

Published Guidelines on Taking Dental Radiographs: Are They Evidence Based?

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Abstract

Guidelines for taking dental radiographs are not intended to be a standard of care or regulations, but rather serve as an adjunct to the dentist's professional judgement. As a result, compliance of dentists to the guidelines is variable. The following study reviewed the literature to determine if the current guidelines for taking dental radiographs were developed based on evidence. The search strategy included online databases of scientific journals, an internet literature search, censuses of the journals *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics* and *Dentomaxillofacial Radiology*, and an expert opinion in the field of dental radiology. The search strategy yielded a total of 10 recent (1994-2007) dental radiographic guidelines that were analyzed in this study. The guidelines were found to be consistent with respect to patient types, relevant options, and potential harms of radiographs. The benefits and costs of dental radiographs were not described for the guidelines assessed and patient preferences were not included. While all the guidelines assessed were based on evidence for regarding radiation safety, no evidence was found to support the efficacy of the guidelines themselves as diagnostic aids in dental practice.

Introduction

Dental radiographs are essential to dentists in diagnosing, treatment planning, and monitoring the development of carious lesions. The process of radiographic guideline development began in 1978 by several small panels of experts associated with the Food and Drug Administration (FDA) (Brooks, 1997). The first document (completed in 1987) assessed patient selection criteria and was based on the premise that dentist should be the final decision makers on whether or not radiographs are required for specific patients; following a thorough clinical examination and after weighing the patient's risk for caries development (Joseph, 1987). While radiation doses, obtained from taking dental radiographs, are minimal (White, 1992), a number of epidemiological studies have indicated that there are increased risks of developing brain, salivary gland, and thyroid tumours from such exposures (Underhill *et al.*, 1988). Detrimental effects obtained from small doses of radiation are stochastic, and therefore the effects are either all or none. Thus, there is no threshold radiation dose below which no effect would occur. The relationship between the probability of stochastic effects occurring in certain tissues and organs and the effective dose equivalent was defined in the International Commission on Radiological Protection (ICPR). This report indicated that the highest estimated risks were indicated for leukaemia (of the bone marrow), and thyroid and bone surface cancer (White, 1992).

One of the most frequent uses for dental radiographs pertains to its ability to diagnose caries. Diagnosis of cavitated lesions is not always an easy task. In addition, radiographs, used as a diagnostic test, are not always accurate and may result in images that do not correspond to gold standards (Wanzel *et al.*, 1993). During the last two decades, the prevalence of dental caries has declined in Western countries and this decline may be attributed to many factors. The reduction in caries prevalence also has been observed in both occlusal and proximal surfaces (Lahti *et al.*, 2001). Current literature indicates that an average carious lesion progresses slowly into the dentin, leaving the outer surface of enamel intact. As a result, dentinal lesions may be left concealed by uncavitated enamel surfaces, making the diagnosis of pit and fissure caries difficult and inconsistent among clinicians (Pitts *et al.*,

1993). Radiographs are not recommended for the screening of pit and fissure caries in patients with an absence of signs and symptoms upon oral examination (White *et al.*,1990). Several studies have been conducted to examine the sensitivity and specificity of radiographs in caries detection. The authors of the Veterans Administration's Dental Longitudinal Study (in Boston) reported that sensitivity results were approximately 60% for radiographs in detecting dental caries. The decreasing prevalence of caries in the North American population, however, actually reduces the sensitivity of dental radiographs, thereby reducing their diagnostic accuracy. In addition, many other studies indicated that the probability of obtaining false positives for caries detection in radiographs could outweigh the number of true positive findings and thus, may result in unnecessary, irreversible operative intervention (Rushton *et al.*, 2002). Thus, routine use of radiographs (as part of diagnosis and recall screening for all patients) has been reported to be unprofessional and inappropriate (White *et al.*,1995).

Radiographic guidelines are set to aid clinicians in selecting patients who would best benefit from a treatment outcome. Because all patients are different, the prescription of radiographs should be individualized and should not be conducted in the absence of signs and symptoms of a carious lesion (Hintze *et al.*, 1994). Firstly, finding a pre-test probability of a disease is essential and is based upon intraoral examination, history of caries experience, and the prevalence of cavitated lesions. Only after the dentist decides that the pre-test probability is high, should the dental radiographs be prescribed (Leake, *et al.*, 1996). Current guidelines are aimed at keeping the exposure levels to radiation as low as possible. As a result, a case in which a cavitated lesion has been detected clinically should not require radiographs as an additional diagnostic test (Leake, *et al.*, 1996). Therefore, current guidelines are set to aid clinicians in the use of a more skeptical approach, which is more favourable over the traditional, routine screening radiography approach.

An increasing number of dentists have been reported to order radiographs on the basis of selection criteria (Kantor and Hill, 1988). Although there are many published guidelines on taking radiographs, the compliance by dentists is variable. A study conducted by Bohay *et al.* (1995),

indicated that 62% of dentists prescribed diagnostic radiographs for all new patients while only 45% prescriptions were made for recall patients. Although the harmful risks associated with radiation from dental radiographs are small, the absence of harm cannot be assumed. Therefore, caution in prescribing radiographs is warranted because radiation exposure is cumulative and exposures throughout the population occur on a daily basis.

Methods

In order to identify relevant published articles on dental radiographic guidelines, several searches were carried out using systematic methods. An individual search was also carried out for background information pertaining to radiographic practices conducted by dentists, exposure levels, doses, caries detection, sensitivity and specificity of radiographs, and patient selection for radiographs.

Database and Internet Search, Censuses, and Expert Opinion

The following data sources were searched from 1980-2008 for articles on recent dental radiographic guidelines: Ovid MEDLINE (In Process and Other Non-Indexed Citations, Corrections), Ovid OLDMEDLINE, EBM Reviews (Cochrane DSR, Cochrane Methodology Register, Health Technology Assessment, ACP Journal Club, DARE, CCTR, CMR, HTA, and NHSEED), EMBASE, Journals@ Ovid Full Text and Ovid Healthstar. An internet literature search was also conducted through Google Scholar (scholar.google.com). Additionally, censuses were conducted for 2 journals [Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics (168 volumes) and Dentomaxillofacial Radiology (168 volumes)] from 1980 to 2007. An expert opinion provided by Dr. Miriam Baghdady (residency student in Oral Radiology at the University of Toronto) was also included in our data analysis.

Inclusion and Exclusion Criteria

The electronic search was limited to articles in English and those concerning humans. All ages were included and articles were limited to the years of publication from 1980 to 2008. Articles from local holdings were included, and inaccessible articles were excluded. Research articles addressing radiographic practices by dentists, exposure levels and doses, radiographs and caries detection, sensitivity and specificity of dental radiographs, and patient selection for dental radiographs also were included in a separate search.

Search Strategy

Table 1, steps 1 to 4 lists the key words and combinations of key words used in the electronic search. Steps 5 to 10 include articles that were retrieved using the appropriate search strategy, and limited according to our inclusion/exclusion criteria for each database.

TABLE 1: Articles obtained from OVID Search Strategy

Step	OVID database Search Terms	# of Articles
1	(dental or dentistry).mp. [mp=ti, ot, ab, nm, hw, kw, tx, sh, ct, tn, dm, mf]	643475
2	(radiographic or radiology or radiograph\$).mp. [mp=ti, ot, ab, nm, hw, kw, tx, sh, ct, tn, dm, mf]	666544
3	guideline\$.mp. [mp=ti, ot, ab, nm, hw, kw, tx, sh, ct, tn, dm, mf]	684340
4	1 and 2 and 3	2260
5	limit 4 to English language	2225
6	limit 5 to human	2198
7	limit 6 to humans	2198
8	limit 7 to yr= "1980-2008"	2190
9	remove duplicates from 8	1908
10	Included on basis of screening title and abstract	52
11	Google Scholar: dental AND radiographic AND guideline\$	7970
12	Google Scholar: Included on basis of screening title and abstract	6
13	Census: Dentomaxillofacial Radiology	3
14	Census: Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics	12
15	remove duplicates from 10, 12, 13, and 14	39
16	Included on basis of reading complete article	16
17	Included after checklist score cut-off (>8/14)	10

The identified articles and their abstracts were reviewed independently by two authors. All known guidelines were retrieved and reviewed for their conclusions to identify additional citations. The total number of articles retrieved from the electronic search, after removal of duplicates, was 52.

Steps 11 to 12 indicate our electronic search through Google Scholar (scholar.google.com). The identified articles and their abstracts were reviewed independently by six authors and limited according to our inclusion/exclusion criteria. The total numbers of articles retrieved from this search was six.

Steps 13 to 14 lists the censuses conducted for two journals [Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics (168 volumes) and Dentomaxillofacial Radiology (168 volumes)] by six independent authors. The identified articles and their abstracts were reviewed by two authors. The total number of articles retrieved from Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics was 12, and the total number of articles retrieved from Dentomaxillofacial Radiology was three.

All 39 articles were retrieved and read, and only articles pertaining to dental radiographic guidelines (16) were scored using the University of Toronto Faculty of Dentistry “Checklist to Assess Clinical Practice Guidelines” (see Appendices 1 and 2). These checklists consist of questions addressing credibility, consistency, search strategy methods, and inclusion and exclusion criteria of guidelines. Only studies with a score of at least 8 (out of a maximum of 14) were included as the guidelines for this review (n=10). The cut-off of 8 out of 14 was established upon reviewing and applying the checklist to the original 16 articles. The 10 guidelines obtained were deemed to represent the most recent and credible guidelines.

Results

The majority of the guidelines included in this assessment were recent, with dates ranging from 1994 to 2007. The authors of the guidelines reviewed in this study are the American Dental Association (ADA), US Food and Drug Administration (U.S. FDA), European Commission, American Academy of Pediatric Dentistry Ad Hoc Committee on Pedodontic Radiology and Council on Clinical Affairs, European Academy of Paediatric Dentistry (EAPD), American Academy of Oral & Maxillofacial Radiology (AAOMR), and various professors and dentists from dental schools. Although they were credible, they were unlikely to be free of bias.

The conditions addressed were consistent with the types of patients for which the checklists for clinical practice guidelines (CPGs) are targeted. Patient types included the elderly, adults, adolescents, children, orthodontic, endodontic, edentulous, implant, and surgery patients. Additionally, all relevant options for most of the guidelines were considered. Relevant options considered in the European guidelines on radiation protection in dental radiology (European Commission, 2004) as well as the review conducted by Beneyto *et al.* (2007) included radiation dosage, risks, the effects of radiation, referral criteria, consent, diagnostic reference levels, previous radiographs/reports, technique, quality standards/assurance, and equipment/dose limitation. Guidelines provided by the ADA and FDA (ADA, 2006; ADA and FDA, 2004) included the following relevant options: new patient assessments, patients' caries risks, periodontal status, stage of growth and development, and other specific circumstances (*i.e.*, existing implants, pathology, restorative/endodontic needs, and treated periodontal disease of caries remineralization). Furthermore, relevant options considered by the EAPD and AAOMR included types of radiographs, film speed, and technique.

The benefits, harms, and costs were not described for all the guidelines assessed. However, for the majority of the guidelines, the benefits towards each option primarily pertained to achieving effective dental diagnoses and treatment planning, all while applying the ALARA (As Low As Reasonably Achievable) principle. Potential harms for the relevant options were also described in many

of these guidelines, which included radiation exposure.

The search for, and appraisal of, all guidelines assessed were consistent with evidence-based methods. The guideline compiled by the European Commission (2004) included a search strategy, while all other guidelines assessed utilized a wide range of references (*i.e.*, systematic reviews, non-analytic and laboratory studies, additional guidelines, and textbooks). Additionally, all guidelines utilized sufficiently wide consultation processes. For all guidelines assessed, the strength of the evidence and the level of recommendations were not provided. Furthermore, considerations of patient preferences were not included.

The expected beneficial outcomes of adhering to the assessed guidelines included the fact that their use may minimize radiation exposure to patients and providers, optimize patient care, and allow for an effective allocation of health care resources. However, potential harms or costs associated with adhering to these guidelines include the potential of missing caries lesions from taking fewer radiographs.

The consistencies of all guidelines assessed were based primarily on the 2001, 2004, and 2006 FDA guidelines as well as the Directive 96/29/Euratom (European basic safety standards), the Directive 97/43/Euratom (Medical Exposures Directive) and European guideline on radiation protection in dental radiology (1991) (European Commission, 2004). The inconsistency of the guideline pertaining to edentulous patients (Kogon *et al.*, 1997) was justified, since the authors concluded that radiographic screening of new edentulous patients was not clinically relevant to support the previous guideline recommendations. As a result, this practice was excluded in the later FDA guidelines (ADA, 2006; ADA and FDA, 2004) and revised such that the need for radiographic examinations would be based on clinical signs and symptoms. Except for one guideline (Rogers *et al.*, 1997), all guidelines mentioned the use of other guidelines.

The majority of guidelines did not state dissenting opinions. However, the guideline compiled by Rogers *et al.*, (1997) utilized a Delphi technique, whereby a survey among independent experts was

conducted to collect their opinions on taking initial radiographs on children.

All guidelines stated important caveats, which included no radiation exposure towards children (less than 12 months for primary dentition and less than 24 months for permanent dentition). Guidelines pertaining to the treatment of pregnant women, women of childbearing age, and radiation therapy patients were recommended not be altered. No justification was reported for taking radiographs in edentulous patients, with the exception of those considering implants. Additionally, patient consent and the qualification of the dentist must be assured. Lastly, all relevant references were cited for all guidelines assessed.

Discussion

Radiation exposure (obtained from dental radiographs) was initially of little concern because early studies indicated that the amount such exposure to patients was minimal. In 1992, White measured the effective dose from a full-mouth examination to be 84 μ Svm. This quantity is reported to be equivalent to one week of daily background radiation exposure through the use of domestic appliances such as the television and microwave (Bristow et al, 1989). Additional studies have suggested that the lifetime cancer risks from exposure to even low levels of ionizing radiation may be greater than previously estimated (Stenstrom *et al.*, 1986; Wall *et al.*, 1979; Silverman, 1984; White, 1992). Such findings have illuminated radiation exposure levels from dental radiographs as a concern to both patient and practitioner.

Dental radiograph exposure dosages have not been evaluated on humans due to the unethical nature and dangers associated with exposing participants to unnecessary levels of radiation. Thus, no randomized control trials involving exposure to dental radiographs have been performed. As a result, safe radiation dosages utilized by the dental radiographic guidelines assessed in this investigation were based on studies performed on phantom heads,

Dental radiographic guidelines are not set rules. Rather, they are statements created to assist practitioners in making appropriate decisions on patient care. The guidelines also help practitioners make decisions on prescribing radiographs to people who may be susceptible to radiation, such as pregnant women, children, and patients receiving chemotherapy. Dental radiographic guidelines help ensure that patients are exposed to the least amount of radiation possible throughout their care (ALARA principle). An initial clinical examination is therefore recommended during dental recall appointments, to help a practitioner recognize and identify patients at high risk of caries and other oral pathologies necessitating dental radiographic examinations. Douglass *et al.* (1988) reported six clinical indicators as effective predictors of the severity of periodontal disease and caries: pocket depth, mobility, number of teeth, denture status, prevalence of caries on oral examination, and age. The

authors of this study reported that the knowledge of these clinical indicators were a major step in reducing the number of unnecessary radiographic prescriptions.

Upon analysis of the available dental radiographic guidelines, the quality of evidence (consistent with the Canadian Task Force assessment) was rated as Level B. This indicates that the guidelines assessed, while based on evidence for radiation safety, are not based on evidence regarding the sensitivity and specificity of radiographs, which vary under different prevalence conditions

Conclusion

In conclusion to this study, the current guidelines for taking dental radiographs are not based on dental evidence, but rather function solely to protect the patient and practitioner from excessive radiation exposure. Furthermore, the trend of declining caries prevalence rates in North America consequently reduces the sensitivity and specificity of dental radiographs, making them less accurate in caries diagnosis. The guidelines should therefore not be regarded as a standard of care or regulations. Nonetheless, they are a useful resource to aid in the dentist's professional judgement in the interest of each patient. It is difficult to assess the efficacy of the current guidelines as a diagnostic aid due to variable compliance across dental practitioners and the unethical nature of experimentally subjecting participants to potentially harmful radiation. Optimistically, further studies will provide evidence for the efficacy of the guidelines in dental practice, and not solely for their effectiveness at reducing radiation exposure to patients and practitioners.

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APPENDIX 1- Checklist for a Clinical Practice Guideline (CPG)

1. Is it recent? What was the date of last revision? (--/--/--) ____
2. Are the authors or issuing body credible and likely to be free of bias? ____
3. Are the conditions addressed consistent with the types of patients for which the CPG is targeted? ____
4. Were the all the relevant options considered? ____
5. Were the benefits, harms, costs described for those relevant options? ____
6. Was the search for, and appraisal of, the evidence consistent with evidence-based methods? ____
7. Were the strength of the evidence and the level of recommendation stated? ____
8. Were the expected benefits, harms, and costs of the derived CPG stated? ____
9. Were considerations of patient preferences stated/included in the CPG? ____
10. Was the consistency or inconsistency of the CPG with other guidelines justified? ____
11. Was there a sufficiently wide consultation process? ____
12. Were dissenting opinions stated and dealt with appropriately? ____
13. Were any important caveats stated? ____
14. Were the relevant references cited? ____

Adapted from: Fletcher, Fletcher and Wagner. Clinical epidemiology – the essentials. 3rd ed.1996, and Sackett et al. Evidence-based medicine: how to practice and teach EBM. 1997

APPENDIX 2- Guideline Summary

INCLUSION/ EXCLUSION	AUTHOR/PUBLISHER	CPG RATING (Out of 14)	Patient type	Additional Info
INCLUDE	European Commission. European guidelines on radiation protection in dental radiology: The safe use of radiographs in dental practice. Radiation Protection Issue 136;1-120, 2004.	12	Patient age (child, adolescent, adult) , dental development age, dentition, caries risk, presence/absence of dental disease, endodontics, orthodontics, implants, dental surgery	
INCLUDE	Beneyto, Y.M., Banos, M.A., Lajarin, L.P., and Rushton, V.E. Clinical justification of dental radiology in adult patients: A review of the literature. Med Oral Patol Oral Cir Bucal 2007;12:E244-251.	12	Patient age (child, adolescent, adult), state of dentition, trauma, presence/absence of dental disease, TMJ problems	
INCLUDE	ADA, The use of dental radiographs (update and recommendations), Journal of American Dental Association,137:1304-1312, Sep. 06.	11	Patient age (child, adolescent, adult) , dental development age, dentition, caries risk, presence/absence of dental disease	Update of 2004 FDA/ADA guidelines
	ADA and FDA, The selection of patients for dental radiographic examinations, ADA, Jan. 04	11		Update of 2001 FDA/ADA guidelines
	ADA Council on Scientific Affairs. An update on radiographic practices: information and recommendations. J Am Dent Assoc. 2001 Feb;132(2):234-8.	8		
INCLUDE	American Academy of Paediatric Dentistry Council on Clinical Affairs. Guideline on prescribing dental radiographs for infants, children , adolescents, and persons with special health care needs, Pediatric Dentistry. 2005-2006; 27 (7 Suppl) 185-186.	11	Patient age (child, adolescent, adult), dentition, special health care needs	(Supplements FDA/ADA guideline above)
INCLUDE	Espelid I. Mejare I. Weerheijm K. EAPD, EAPD guidelines for use of radiographs in children, Journal of Paediatric Dentistry. 4(1):40-8, 2003 Mar	11	Children and adolescents (5-14 years of age), dental development age	
INCLUDE	SC White, EW Heslop, LG Hollender, KM Mosier, Parameters of radiologic care: An official report of the American Academy of Oral and Maxillofacial Radiology, Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;91:498-511	10	Adults, presence/absence of dental disease	

INCLUDE	White, S.C. & Pharoah, M.J. Guidelines for prescribing dental radiographs. Oral Radiology: Principle and Interpretation (5th edition). Mosby, 2003.	9	Patient age (child, adolescent, adult) , dental development age, dentition, caries risk, presence/absence of dental disease	
INCLUDE	Rogers, C.E.A., and Hector, M.P. The establishment of current opinion within consultants in paediatric dentistry in the UK for the taking of dental radiographs of children. International Journal of Paediatric Dentistry 1997; 7:191-198.	8	Children and adolescents	Expert Opinion by paediatric dentists in the U.K.

EXCLUDED AFTER CPG CHECKLIST

EXCLUDE	Kogon, S.L., Stephens, R.G., and Bohay, R.N. An analysis of the scientific basis for the radiographic guideline for new edentulous patients. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;83:619-23.	7		
EXCLUDE	White, S.C., Atchison, K.A., Hewlett, E.R., and Flack, V.F. Efficacy of FDA guidelines for ordering radiographs for caries detection. Oral Surg Oral Med Oral Pathol 1994; 77:531-40.	7		
EXCLUDE	Nowak, A.J. The selection of patients for dental radiographic examinations. In: <i>Synopses of monthly meeting lectures</i> . Hong Kong Dental Association Yearbook, Vol. 1989; 38-39.	3		
EXCLUDE	Flores MT, Andreasen JO, Bakland LK, Feiglin B, Gutmann JL, Oikarinen K, Ford TR, Sigurdsson A, Trope M, Vann WF Jr. Guidelines for the evaluation and management of traumatic dental injuries. Dent Traumatol 2001 Apr;17(2):49-52.	6		
EXCLUDE	Matteson SR, Joseph LP, Bottomley W, Finger HW, Frommer HH, Koch RW, Matranga LF, Nowak AJ, Rachlin JA, Schoenfeld CM, et al. The report of the panel to develop radiographic selection criteria for dental patients. Gen Dent. 1991 Jul-Aug;39(4):264-70.	6		

