A comparison of Flow and Kodak dental X-ray films by means of perceptibility curves

Björn Svenson and Arne Petersson

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

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Flow D- and E-speed group dental X-ray films (DX-58 and EX-58) have recently been introduced to the market. By means of perceptibility curves these films were compared with commonly used dental X-ray films (Kodak Ultraspeed and Ektaspeed). No major differences between the films were found with regard to contrast and the subjectively assessed number of small contrast differences. The exposure for EX-58 had to be lowered by 66% and Ektaspeed by 39% compared with Ultraspeed film to obtain the same density. DX-58 and Ultraspeed were of the same sensitivity. □ *Perceptibility curves; X-ray film, dental*

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

One of the major factors contributing to reduction of the radiation dose is the introduction of faster film materials (1, 2). It has been estimated that the exposure time when taking a full-mouth examination with intraoral films in the beginning of the 1980s is 0.3% of that used in the early 1920s (3). However, when choosing between different film imaging systems, the first consideration should be their diagnostic usefulness.

Ultraspeed and Ektaspeed (Eastman, Kodak Co., Rochester, N.Y., USA) are the predominant film brands (4, 5), and in 1989 a new film, Dentus M4 (Agfa Gevaert NV, Mortsel, Antwerp, Belgium), was introduced. The sensitometric and diagnostic qualities of these films have been examined in several studies (6–17). It has been shown that the film contrast of Ultraspeed and Ektaspeed is of the same magnitude (18, 19), whereas Dentus M4 was found to have a somewhat lower film contrast (17). Dentus M4 has the highest sensitivity of the dental X-ray films compared (14, 17). The diagnostic accuracy of Ultraspeed and Ektaspeed has been investigated in several studies and has been found to be of similar magnitude for various tasks (17, 20–22), whereas Dentus M4 was found to have a lower diagnostic accuracy at radiography of small caries lesions than both Ultraspeed and Ektaspeed (17).

Flow dental X-ray films of both speed groups D and E (Flow X-ray, West Hempstead, N.Y., USA) have recently been introduced to the market. Their diagnostic potential and sensitometric properties should be compared with other commonly used dental X-ray films.

The purpose of this study was to evaluate the subjectively assessed contrast differences of Flow dental X-ray films of speed groups D and E and compare them with Kodak D- and E-speed films by applying perceptibility curves, and to study the film characteristics, speed, and contrast of Flow and Kodak D- and E-speed films.

Materials and methods

Four series, each containing 16 radiographs, were exposed: Kodak Ultraspeed and Ektaspeed and Flow DX-58 and EX-58 taken from the same batch. A test object consisting of a rectangular block of aluminum with a thickness of 7 mm was radiographed (Courtesy of Dr. U. Welander, Department of Oral Radiology, School of Dentistry, Stockholm, Sweden). The alu-

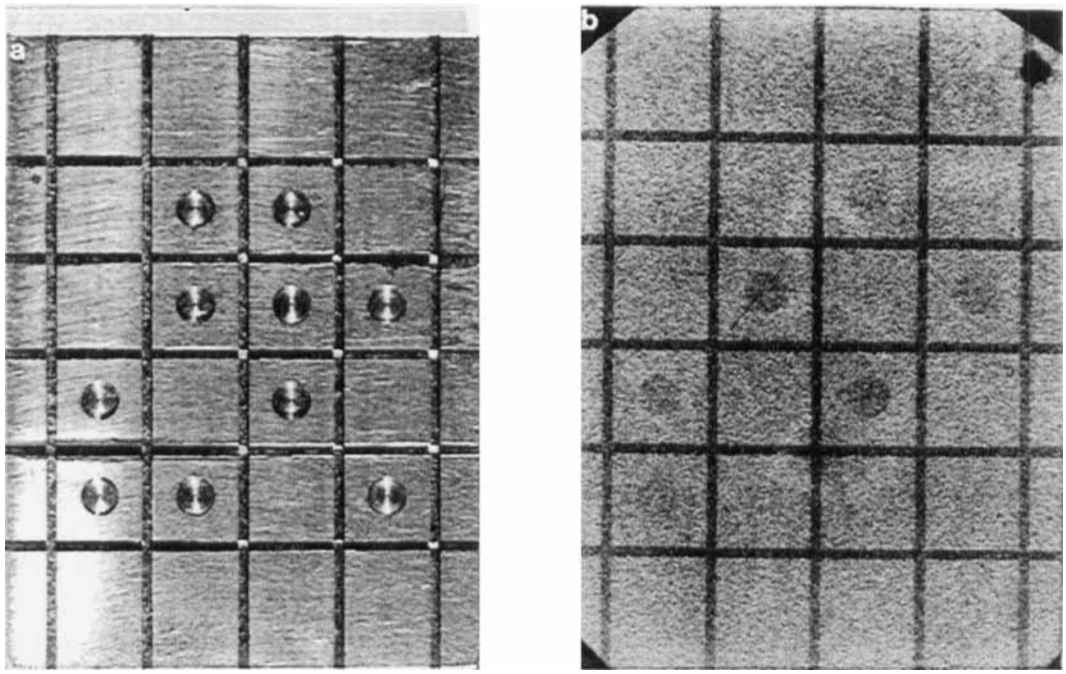

Fig. 1. Test object (a) and radiograph of the test object (b).

minum block had 10 cylindrical holes (Fig. 1) with a diameter of 2 mm and ranging from 0.05 to 0.50 mm in depth in steps of 0.05 mm. Sixteen films of each film type (altogether 64 films) were exposed, with exposure times ranging from 0.02 to 8.50 sec, with a Minray DC, dental X-ray machine operating at 60 kV and with a filtration of 2.5 mm Al (Soredex, Orion Corp. Ltd., Helsinki, Finland). The focus-film distance was 50 cm. The films were developed in an automatic processor (Pantomat, P10, Hope Industries, Willow Grove, Penna., USA; G 353 developer and G 354 fixer, Agfa Gevaert NV) at a temperature 26°C. Processing time was 6 min. The stability was checked at regular intervals during the experiment.

The radiographs were mounted in frames to block out extraneous light from the view-box and were presented to 11 dentists in random order. The radiographs were evaluated under ideal viewing conditions. After having examined each radiograph, the observer noted the number of visible images of the holes in the test object on a form.

Perceptibility curves were constructed for each film. The perceptibility curve was introduced by de Belder et al. (23) and is an approach in the evaluation of the radiographic system. This method of evaluating the radiographic system is a psychometric method in which the minimum perceptible exposure difference at different exposure levels is established. In perceptibility curves, generally displayed graphically, the inverse of the minimum perceptible exposure differences is plotted as a function of the logarithm of the exposure. To produce perceptibility curves, a series of radiographs are taken at different levels of exposure. The radiograph should have several image details of equal size with successively increasing contrast. If the object is constructed in such a manner as to enable a linear increase in successive exposure differences, perceptibility curves can be plotted for the number of visible objects as a function of the logarithm of the exposure (24). The height of the curve expresses the minimum perceptible contrast in the image as a function of exposure. The width is a measure of the exposure range, the latitude, within which minimum perceptible contrasts are portrayed in the image. The area under the perceptibility curve may be considered a representation of the total information available in the image. Optimal exposure of the system is found at the peak of the perceptibility curve.

To measure speed and contrast of the 4 different films, 30 exposures were made for each film at exposure times ranging from 0.01 to 4.74 sec at a focus–film distance of 100 cm, using a Minray DC dental X-ray machine. The optical density was measured with the aid of a digital densitometer (Victoreen Digital Densitometer II, Victoreen Inc., Melbourne, Fla., USA), and density curves were composed. The relation between dose and exposure time was checked with an ionizing chamber (MDH industries model 1015, X-monitor, Monrovia, Calif., USA) and was shown to be linear. Speed was calculated as the reciprocal of exposure, measured in C/kg required to produce the density of 1.0 above base and fog densities according to ISO 3665 (25). Contrast was determined according to ISO 3665 (25). To calculate base plus fog increment, five films of each type were developed at the beginning of the study and five films 14 months later. The increase in base plus fog density was measured as the difference of the average of the density of the films of each type at the beginning of the study and 14 months later. The density was measured with a digital densitometer. The films were developed in an automatic processor.

Statistical testing of the films was performed by using ANOVA and Scheffés F test to test the difference between the number of perceptible holes for each exposure time and film averaged across 11 observers. A statistically significant difference was considered when $p < 0.05$.

Results

Perceptibility curves

The average number of perceptible images of holes was highest for Ektaspeed and lowest for EX-58 (Table 1). However, no statistically significant differences were found between any of the films (Table 1). The shapes of the perceptibility curves are displayed in Fig. 2. The perceptibility curve for EX-58 is placed to the left in the graph, indicating that this film is the one most sensitive to radiation. The peak of the perceptibility curves indicated that EX-58 film had the lowest subjective contrast of the films compared. The three other films had peak values of a similar magnitude.

Table 1. Average number of perceptible images of holes for the different films. The calculations are based on observations of 11 observers and 16 films of each type

Film type	Average no. of perceptible images of holes	Standard deviation
Ultraspeed	5.11	2.58
Ektaspeed	5.73	2.27
DX-58	5.38	2.62
EX-58	5.06	2.74

No statistically significant differences were obtained between the films ($p > 0.05$).

Speed, contrast, and base plus fog density

Flow EX-58 had the highest speed of the compared films (Fig. 3, Table 2). The exposure for EX-58 had to be lowered by

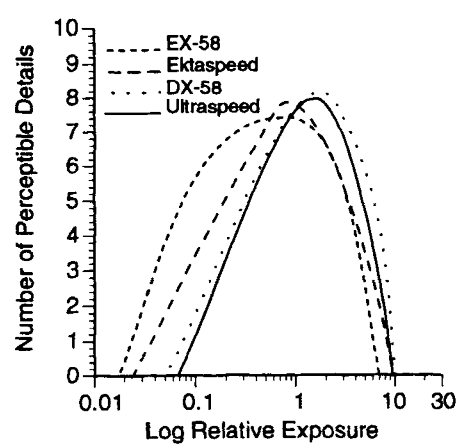

Fig. 2. Perceptibility curves for Kodak Ultraspeed and Ektaspeed films and for Flow X-ray DX-58 and EX-58 films.

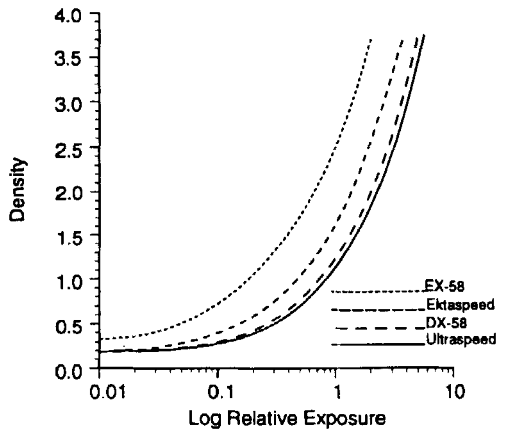

Fig. 3. Density curves for Kodak Ultraspeed and Ektaspeed films and for Flow X-ray DX-58 and EX-58 films.

Table 2. Speed and contrast of four dental X-ray films. Speed and contrast measured in accordance with ISO 3665 (25)

Film type	Relative speed	Contrast
Ultraspeed	22.0	1.80
Ektaspeed	37.7	1.59
DX-58	24.0	1.79
EX-58	64.4	1.60

66% compared with Ultraspeed to obtain a density of 1.0. Moreover, the exposure for Ektaspeed had to be lowered by 39% to obtain a density of 1.0 compared with Ultraspeed film. DX-58 and Ultraspeed were of the same speed. The two films of each speed group (D and E) had similar contrasts, but the D-speed films had a higher contrast than the E-speed films (Table 2). EX-58 had the highest base plus fog density at the start of the experiment and the highest net density increase during a 14-month period (Table 3). The base plus fog density of EX-58 was unacceptably high both at the beginning and at the end of the study. The three other films had an acceptable base plus fog density at the start of the study but passed the accepted density of 0.20 according to ISO 3665 (25) in advance of expiry date.

Discussion

Four dental X-ray films (Kodak Ultraspeed and Ektaspeed, Flow DX-58 and EX-58) were compared, and the results showed that EX-58 had a radiographic contrast comparable to Ektaspeed and the highest speed of the films compared. However, improvements in film speed may result in poorer image quality, and many clinicians hold the opinion that radiographs obtained with Ektaspeed film are of inferior diagnostic quality compared with those obtained with Ultraspeed film. In this study there was no apparent difference in the ability to display small contrast differences, using perceptibility curves to describe the diagnostic potentials of the films compared. This method is a rapid technique to obtain results compared with the use of receiver-operating characteristic (ROC) analysis (26), but it reduces the observer performance to pure detection without taking diagnostic decision-making into account.

Table 3. Increase in base plus fog density during a 14-month period for the four films compared

Film type	Emulsion no.	Expiry date	Months to expiry date	Base plus fog density	Increase in net density
Ultraspeed	158 0130	Mar. '93	20	0.15	0.09
			6	0.24	
Ektaspeed	154 0123	Oct. '93	27	0.20	0.14
			13	0.34	
DX-58	2412	Mar. '93	20	0.18	0.11
			6	0.29	
EX-58	5415	Apr. '93	21	0.29	0.16
			7	0.45	

EX-58 was the fastest of the four films compared, and the exposure had to be lowered by 66% compared with Ultraspeed film to obtain a density of 1. Dentus M4 (Agfa Gevaert NV) also had a speed that reduced the exposure time by 66% compared with Ultraspeed (17). Thus, EX58 and Dentus M4 would be of the same speed group. Benz (14) concluded in a comparison of speed and contrast of Ultraspeed, Ektaspeed, and Dentus M4 that Dentus M4 would be the first film of speed group F, which was confirmed by Svenson et al. (17). The higher sensitivity to radiation for EX-58 was also reflected by a higher base plus fog density and increase in density during storing. It is important that faster film materials have a shorter storage time than is recommended by the manufacturer to keep film fogging within acceptable limits.

The relatively low interest in Kodak Ektaspeed film among general practitioners might be due to a subjectively assessed low quality of the film. Goren et al. (5) found that 26% of the dental schools in the USA used Ektaspeed films, but only 13% of the general practitioners. In Sweden all dental schools use Ektaspeed film, while 31% of the practitioners do (4). As consultants in oral radiology, we must encourage the use of the fastest available film material, as long as the diagnostic level is maintained, since the use of faster film materials is one of the most important means of lowering the radiation dose to the patients (2).

Most studies performed comparing Ultraspeed and Ektaspeed films for various diagnostic tasks have not been able to show any significant differences in diagnostic accuracy between the films (17, 20–22). One study showed that Ultraspeed film outdoes Ektaspeed film in the visualization of small contrast differences (8). In our study, however, Ektaspeed was found to have the highest number of perceptible contrast differences.

We could not find any differences between the examined films when using perceptibility curves. However, the diagnostic performance of the new faster film, EX-58, must be evaluated by using ROC curves or other techniques calculating diagnostic accuracy before the film is recommended for clinical use.

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