

Comparison of dental intraoral films by means of radiographic characteristics

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ABSTRACT

Statement of the problems: Nowadays in many of the dental radiography centers in Iran, three types of intraoral films are being used. There is a controversy about the best film regarding to sensitivity properties.

Purpose: In this study, we aimed to compare sensitivity characteristics and detail recording of intraoral films.

Methods and materials: In this experimental study, three types of intraoral dental films (Agfa E&F-speed Dentus M2 Comfort, Kodak Intraoral E-speed and Foma Dentix Intraoral E-speed) were evaluated by drawing the characteristic curves of these three types of films. Sensitivity characteristics of each film were defined considering their characteristic curves. To measure the accuracy of the films in recording details an aluminum test object was used. Finally, the sensitivity characteristics of the films and their ability in detail recording in different processing conditions were compared. Data were analyzed using the ANOVA test.

Results: The findings indicate that Foma-dentix film presents the highest base plus fog density using both fresh and used developer solutions. The relative speed of Kodak film was higher than the others. Kodak and Foma-dentix films had the highest and the lowest contrast, respectively. Considering the rate of detail recording, it was found that the detail recording of Agfa film was much better than the two other films in different developing and exposure conditions. The One-way ANOVA test showed significant statistical difference.

Conclusion: The sensitivity characteristics of Kodak films are better than the other ones. The accuracy of detail resolution of Agfa film was the highest. To achieve a high quality film, it is advised to use a new developer solution.

Key words: Dental film, Sensitivity characteristics, Radiation

INTRODUCTION

Dental radiography is one of the most common methods of determining dental caries especially in proximal surfaces of teeth ⁽¹⁻³⁾. Although the radiation dose received by patients in dental radiography is low, any radiological procedure should be

justified and optimized in order to keep the radiation risk as low as reasonably achievable ⁽⁴⁾.

Nowadays, it is advised to use faster films to reduce the radiation dose as low as reasonably achievable, But faster films often have lower quality and may not show some decays or the exact depth of caries ⁽⁵⁻⁸⁾.

Obtaining a satisfactory condition could be achieved by using the fastest film that gives a qualified image ⁽⁹⁾.

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To measure the response of film density to exposure. Image quality could be tested using a method called film sensitometry,

The sensitometry gives a lot of information about the film such as speed, contrast, latitude⁽⁹⁾.

However, there are many variables that may influence the quality of the image obtained⁽¹⁰⁾. For example, Image quality is influenced by the processing condition and it has been observed that depletion of processing chemicals can have a harmful effect on image quality^(11,12).

Although, radiographic films are going to be replaced by digital detectors⁽¹³⁾, but, there is still different films that are being used in Iran for intraoral dental radiography. There is still controversy in the quality of dental films.

Some studies have compared the efficacy of different films use in dental radiography^(14,15).

In this study, three types of commonly used films in Iran (Agfa E&F-speed Dentus M2 Comfort, Kodak Intraoral E-speed and Foma Dentix Intraoral E-speed), were evaluated. To the best of our knowledge, there is no similar study comparing the sensitivity characteristics of these three types of films.

The sensitivity characteristics such as contrast, latitude, accuracy (visibility) and speed were compared. In addition, sensitivity characteristics of these films in different developing conditions has been assessed.

METHODS AND MATERIALS

In this experimental study, one of each type of film (totally 3 pieces) was placed on a moveable board at a distance of 28 and 32 cm from x-ray source and were coincidentally exposed by using a Soredex intraoral x-ray unit (made in Finland, filtration of 1.5 mm aluminum). Then, the process was repeated at distances of 37 cm to 118 cm with 9 cm intervals (Fig.1A). To eliminate the backscatter radiations, a lead cover was placed on the back of the board (Figure 1A).

Exposure factors used for all films were 70KVp with 7mA and 0.8 second.

After exposure, the films were developed by a 3 minute automatic processor system (Hope Dental Max, made in the USA, process 6 films coincidentally) using Tetenal developer solution (Made in Germany, developer temperature of 28°C). Then densities of all processed films were measured by a film densitometer machine (Konica PDA 85, made in Japan with 2mm aperture diameter). The densities of three different spots of each film were measured by a densitometer and the total density was calculated by averaging the collected. Finally, resulted densities diagram of each film were drawn based on relative exposure logarithm. It is noted that the relative exposure was calculated by inverse square law and the distance of 4 meters was considered as reference distance⁽¹⁶⁾. So, the relative exposure at the distance of 2 meters was.

$$\left(\frac{4}{2}\right)^2 = 4$$

It is worthy to mention that by using this diagram, sensitometric characteristics of films such as contrast, latitude, speed and base plus fog density can be calculated. The contrast of each film can be measured in certain exposure condition by calculating the gradient of tangent line on the characteristic curve in that point. As shown in Figure 2A, it is possible to calculate the average gradient by calculating the gradient of the line which joins two spots with 0.25 and 2.5 densities⁽¹⁶⁾. As the base plus fog density of intraoral dental films is higher than 0.25, the average gradient density can be calculated between base plus fog and 3 densities of examined films.

The speed of films can be determined by reversing the exposure needed to obtain 1+B+F density. To measure the accuracy of the films in details recording (detail resolution), an aluminum test instrument with 15×25 mm dimension having 10 holes in different sizes (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 mm) was put on the films. The holes were created using a 2mm diameter drill (Fig 1B).

According to Fig 2B, the latitude of the film explains the extent of required relative exposure to achieve the recognition of useful densities⁽¹⁶⁾.

Twelve pieces of each type of film was put at a distance of 26 cm, while aluminum test instrument was on it. The films were exposed in different exposure conditions. Exposure conditions used to irradiate these film were 70KVp and 7mA and exposure times were in ascending order as 0.02, 0.03, 0.04, 0.06, 0.08, 0.1, 0.12, 0.16, 0.2, 0.25, 0.4, 0.6 seconds. After exposing, the films were processed by the automatic processor (Hope Dental Max).

To evaluate the detail resolution of films, 20 dentists and dental students reported the number of the holes they could see on each film. After calculating the means of the numbers, detail resolution in different exposure conditions and different type of films were compared.

At the first phase, all the processing stages were done using new developer solution. Then, all the steps were repeated using exhausted processing solutions. After processing of 450 films in fresh processing solution it transformed to exhausted processing solution. So, the effects of depleted processing solution on sensitometric properties and detail recordings were assessed.

Finally, the sensitivity characteristics of the films and their ability in detail recording in different processing conditions were compared. Sensitivity properties of different types of films in various processing conditions were analyzed. To compare the sensitometric properties of films One-way ANOVA test with SPSS software, version 10 was used. Continuous variables were analyzed by means of ANOVA. All statistical analyses were carried out with SPSS software version 10, and P-values less than 0.05 were considered as significant.

Results

Diagram 1 shows the characteristic curves of films in different processing conditions.

Base plus fog density, mean contrast, speed and latitude of each film in different

processing conditions (fresh and used developing solutions) are shown in Table 1.

The study revealed that base plus fog density of Foma Dentix was the highest and that of Agfa film was the lowest in all processing conditions. But, in the case of using used developer solution, base plus fog of all films increased significantly.

By using new developer solutions, the proportional speed of Kodak film was 1.18 times more than Agfa film and 1.11 times more than Foma Dentix. But, by using used developer solutions the proportional speed of Kodak film was 1.32 times more than Agfa film and 1.11 times more than Foma film.

The latitude of film was considered as interval within the logarithm of relative exposure in useful recognition density range (0.2 to 2.5). As base plus fog density of Foma Dentix films increased to 0.69, an interval within the logarithm of relative exposure was seen in density range of 1 to 3 as the latitude of films.

Table 1 shows the films latitude, as well. The results revealed that Agfa film had the highest latitude and Kodak film had the lowest.

By using used a developer solution the latitude of films increased proportionally due to reducing the speed of films.

Considering the rate of detail recording, after using test instrument, it was found that the detail recording of Agfa film was much better than the others in different developing and exposure conditions (as shown in Table 2). The One-way ANOVA test showed significant statistical difference ($P < 0.05$).

The results indicated that exhaustion of processing solutions affected the sensitivity properties of all films and this effect was more obvious in Foma Dentix films, whereas the Kodak film was more resistant to different processing solutions.

Fig 1: A view of a film exposed to radiation in different distances from x-ray source (A) and aluminum test object used in this study (B).

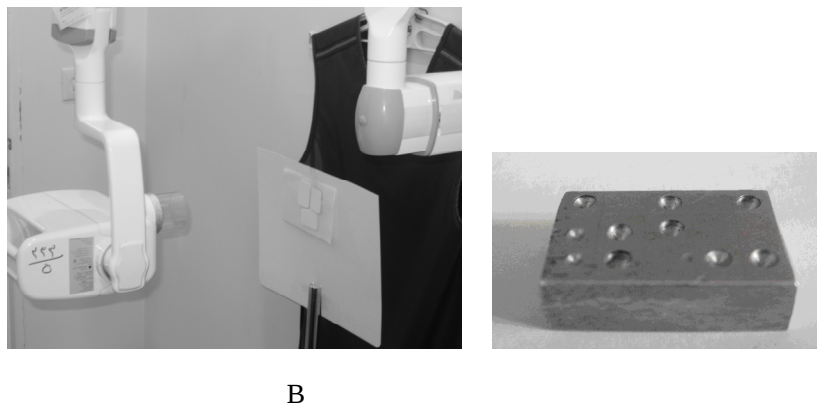


Fig 2: Calculation of the contrast of film in each exposure condition (a) and mean contrast of film (b) regard to characteristic curve.

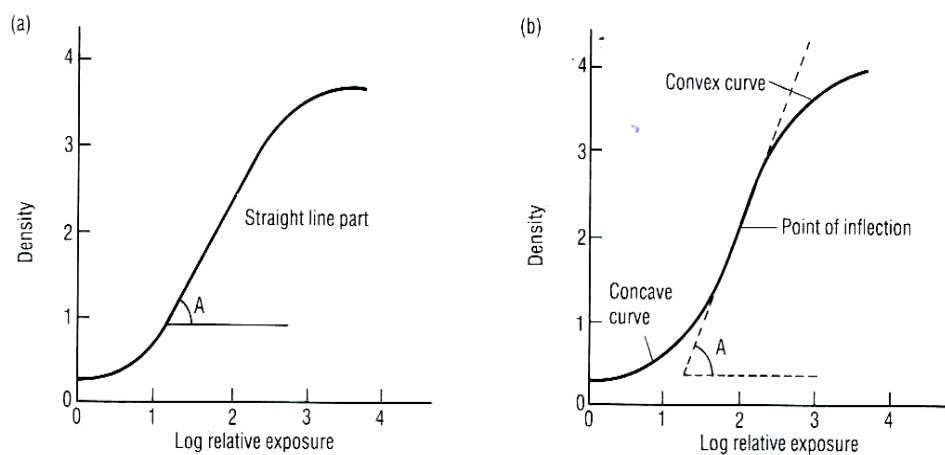
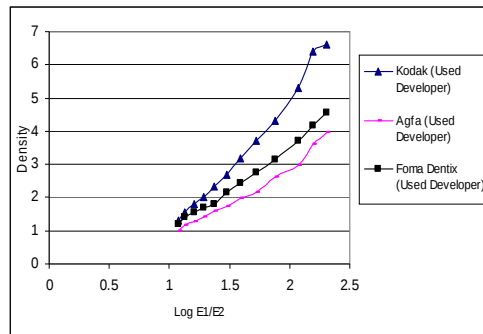
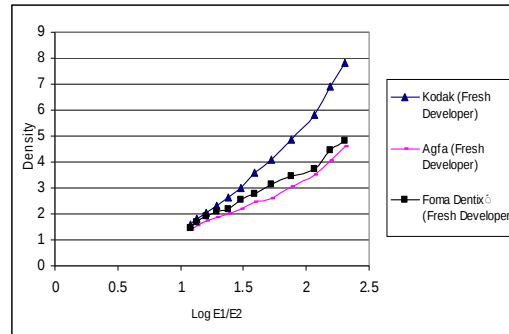


Diagram 1: Comparing characteristic curves of different films using fresh developer (A) and used developer (B) solutions

A



B

Table 1: Sensitometric properties of each type of film in different processing conditions fresh and used developer solutions

	Fresh Developer			Used Developer		
	Kodak (E-Speed)	Agfa Dentus M2	Foma Dentix (E-Speed)	Kodak (E-Speed)	Agfa Dentus M2	Foma Dentix (E-Speed)
B+F Density	0.41	0.31	0.62	0.51	0.38	0.69
Mean Contrast	3.28	2.41	3.03	3.28	2.32	2.60
Speed	67.5	60.0	48.5	56.5	43.3	40.05
Latitude	0.61	0.83	0.66	0.61	0.86	0.77

Table 2: Rate of detail recording in different exposures and processing conditions on each type of film

Detail recording Relative exposure	Fresh Developer				Used Developer			
	Kodak (E-Speed)	Agfa Dentus M2	Foma Dentix (E-Speed)	P- value	Kodak (E-Speed)	Agfa Dentus M2	Foma Dentix (E-Speed)	P- value
0.772	8	9	6	0.000	8	7	7	0.000
0.948	9	9	8	0.000	8	9	6	0.000
1.073	10	10	8	0.001	10	9	8	0.000
1.249	10	10	9	0.443	9	10	9	0.000
1.374	10	10	9	0.374	10	10	9	0.001
1.471	10	10	10	0.059	8	10	9	0.001
1.55	10	10	10	0.812	9	9	10	0.443
1.675	10	10	10	1.000	10	10	10	0.774
1.772	10	10	10	0.587	10	10	10	0.774
1.869	10	10	10	0.355	10	10	10	0.911
2.073	10	10	10	0.609	9	10	9	0.196
2.249	9	10	8	0.001	9	9	8	0.001

DISCUSSION

The results showed that Agfa film had the lowest base-plus-fog density and Foma film had the highest. These findings are in agreement with the results of Dabbaghi *et al.*⁽¹⁷⁾. So, by using used developer solution, the base-plus-fog density of all films increases. Regarding characteristic curve of films, we also found that Kodak film had the highest speed and Agfa film had the lowest one. As Kodak film had higher speed, so to get an image with certain density and to decrease the radiation dose, lower radiation conditions are needed. This finding shows that by using exhausted developer solution, the speed of Agfa film and Foma film reduce more than Kodak film and by using new developer solution the speed of Kodak film increases by 19%. These figures are 48% and 42% for Foma film and Agfa film, respectively. Wakoh *et al.*, Nesbit *et al.* and Alsubael found the same results for depleted processing chemicals^(5,9,15).

Regarding the mean contrast of films, the contrast of Kodak film was the highest^(3,42). The mean contrast of Agfa film was the lowest^(2,16) after using fresh processing solution. Higher mean contrast indicates better sharpness of image^(16,18). So, Kodak images were sharper than the others.

Agfa film had the greatest latitude and Kodak film had the most limited one. Considering the high speed and contrast of Kodak film these results were predictable. Wide ranges of latitude results in choosing a wide range of exposure factors. It means that with minor errors in exposure condition we can still get a proper image quality. The detail recording of Agfa film was much better than the others as all of the holes on the test object were visible in many different densities.

CONCLUSION

Kodak E-Speed film provides relatively fast speed and high contrast images than the others in both fresh and exhausted processing solutions. These results support that Kodak film has the lowest latitude.

In general, as processing solutions become exhausted, all types of films have an increase in latitude values and a decrease in speed and contrast. There is also a

significant to better detail recording using Agfa film compared to the others.

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