Received: 24 Feb. 2012 **Accepted: 11 Jun. 2012**

Original Article

Sensitometric characteristics of D-, E- and F-speed dental radiographic films in manual and automatic processing

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Abstract

BACKGROUND AND AIM: The purpose of this study was to evaluate the sensitometric characteristics of Ultraspeed, Ektaspeed Plus and Insight dental radiographic films using manual and automatic processing systems.

METHODS: In this experimental invitro study, an aluminum step-wedge was used to construct characteristic curves for D-, E- and F-speed radiographic films (Kodak Eastman, Rochester, USA). All films were processed in Iranian processing solution (chemical industries Co., Iran, Tehran) both manually and automatically in a period of six days. Unexposed films of three types were processed manually and automatically to determine base plus fog density. Speed and film contrast were measured according to International Standard Organization definition.

RESULTS: There was significant difference in density obtained with the D-, E- and F-speed films in both manually and automatically processing systems ($P < 0.001$). There was significant difference in density obtained with the Ultraspeed and insight films. There was no significant difference in contrast obtained with the D-, E- and F-speed films in both manually and automatically processing systems ($P = 0.255$, $P = 0.260$). There was significant difference in speed obtained with the D-, E- and F-speed films in both manually and automatically processing systems ($P = 0.034$, $P = 0.040$).

CONCLUSIONS: The choice of processing system can affect radiographic characteristics. The F-speed film processed in automatic system has greater speed in comparison with manual processing system, and it provides a further reduction in radiation exposure without detriment to image quality.

KEY WORDS: Automatic Processing, Dental Radiography, Manual Processing, Radiographic Film Classification, Sensitometry, X-ray Film

J Oral Health Oral Epidemiol 2012; 1(2): 60-64

Great efforts in radiology are to improve the quality of radiographs and reduce the patient's exposure to radiation.[1] The radiation dose received by patients in dental radiography is low, but any radiological procedure should be justified and optimized in order to keep the radiation risk as low as reasonably achievable.[2] Thus, this may be achieved with the use of the fastest film.[3]

Kodak Company recently has introduced Insight, an F-speed direct exposure intraoral x-ray film, which is 20% faster than Ektaspeed Plus, and it maintains the same image quality.[4] Processing procedures and various processing solutions may influence on film sensitometric properties (density, speed, contrast, fog and resolution).[5] Some studies have compared the efficacy of different dental radiographic films when these films were developed manually and automatically with various processing solution.[4-6]

However, there has been a lack of research evaluating the sensitometric properties of these films with the use of manual and

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automatic Iranian processing solutions. Therefore, the goal of this study was to evaluate the sensitometric characteristics of Insight, Ektaspeed and Ultraspeed films automatically and manually processed using Iranian processing solution and compare them with other researches.

Methods

In this experimental in vitro study, Ektaspeed Plus (E-speed film), Ultraspeed (D-speed film) and Insight (F-speed film) films (Kodak Eastman, Rochester, USA) were exposed by using a Planmeca x-ray unit (Planmeca Intra Oy 00880 Helsinki, Serial No:ITHC76503, Tube type: D-711sb, Tube No:49824,70 Kv max, total filtration 2,0 mmGquAI Finland) with exposure factors of 70 KVp with 8 mA and 2 second, and a tube-to-film plane distance of 20 cm**.** Speed and film contrast were measured according to International Standard Organization definition.

To study radiographic contrast, a ten-step aluminum step-wedge with a thickness of 1.5 mm (Figure 1), was exposed to radiation. The step-wedge was radiographed on each type of film (Figure 2).Two films of Ultraspeed, Ektaspeed Plus and Insight films were exposed each day, and two unexposed films of each film type were considered to determine the base plus fog density for each day. One exposed and unexposed Ultraspeed, one exposed and unexposed Ektaspeed Plus, one exposed and unexposed Insight formed first set of dental films. The process was repeated for 6 days.

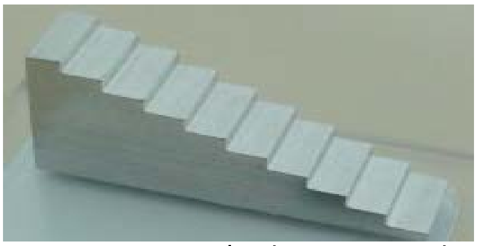

Figure 1. A ten-step aluminum step-wedge

Radiographic processing was performed manually and automatically on the same day of exposure, in less than one hour after being exposed, to keep the image quality. A total of 72 films (24 Ultraspeed, 24 Ektaspeed and 24 Insight films) were being exposed and developed at the end of sixth day.[6]

Figure 2. Expose film with aluminum step-wedge

All films were developed using Iranian solution (World chemical industries Co., Iran, Tehran) for manual and automatic processing systems. Automatic processor system (VELOPEX, intra oral processor, England) was set at 27° C, 2.5 min processing time. Manual processing system was at 24° C, and based on the table provided by the film manufacturer, film immersion times in the developer (1450 ml) and in the fixer (1450 ml) were 10 second and 1 minute, respectively.[7] The first set was processed manually, and the second set was processed automatically.[7] The processing solution in both manually and automatic systems was not changed during the experiment to evaluate the effect of depletion of chemicals on image quality.

After processing, film densities were measured with a film densitometer machine (Transmission densitometer DT 1505; Alrad instruments Ltd, Newbury). The densities of three different spots of each steps of step-wedge were measured by a densitometer, and average density was determined for each step. To evaluate the base plus fog density, the three different spots of each unexposed film were measured.[7] Finally, characteristic curves for each film type, processing system and processing day were constructed by plotting the optical density against the logarithm of exposure.[8] The characteristic curves were used to calculate film speed, inherent contrast and exposure latitude. Film speed was calculated as the exposure time (in seconds) required producing a density of 1.0 above base-plus-fog.[9]

To construct the characteristic curves, we also needed the exposure levels. Exposure level of all processed films, where there was no steps, were measured by a dosimeter machine (RadexRD 1706 Geiger Counter with Range of dose rate indication 0.05 – 999 uSv/Hr, Energy range registered: Gamma 0.1 – 1.25 Mev; X-Ray 0.03 – 3.0MeV, Beta 0.25 – 3.5MeV, Germany) in the same condition of 70 KVp with 8 mA and 2 seconds. Then we placed an aluminum sheet with 1.5 mm diameter that was similar to the step-wedge in front of dosimeter machine to determine the exposure of first step. The process was repeated to 10 aluminum sheet in the same condition of 70 KVp with 8 mA and 2 seconds. The exposure of each step calculated for 3 times and average was determined for each step as an exposure of each steps.[6,7,10]

Contrast evaluation

Film's contrast evaluation was visually performed, and contrast level was completed in a sample list by two radiologists. During the rating process, the radiographs were viewed on a Medical Negatoscope with no identifying information visible or available about film type and type of film processing to the two observers. Each radiologist rated all films independently of the other one.

For the statistical analysis, the mean of the two observers' ratings was used as a single score for each Film type. Judges used a three-point rating scale: 1 = High, 2 = moderate, 3 = poor (Figure 3). Finally, to compare the sensitometric properties of films, one-way ANOVA test, Student's t-tests, Welch and Tukey's post-hoc test with 5% level of significance were employed using SPSS software, version 18 (SPSS, Inc., Chicago, IL, USA).

Results

The study revealed that Insight had the highest density in both automatic and manually processing system in first day. The characteristic curve of Insight, Ektaspeed Plus, and Ultraspeed films are shown in Figure 3. The location of the characteristic curves of different films along the X-axis relates to the speed of the films. According to the shift of curves, Insight had the highest speed.

Ultra-speed had the lowest density in manually processing system. Density gradually decreased from the first day to fifth day for all film types. The base-plus-fog density values are shown in table 1.

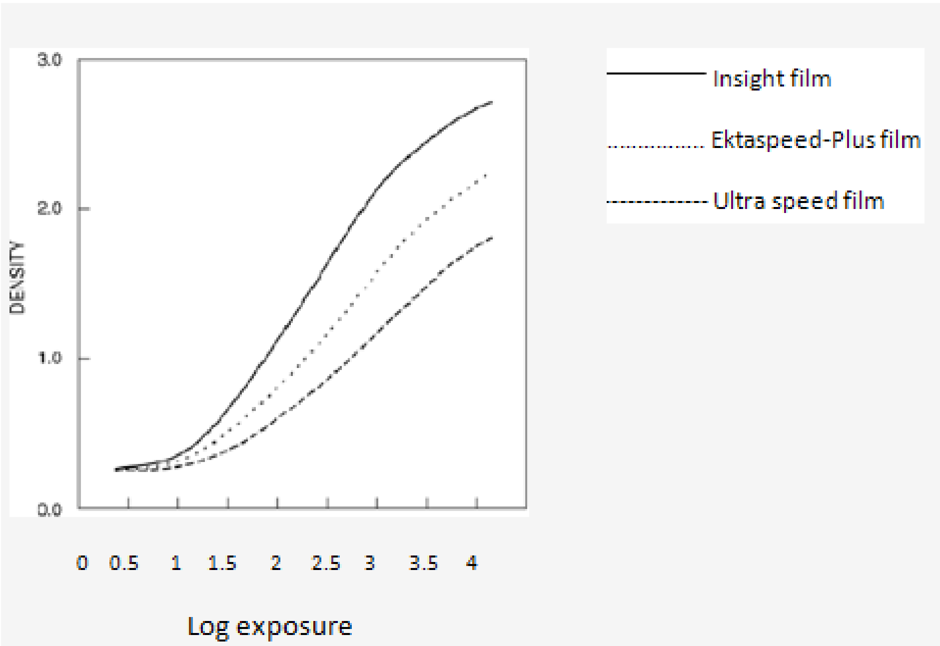

Figure 3. Characteristic curves of Insight, Ektaspeed Plus and Ultraspeed films

Table 1. Comparison between types of film density in manual and automatic processing systems

Kind of film	Speed	No	Mean ± SD	Test
	D	6	0.151 ± 0.024	Df = 2
Manual processing	E	6	0.190 ± 0.230	F = 30.13
	F	6	0.236 ± 0.027	P < 0.001
	D	6	0.161 ± 0.038	Df1 = 2
Automatic processing	E	6	0.226 ± 0.049	Df2 = 15
	F	6	0.273 ± 0.021	P = 0.026

SD: Standard deviation

Table 2. Comparison between types of film contrast in manual and automatic processing systems

Kind of film	Speed	No	Mean ± SD	Test
	D	6	5.36 ± 0.024	Df1 = 2
Manual processing	E	6	5.34 ± 0.041	Df2 = 8.23
	F	6	5.61 ± 0.390	P = 0.255
	D	6	5.27 ± 0.161	Df = 2
Automatic processing	E	6	5.39 ± 0.279	F = 1.458
	F	6	5.53 ± 0.311	P = 0.264

SD: Standard deviation

Table 3. Comparison between types of film speed in manual and automatic processing systems

Kind of film	Speed	No	Mean ± SD	Test
	D	6	15.11 ± 0.993	P = 0.034
Manual processing	E	6	16.40 ± 1.193	
	F	6	16.83 ± 0.996	
	D	6	16.84 ± 1.250	Df1 = 2
Automatic processing	E	6	18.54 ± 0.200	Df2 = 7.42
	F	6	18.65 ± 0.630	P = 0.042

SD: Standard deviation

There was significant difference in density obtained with the Ultraspeed, Ektaspeed Plus and Insight films (P < 0.001). Insight had the highest contrast in both automatic and manually processing system in first and second day, and Ultraspeed had the lowest contrast in automatic processing system in the first day.

The contrast values are shown in table 2. There was no significant difference in contrast obtained with the Insight, Ultraspeed, Ektaspeed Plus films in both manually and automatically processing systems (P = 0.255 , P = 0.260). There was significant difference in speed obtained with the Ultraspeed, Ektaspeed Plus and Insight films in both manually and automatically processing systems (table 3).

Discussion

In this study, speed, contrast, base-plus-fog density of Insight, Ultraspeed and Ektaspeed Plus films were evaluated. The results of this study showed that the different film types respond differently to various films processing systems and to depletion of chemicals.

The speed of films in automatic processing system is higher than in manually processing system. Insight film is faster than other film type that is consistent with previous studies.[1,5-7,11] There was significant difference in density obtained with the Insight, Ultraspeed, and Ektaspeed Plus films that density of Ultraspeed was lower than Ektaspeed Plus, and Ektaspeed Plus was lower than Insight. Density values gradually decreased from the first day to sixth day for all film types to solution depletion (diagram 2) as previously reported by Geist and Brand,[5] Dabaghi et al.[6] and Farman TT et al.[12] On the other hand, Bernstein et al.[4] found no significant difference in density obtained with Ultraspeed and Insight. There was no significant difference in contrast obtained with the Insight, Ultraspeed, Ektaspeed Plus films in both manually and automatically processing systems which is consistent with those of previous studies.[5,6,11] On the other hand, Diehl et al[13] found that the contrast of Ultraspeed was greater than Ektaspeed Plus in manually processing system. In this study, contrasts of almost three films were similar during 6 days. Just Ektaspeed Plus had the highest contrast in automatic processing system in the first day and Insight had the highest contrast in automatic processing system in the first and fifth days and Insight had the highest contrast in manually processing system in the first and second days but these were not significant, that does not match with Dabaghi et al. study.[6] The silver halide grains in Insight film are flat, and it has a tabular crystals with a mean diameter of about 1.8 pm and the tabular grains of the Insight film are oriented parallel with the film surface to offer a large cross-sectional area to the x-ray beam, so Insight had the highest contrast.[14] Hadley et al.[15] showed in their study that Insight is more acceptable than Ultraspeed.

Conclusion

Based on these findings, Insight film provides a further reduction in radiation exposure, without any significant changes in image quality. Therefore, the use of Insight film could be suggested to reduce patient exposure to radiation. Moreover, the image quality of all the film types was decreased in depleted chemicals. In addition, there was no significant difference between Iranian processing solutions and those were used in other studies. The use of Iranian processing solution could also be suggested.

Conflict of Interest

Authors have no conflict of interest.

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