more into the dentin for 9 surfaces that were carious but not cavitated, representing 9 possible restorations of non-cavitated lesions. The equivalent value for clinical examination was 6 surfaces.

A more recent study of teeth from 12 year-old children by de Vries *et al.* (1990) reported that radiographic and clinical diagnosis of a sound surface was in agreement for 5651 of the 6781 (83%) proximal molar and premolar surfaces examined. Radiographs showed dentin lesions (radiolucencies extending into the dentin) in 135 of the surfaces, whereas clinical examination diagnosed only 21 dentin lesions. Unfortunately histological examination of the teeth was not performed so that the true number of lesions could not be determined. However, if one assumed that all dentin lesions were cavitated and required restoration, the prevalence would range from 0.3% (21/6781) to 2% (135/6781) of the surfaces. This may be an underestimate, but even a 100% increase would produce a prevalence of only 1-4%.

Studies by Ruiken *et al.* (1982, 1986) were very similar to the study by de Vries *et al.* (1990). These studies reported a prevalence of cavitated lesions in the permanent molars and premolars from 8, 10, and 12 year old children that was equal to or less than that found by de Vries *et al.* The authors of these studies concluded that for low caries risk children younger than 12, omission of the x-ray from dental exams would not result in a serious loss of information.

Omission of radiographic screening may result in some carious surfaces being diagnosed as sound (false negative), but the consequences of not detecting an early, non-cavitated lesion do not appear severe. There is a good possibility that the lesion will arrest or be "repaired". Even if the lesion does progress, the oversight will be probably be corrected at a later visit before a large cavity extending deep into the dentin develops (Rock 1987). A 1983 New Zealand study compared children from a school dental program with no x-ray generators with children who received dental care at a university clinic that used x-rays as a diagnostic aid. The results showed that the university treated group were exposed to substantially more radiation but neither group had significantly more restorations placed by the age of 13 (Silverstein & Stokes 1983).

Although the rate of decay may be much higher in a high caries risk patient, screening for interproximal caries still may not be necessary. A high caries risk patient may already be receiving preventive care, such as topical fluoride. A clinical exam may often indicate that a radiograph is necessary for complete diagnosis or adequate treatment. A study by Mejare and Malmgren (1986, 1988) of 60 permanent

teeth (molars and premolars) showed that all teeth with carious lesions extending to the inner half of the enamel or into the dentin showed enamel discoloration, although it is not apparent how much of this discoloration was visible during the clinical exam.

A more liberal use of dental x-rays will increase the patients risk of having a sound tooth restored (false positive). After reviewing the literature, Grondahl (1989) calculated that if all radiolucencies are diagnosed as cavities, the sensitivity is about 90% and the specificity is about 78%. This means that only 10% of the carious surfaces would be overlooked, but 22% of the sound surfaces would be diagnosed as cavitated and possibly restored. These error values should not be taken too lightly, as studies have shown radiographs are used exclusively as a means of caries diagnosis by more than half of the dentists surveyed. When a radiograph, rather than just a clinical exam, was used for diagnosis, placement of a restoration was found to be more common (Bille & Thylstrup 1982; Mejare *et al.* 1985).

The results of Mejare *et al.* (1985) coincide with Grondahl's conclusions. Mejare's study found that "to obtain a true positive rate of about 82% by considering all radiolucencies as positive for carious cavities, we must accept a false positive rate of close to 20%." Using a hypothetical example of examining 1000 surfaces, 50 (5%) of which were cavitated, the authors showed that 41 of the interproximal surfaces would be correctly filled but 20% of the remaining 950 sound surfaces (**190 surfaces**) would also be filled. Filling such a high number of sound surfaces, compared to the number of cavitated surfaces that would be filled, is unacceptable. If a more strict restoring criterion of radiolucencies extending into the dentin was used, no sound

surfaces would be restored but only 11 (22%) of the cavitated surfaces would be restored. This value is very similar to the results of the clinical examination which produced a true positive rate for detecting cavities of 28.6% and a false positive rate of 1.1%.

Restoring all radiolucencies may appear to be an unrealistic restoration criterion, but recent studies have shown that many dentists fill enamel lesions. A survey of 243 dentists by Espelid (1986) showed that 76% of dentists fill lesions that appear as radiolucencies extending into the inner half of the enamel. Espelid and Tveit (1985) showed that 2/3 of the dentists studied would restore a lesion that is radiographically confined to the enamel, but only about 50% of radiolucencies confined to the enamel represent cavities (Espelid *et al.* 1985; Grondahl 1989). Another study of 263 dentists by Thylstrup *et al.* (1986) reported that dentists restored many white spot lesions and only 13% of restored surfaces represented "true cavitation".

The probability of restoring a sound surface also increases as the number of radiographs taken increases (Tulloch *et al.* 1986; Rock 1987) and as the prevalence of interproximal caries decreases (Grondahl 1989; Grondahl *et al.* 1992). Human errors when taking dental x-rays appear to be frequent (Nysether & Hansen 1983; de Vries *et al.* 1990), making retakes inevitable. Radiographic screening will therefore, increase the number of unnecessary radiographs and increase a child's risk of a false positive diagnosis.

Up to this point the discussion has focused on the diagnosis of interproximal

caries, but recent studies have also investigated the use of radiographs for the diagnosis of occlusal caries. Diagnosis of pit and fissure caries, whether by clinical examination or radiographs, is difficult and often unreliable. Because of the increased use of fluorides, the enamel of a fissure may only experience minimal decay or may reform, hiding a carious dentinal lesion underneath (Weerheijm *et al.* 1989).

In the past some investigators have felt that visual inspection should be used to detect occlusal caries and that radiographs were a poor and unproductive method (Stephens *et al.* 1981; Rock 1987). However, at least two recent studies recommend the use of bitewing radiographs to aid in diagnosing occlusal caries. A study by Weerheijm *et al.* (1989) concluded that along with a clinical exam it is useful to include bitewing radiographs when diagnosing occlusal caries. The strength of these conclusions is limited however, due to the small sample size (26 molars/premolars) and the way the data are presented.

Wenzel *et al.* (1991) also compared visual and radiographic diagnosis of occlusal caries by eight observers. Histological examination of 166 molars and premolars revealed that 33% of the teeth had carious lesions extending into the dentin. No raw data were given, but when diagnosing dentinal caries, sensitivity for the clinical examination was "approximately 20% (range 16-40%)" with a false positive of about 5%. Sensitivity using radiographs was "approximately 40% (range 28-46%) with only a very small increase in the number of false positive findings." Likelihood ratios for radiographic diagnosis were significantly higher than for visual inspection. Positive and negative predictive values were also found to be greater for radiographic

diagnosis, but statistical analysis of the data revealed that only the negative values were significantly different (t-Test, sig. 0.05). Wenzel *et al* (1991) concluded that "detection of dentinal caries in occlusal surfaces without macroscopic cavitation can be substantially improved by the use of conventional film radiography compared with mere visual inspection."

Thus, it appears that the inclusion of a bitewing radiograph may aid the dentist when diagnosing or treating dentinal cavities below the occlusal surface (Kidd 1984; Elderton 1985; Eccles 1989). Radiographs may help the dentist determine if a "suspect" fissure requires sealant or is decayed enough to require restoration. However, prescription of the radiograph must still be made based on clinical evidence; radiographic screening of apparently sound teeth is not recommended. A number of recent studies have indicated that sealing over occlusal decay is not detrimental and so dentists need not be extremely concerned about a false negative diagnosis (Mertz-Fairhurst *et al.* 1979a,b, 1991; Roulet & Noack 1991). Radiographs should be prescribed carefully and in a conservative manner.

Conclusion:

A conservative and "individualized" approach should be adopted when prescribing radiographs. Radiographs should only be prescribed:

- (1) when there is a perceived need to obtain specific information leading to a correct diagnosis, treatment, or preventive action; and,
- (2) after performing a clinical exam and reviewing each patients history.

Recommendations for Prescribing Radiographs

A radiograph should only be taken:

- if the findings of a clinical examination and/or patient history require further investigation; **and**
- when the treatment choice is not clear; **and**
- when additional information from the x-ray is expected to identify the need for and/or type of treatment; **and**
- the information cannot be readily obtained by other means.

Type of radiograph to prescribe.

Many of the recent articles concerning radiograph use have also recommended the type(s) of radiograph that should be used according to the condition being investigated. The posterior bitewing is generally recommended for most conditions, especially proximal caries (e.g. Valachovic & Lurie 1980; Council on Dental Materials, Instruments, and Equipment 1989; Stephens & Kogon 1990), **using the largest film allowed by the patient's anatomy** (Valachovic & Lurie 1980). Periapical and occlusal radiographs have also been recommended for various situations, but because of the numerous clinical conditions that can exist, devising set guidelines for the type of radiograph to use in each condition is not possible (Council on Dental Materials, Instruments, and Equipment 1989; Stephens & Kogon 1990). Each case should be individualised and the type of radiographs prescribed should be based on the patient's need (Kogon & Stephens 1982). The dentist's professional judgement must be relied upon to choose the type and number of radiographs that will yield the necessary

information with the least amount of risk to the patient.

Panoramic radiographs cannot be recommended for a public dental program. Panoramic radiograph generators are expensive and require a substantial amount of specific equipment. Results from a number of recent studies assessing the effectiveness of the panoramic radiograph do not support its use for routine patient assessment (Balis 1981; Kogon & Stephens 1982; Pilo *et al.* 1987; Ignelzi *et al.* 1989; Hintze & Wenzel 1990).

Film speed should also be considered when choosing what type of radiograph to prescribe. Kantor *et al.* (1989) reviewed the literature and found that E-speed film is approximately twice as fast as D-speed film, and has the same or slightly lower resolution. The increased speed of the E-speed film also reduces the patient's radiation exposure. However, D-speed film is more forgiving to "careless" processing than E-speed film and may perform slightly better than E-speed film when diagnosing caries. Overall, Kantor *et al.* (1989) concluded that E-speed film is a suitable alternative to D-speed film if proper processing techniques are used.

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