Questionnaire survey on the use of dental X-ray film and equipment among general practitioners in the Swedish Public Dental Health Service

Björn Svenson and Arne Petersson

Department of Oral Radiology, Postgraduate Dental Education Center, Örebro, and Department of Oral Radiology, Centre for Oral Health Sciences, Lund University, Lund, Sweden

Svenson B, Petersson A. Questionnaire survey on the use of dental X-ray film and equipment among general practitioners in the Swedish Public Dental Health Service. Acta Odontol Scand 1995;53:230–235. Oslo. ISSN 0001–6357.

A questionnaire was sent to all clinics in the Public Dental Health Service in Örebro County in 1989 and 1993. The survey comprised questions about X-ray film and developing technique. The questionnaire of 1993 was accompanied by questions on the type of dental X-ray film and collimator each dentist used, altogether 175 dentists. The results showed that Kodak Ektaspeed dental X-ray film was used by 53% of the dentists in 1993. The mean number of months to the expiry date for all film packages irrespective of film type increased from a mean of 7.5 months to a mean of 13 months from 1989 to 1993. Only 11% of the Ektaspeed film packages in 1989 had a base plus fog ≤0.25, whereas the figure in 1993 was 30%. Rectangular collimation adjusted to the size-2 film (31 mm × 41 mm) was used by 36% of the dentists in 1993. In 1993, 88% of the clinics used automatic processing, and in 85% of the clinics both automatic and manual processing was used. The processing time and temperature varied greatly for both automatic and manual processing. The results indicate that film and developing procedures in Swedish general dental practice are not always in accordance with the recommendations and guidelines of the Swedish National Radiation Protection Institute (SSI) and that attempts should be made to improve dentists' behavior with regard to radiation safety. A major dose reduction would be achievable without jeopardizing diagnosis if the regulations of the SSI were followed by using the fastest available film and optimum developing procedures. A further dose reduction would be possible by adjusting the size of the radiation field to the size of the film. □ *Collimator; dental; processing; radiation; radiography; X-ray film*

Björn Svenson, Department of Oral Radiology, Postgraduate Dental Education Center, P.O. Box 1126, S-701 11 Örebro, Sweden

Several dose-reducing methods have been introduced in oral radiology over the years (1–4). However, as it is not known whether exposure to the low levels of radiation used in oral radiology is dangerous (5), it is advised to keep the radiation dose low.

The Swedish National Radiation Protection Institute (SSI) supervises all radiologic work in Sweden, and in its rules and recommendations it is stated that the fastest available dental X-ray film should be used (6). The use of the fastest available film is one of the most dose-reducing methods in oral radiology (5, 7–9), and the use of E-speed film (E-film) makes it possible to reduce the radiation dose to the patients by approximately 40% compared with D-speed film (D-film) (3, 10, 11). Although the technical and diagnostic quality of the films do not differ (5, 12), the E-film has not outperformed the D-film since its introduction in the beginning of the 1980s (9, 13–16).

The use of rectangular collimators adjusted to the size of the film is recommended by the SSI (17). It has been estimated that the change from a circular open-ended collimator with a diameter of 6 cm to a rectangular open-ended collimator adjusted to the size of the film (no. 2) would reduce the absorbed radiation dose to most of the radiosensitive organs by about 50% (5). In a study performed by the SSI in Sweden in 1984, a beam diameter larger than 6 cm was found to be used in less than 1% of practices (13), but the use of rectangular collimation was not reported.

Dental X-ray films must be processed in accordance with the recommendations of the manufacturer; the developing temperature must be checked, and the solutions must be changed regularly (6). Correct processing may lead to a reduction of the radiation dose by 30–50% (5), and it is all too commonly found that patients are subjected to larger radiation doses than necessary to reduce the processing time (8, 18).

The aims of this investigation were to study the dose-reducing methods applied in the Public Dental Health Service in the County of Örebro during the years 1989 and 1993 and how closely dentists follow the recommendations and guidelines of the SSI.

Materials and methods

A questionnaire was sent to all clinics ($n = 26$) in the Public Dental Health Service in 1989. The questionnaire

Table 1. Numbers and percentages of dentists using D-speed or E-speed dental X-ray films in combination with round or rectangular collimator in 1993

X-ray film	Collimator		
	Round ≤60 mm in diameter	Rectangular 34 mm × 44 mm	Total
D-speed Kodak Ultraspeed Agfa Gevaert Comfort M2 Flow DV 58	59 (34%)	23 (13%)	82 (47%)
E-speed Kodak Ektaspeed	53 (30%)	40 (23%)	93 (53%)
Total	112 (64%)	63 (36%)	175

comprised questions about film type, expiry date of the films, processing method, type of chemicals, processing time, and temperature of the developing solution. The clinics were asked to check the function of the darkroom safe light by placing a pre-exposed dental X-ray film under the safe light for 2 min with a coin placed on top and then develop the film (penny test). To check the base plus fog density of the different films, one film from each unopened film package with different expiry dates, film types, and sizes was developed in each of the clinics. The questionnaire and the radiographs from each clinic were sent to the Department of Oral Radiology in Örebro for analysis. The density of the radiographs was measured with a digital densitometer (Victoreen Digital Densitometer II, Victoreen Inc., Melbourne, Fla., USA).

In 1993 the study was repeated. The study was accompanied by questions on what type of dental X-ray film and collimator each of the 175 dentists used.

Results

Participants

All clinics answered the questionnaires in 1989 and 1993, and all dentists answered the questions about film type and collimation system used in 1993. The questionnaires were answered by the head of the clinic, and the questions about type of film and collimation in 1993 were answered by the individual dentists. All clinics returned film material for analysis of the base plus fog density and the function of the darkroom.

Dental X-ray film

Film type. Ektaspeed (Eastman Kodak Co., Rochester, N.Y., USA) dental X-ray film (E-film) was used by 93 (53%) of the dentists (Table 1). From 1989 to 1993 two new film types of sensitivity group D, DV 58 (Flow X-ray, West Hempstead, N.Y., USA) and Comfort M2 (Agfa Gevaert NV, Morstel, Antwerp, Belgium), were introduced, and a few dentists used these films. Altogether, including Ultraspeed film (Eastman Kodak Co.), D-films were used by 82 (47%) of the dentists in 1993.

The number of clinics in which Ektaspeed film was available for use increased from 13 to 16 from 1989 to 1993, whereas the availability of Ultraspeed film (D-film) decreased from 18 to 17 of the clinics. In 1993 the only choice was D-film in 10 clinics and E-film in 8. In eight of the clinics both D- and E-film were available.

Expiry date and base plus fog. From 1989 to 1993 the mean number of months to the expiry date for all film packages irrespective of film type increased from a mean of 7.5 months to 13 months (Table 2). In 1989 the range was from 17.2 months before the expiry date to 15.4 months past expiry. The corresponding figures for 1993 were 28.3 and 6.3 months.

Table 2. Months to expiry date and base plus fog values for four different types of film (mean values; range within parentheses)

X-ray film	Months to expiry date		Base plus fog	
	1989	1993	1989	1993
Kodak Ultraspeed 1989; $n = 51$ 1993; $n = 36$	7.8 (−15.4–17.2)	12.4 (−7.3–20.1)	0.25 (0.16–0.58)	0.27 (0.14–0.92)
Kodak Ektaspeed 1989; $n = 35$ 1993; $n = 46$	6.6 (−5.4–15.2)	12.9 (−6.3–20.2)	0.31 (0.22–0.53)	0.33 (0.20–0.57)
Agfa Gevaert Comfort M2; $n = 1$	–	28.3	–	0.23
Flow DV 58 $n = 2$	–	17.1	–	0.27
All films	7.5 (−15.4–17.2)	13.0 (−6.3–28.3)	0.27 (0.16–0.58)	0.30 (0.14–0.92)

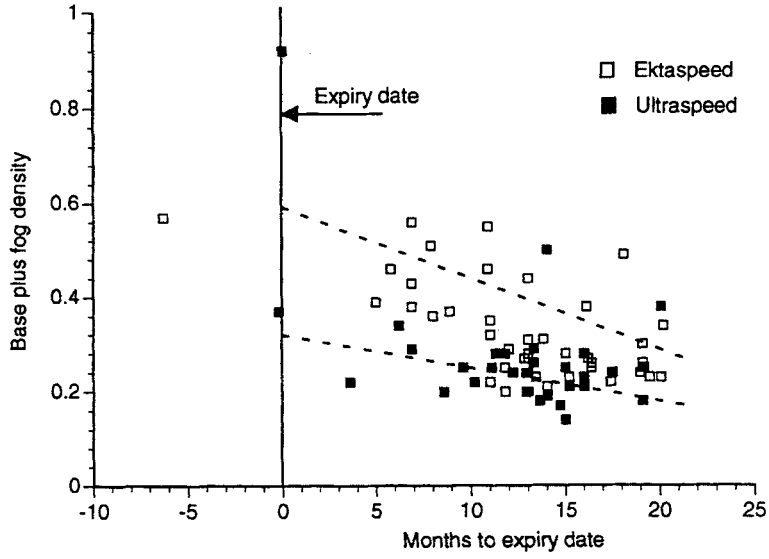

Fig. 1. Base plus fog as a function of months to expiry date for 1993 for all film packages of Ektaspeed (n = 46) (□) and Ultraspeed (n = 36) (■) film.

The mean base plus fog density for all types of film was of the same magnitude in 1989 and 1993. The Ektaspeed film had a slightly higher base plus fog density than the Ultraspeed film in both 1989 and 1993 (Table 2). The base plus fog increment for Ultraspeed and Ektaspeed films from 20 months ahead of the expiry date to the expiry date is displayed in Fig. 1. The increment of fog increased more steeply with Ektaspeed film than with Ultraspeed film. In 1989, 35 of 51 (69%) Ultraspeed film packages had a base plus fog ≤ 0.25, whereas in 1993 the figure was 21 of 36 (58%). For Ektaspeed only 4 of 36 (11%) in 1989 had a base plus fog ≤ 0.25, whereas in 1993 14 of 46 (30%) had a highest value of 0.25.

Collimation

Of 175 dentists, 112 (64%) used a round collimator with a field size diameter of 60 mm, whereas a rectangular collimator adjusted to the size-2 film (31 mm × 41 mm) was used by 63 (36%) dentists in 1993.

Film and collimator

Fifty-nine (34%) of the dentists used a D-film in combination with a round collimator (60 mm in diameter), whereas 40 (23%) used the E-film and a rectangular collimator (Table 1).

Processing methods

In 1989, 17 clinics (65%) used automatic processing, whereas in 1993, 23 (89%) used this type of developing system. In 1993 manual processing was used in 25 clinics (96%), most often in combination with automatic processing (85%). In 1993 manual processing was the only available method in three clinics, and in one clinic only automatic processing was used.

In 1989 the automatic processing was controlled thermostatically in 13 (77%) of the clinics, whereas in 1993 the process was controlled thermostatically in all clinics. The temperature in the thermostatically controlled units ranged between 23°C and 29°C in 1989 and between 27°C and 34°C in 1993. The interval between change of solution in the automatic processor ranged from 2 to 12 weeks in 1989 and from 5 to 17 weeks in 1993.

The processing time, temperature, and interval between change of solution for manual processing in 1993 are shown in Table 3. The time and temperature used for processing of the films varied greatly. The G153 (Agfa Gevaert NV) X-ray developer is intended to be used for automatic processing, and there are thus no recommendations for the manual developing procedures. Nevertheless, six clinics used this developer as a fast processing solution. The intervals between change of solution, the developing time, and the temperature used were of the same magnitude in 1989 as in 1993.

Darkroom

The darkroom safe light system was tested with the 'penny test'. A considerable improvement of the function of the darkroom was observed in 1993. In 1989 only 15 (58%) of the darkrooms had a safe light system functioning optimally, whereas in 1993 the figure was 20 (83%).

Table 3. Mean values of processing times, temperatures, and intervals between change of solution for manual processing for the different chemicals in the clinics in 1993 ($n = 26$). Range is given within parentheses

Type of chemistry	Recommended processing time and temperature	Processing times	Temperature, °C	Interval between changes (weeks)
Kodak Dental ($n = 10$)	40 sec; 20°C	60 sec (40–90 sec)	21.9 (20–24)	2.8 (2–4)
Agfa Gevaert G 150 ($n = 8$)	240 sec; 20°C	80 sec (60–90 sec)	22.5 (19–24)	2.9 (1–6)
Aga Gevaert G 153 ($n = 6$)	Not intended for manual processing	70 sec (60–90 sec)	22.2 (21–23)	2.2 (1–3)
Rapid 40 ($n = 1$)	40 sec; 20°C	40 sec	22	2

Discussion

The greatest dose reduction in Sweden would be achieved if all dentists changed to a dental X-ray film of the highest speed (E-film) (8). It was shown in our study that 53% of the dentists were using the E-film in 1993. In several studies from different countries it has been shown that most dentists do not use E-film (9, 13–15). The regulations of the SSI (6) state that the most sensitive film must be used if it is in accordance with the diagnostic situation. On the basis of the data from this study nearly 50% of the dentists are not working in accordance with the regulations. Gibbs et al. (19) showed that the effective dose-equivalent is approximately halved after changing from D- to E-film and stated that 'the use of D-speed films can no longer be justified'. In the USA about 26% of the dental schools use E-film (20). As the dental schools serve as a model for the profession, there is an obvious risk that students not taught to use high-speed films will not use this type of film in the future. However, in professional work a modification of the approach to the use of film may take place. Despite information and courses for the personnel in the Public Dental Health Service clinics, the availability of E-film increased only marginally during the years 1989 to 1993. The motives for changing to a more sensitive film must be clearly stated for the benefit of the patient. The reason for not changing may be the perceived lower quality of the E-film and hence assumed lower diagnostic quality. Attitudes towards new products and unwillingness to change, even though several studies of image quality have failed to demonstrate any significant loss of quality after changing from D- to E-film (12), are not clearly understood, and this will be a future research project.

Two major factors, film speed and collimator size, exert a major influence on the effective dose-equivalent and patient risk in oral radiography (4, 7, 19, 21). A major reduction of the dose and the patient risk in oral radiology could be achieved by changing both to E-film and rectangular collimator (7, 21). There are few reports on the number of dentists using a rectangular collimator in their daily work. The regulations of the SSI (17) state that the collimator must be circular and open-ended, and its diameter must not exceed 6 cm. Therefore, from the point of view of the authorities, it is more important to study how many dentists use a collimator larger than that permitted. It has been reported from different countries that collimators with a field size larger than permissible (6 cm) is used by about 20% of the dentists (9, 18), whereas a film-adjusted rectangular collimation system is used by a few of the dentists (21, 22). This is deplorable, as it has been shown in several studies that rectangular collimators are not more difficult to use than circular collimators (23, 24). It was found in this survey that 36% of the dentists used a rectangular collimator. This relatively high figure may be the result of information and refresher courses for the dentists.

Most of the patients attending the clinics of the Public Dental Health Service are less than 19 years old (13) and may be more sensitive to radiation than adults, as the risk of developing thyroid cancer is higher for children and adolescents (19). Patients and parents of young children count on the dentist to use all available methods to minimize exposure (25). However, there are some costs associated with a change. A change from D- to E-film does not involve extra costs in Sweden, but the change to a rectangular open-ended collimator is associated with costs, which should not exceed $100 per unit (5). It was observed in this study that every fourth dentist used both E-film and a rectangular collimator, whereas most dentists used D-film and a round collimator. In a nationwide survey in Sweden only 15% of the dentists used both E-film and a rectangular collimator (B. Svenson, B. Söderfeldt, H.-G. Gröndahl. Unpublished observations). The rate of implementation of radiographic techniques giving a reduced radiation dose seems low.

The base plus fog density was seemingly high for Kodak Ektaspeed film even when there were 10 months remaining to expiry date. The increase of base plus fog up to the expiry date was most pronounced for the Ektaspeed film, whereas the total base plus fog density

irrespective of film type was of the same level in 1993 as in 1989. However, the number of months to expiry increased during this period by 11 months, and there were fewer film packages that had passed the expiry date. This may be due to education of the dental assistants and information to the clinics.

In 1993, 23% more clinics used automatic processing than in 1989. In automatic processors the processing is standardized, and this should lead to higher radiographic quality. However, automatic processors were not found to have improved the overall processing standards, as it has been shown that where automatic processors were in use, the exposure of the radiographs was 50% greater than considered necessary for optimum radiographs in 30% of the cases (18). Automatic processors need proper maintenance and correct renewal of the processing solution for optimum function, and neglect of these factors may often be the reason for poor operation. When processors with thermostatically controlled temperature were used, there was a wide variation of both processing temperature and intervals between change of solution in both 1989 and 1993. This may partly explain the poor technical quality of radiographs found for prosthodontic treatment planning by general dentists in the Public Dental Health Service (26), and it may also explain the low acceptability of the E-film, as a relatively poor technical quality is obtained when E-film is incorrectly handled (27, 28).

Processing of films in oral radiology seems rarely to be of an optimum standard. The SSI states that the recommendations of the manufacturer must be followed. However, the developing times recommended by the manufacturers for rapid manual developers are often too short (28–30), and a shortening of the developing time will lead to an unacceptably low contrast and density. Our results showed that the correct developing time for the rapid developers was used in 70% of the clinics. In 30% of the clinics the average developing time was too short, and it might be suspected that the films had a low contrast and density.

Conclusions

The results indicate that film and developing procedures in general dental practice are not always in accordance with the recommendations and guidelines of the SSI. Attempts should be made to change dentists' behavior with regard to radiation safety. A major dose reduction would be achievable without jeopardizing diagnosis if the regulations of the SSI were followed by using the fastest available X-ray film and optimal developing procedures. A further dose reduction would be possible by using rectangular collimation.

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Received for publication 8 July 1994
Accepted 3 November 1994