

# Sensitometric evaluation of a periapical radiographic film Dentix E™: effect of different processing conditions

*Avaliação sensitométrica do filme radiográfico periapical Dentix E: efeito de diferentes condições de processamento*

Bruno Tochetto Primo\*  
Bruno Ferri Raymundi\*  
Francisco Haiter-Neto\*\*  
Gisele Rovani\*\*\*  
Mateus Ericson Flores\*\*\*  
Ferdinando de Conto\*\*\*  
Melissa Feres Damian\*\*\*\*

## Abstract

*Objective: Knowing the properties of new radiographic films is essentially important, because from this evaluation depends the learning of such films, directly affecting the radiation dose received by the patient in radiographic examination. Thus, the aim of this study was to evaluate the sensitometric properties of a new film – Dentix E™, and compare it to E-speed™ and Insight™ films, processed with different liquids and under different conditions. Methods: The films were exposed at predetermined times and manually processed, using the temperature/time method and ready-to-use liquids from Kodak and Prograd, and were automatically processed with Kodak liquids. Later, the density of those X-rays was measured and the characteristic curves were built in order to determine their sensitometric properties, such as contrast, indicative value of sensibility, and latitude. The values of properties were evaluated by the inclination of curves in the graphs and by descriptive statistics. Results: It was possible to observe that Dentix E™ film presented similar characteristic curves and sensitometric properties to E-speed™ film, regardless of processing. Conclusion: This result indicates that Dentix E™ presents contrast, sensibility, and latitude compatible to films classified as E sensibility.*

**Keywords:** X-Ray film. Processing. Densitometry.

## Introduction

Radiographic examination has shown to be a valuable sensitometric resource to diagnose lesions in the oral cavity, besides being an important document for dentists<sup>1</sup>. However, the applicability, importance level, and achievement condition of a radiograph depend on the quality of the image obtained, being a good quality radiograph the one presenting maximum detail, minimum distortion, and medium levels of density and contrast<sup>2</sup>. Four main factors relate to radiographs with this pattern: operator's ability, unit generating X-rays, register surface for the image or X-ray films, and conditions and solutions for processing<sup>3</sup>.

A film is composed by a polyester base coated on both sides by an emulsion, which is a gelatin substance containing silver halide crystals (AgBr and AgI)<sup>2</sup>. The shape, size, and concentration of silver halide crystals determine the sensitometric properties of the radiographic films: contrast, sensibility, and latitude, besides their resolution and detail. The contrast is represented by a numeric value named average gradient, and can be determined by density differences in two areas of a radiograph. Sensibility, also known as speed, is related to the film's ability to produce images with higher or lower quantities of X radiation<sup>4,5</sup>.

\* Dentist – Passo Fundo, RS, Brazil.

\*\* Professor in Radiology at FOP/UNICAMP – Piracicaba, SP, Brazil.

\*\*\* Professor at the University of Passo Fundo Dental School – Passo Fundo, RS, Brazil.

\*\*\*\* Professor at the Federal University of Pelotas Dental School – Pelotas, RS, Brazil.

The sensitometric properties are particularly studied for each film, by means of a plotted curve known as characteristic curve or sensitometric curve. This curve is obtained by plotting a graph with different film densities, and by the log of exposure times necessary to obtain the respective densities<sup>2</sup>. Several authors have focused on studying the sensitometric properties of radiographic films since their constant improvements demand frequent update of their behavior. Such industrial improvement mostly aims to reduce the exposure to radiation doses received by patients during the radiographic procedure without losing quality, which would compromise the diagnosis and radiograph achievement<sup>6-12</sup>.

Recently, Foma Company marketed an E sensibility dental radiographic film, named Dentix E<sup>TM</sup>. According to the manufacturer<sup>13</sup>, this film presents medium speed, high contrast, and thin crystals, resulting in high quality images, detail, and definition. Regarding radiographic films it is known that manufactures often market new products aiming to reduce the radiation received by patients and to improve the quality of radiographic images<sup>4</sup>. However, depending on the manufacturer and processing, radiographic films may acquire different behavior regarding sensibility and final image quality for diagnosis. Thus, the purpose of this study was to evaluate the sensitometric properties of a new radiographic film, Dentix E<sup>TM</sup>, processed with different liquids and under different conditions, and compare it to E-speed<sup>TM</sup> and Insight<sup>TM</sup> films.

## Materials and methods

The present study employed Dentix E<sup>TM</sup> films, an intraoral radiographic film presenting E sensibility and manufactured by Foma (Foma Bohemia spol. s r.o., Hradec Králové, Czech Republic). Insight<sup>TM</sup> and E-speed<sup>TM</sup> intraoral films, from Kodak (Kodak do Brasil Comércio e Indústria Ltda., São José dos Campos, São Paulo, Brazil), which respectively present E/F and E sensibility, were also employed. All films used were simple, presented 1.2 shape (according # 22 American Dental Association specification)<sup>14</sup>, and were within the due date. Seventy-five films of each type were employed. Metallic letters on the superior edge of radiographs identified the films according to their commercial brand, sensibility, liquid, and method of processing.

A Gendex 765DC X-ray machine, located at Kozma clinic in Passo Fundo, was employed. It presents 70 kVP, 7mA and fractionated doses of radiation. The focus-film distance was set at 40 cm and standardized by means of a device especially developed for this study. The exposure times were predetermined at 0.020 s, 0.16 s, 1 s, and 5 s in order to build the characteristic curves<sup>10,15</sup>. Five films of each brand were exposed for each exposure time, sensibility, processing liquid, and processing type.

Temperature/time process manually processed part of the films (150), while the other part (75) was automatically processed. The automatic processing was performed using an AT2000 Plus processor (Air Techniques INC, Corporate Headquarters, Hicksville, NY, USA), located at the SOD - UPF exam and triage sector. Kodak RP X-OMAT processing liquids (Eastman Kodak Company, Multirad Com. Mat. Hospitalares, Porto Alegre, RS, Brazil) were used for the automatic processing. They were prepared 24 hours prior to the project in order to have their properties stabilized. GBX from Kodak and Prograd (Prograd Comercial Médica Ltda, Curitiba, Paraná, Brazil) ready-to-use liquids were used for the manual processing. They were placed in 250 mL recipients, inside a darkroom with labyrinth entrance located at the SOD - UPF radiology clinic. Non-running water was used for the intermediate and final washing in the manual process. Developing and fixing liquids were renewed after 50 radiographs taken<sup>16,17</sup>, while water was renewed after 5 radiographs<sup>18</sup>. Five films that received no exposure were also developed aiming to build the characteristic curves and to measure the basic density and veiling (BDV) for each group.

The radiographs obtained in each group (brand/sensibility/processing liquid/ processing type) were measured according to density. A photodensitometer (MRA<sup>TM</sup>, Indústria de Equipamentos Eletrônicos Ltda, Ribeirão Preto, SP, Brazil), calibrated with 1 mm opening diaphragm was used for all readings. The mean of five measurements randomly allocated to each radiograph determined the mean density for each radiograph. The mean density for each group was then achieved.

After determining densities, data was plotted into graphs in order to obtain the sensitometric properties of the films. The exposure times were converted to logarithms and plotted on the x-axis (abscissa), while the mean optical densities obtained from the 5 radiographs for each exposure time were plotted on the y-axis (ordinate). The contrast, indicative value of sensibility, and latitude were obtained from the curves. The sensitometric properties for each tested combination will be compared by means of curve angulations on the graphs and descriptive statistics.

## Results

Figure 1 shows Dentix E<sup>TM</sup> characteristic curves, processed under different conditions: manually processed with Prograd liquid, manually processed with Kodak liquid, and automatically processed with Kodak liquid. It can be observed that the curves are superposed, indicating the sensitometric characteristics of Dentix E<sup>TM</sup> film do not alter with different radiographic processing liquids and procedures.

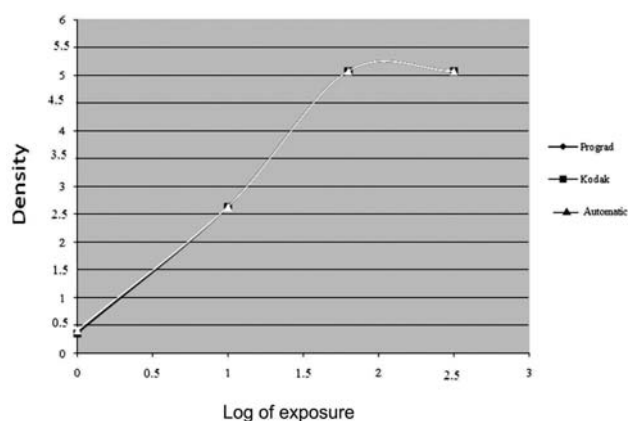


Figure 1 - Characteristic curves of Dentix E<sup>TM</sup> film, processed under different conditions

Figures 2, 3, and 4 show the curves grouped together for comparison among Dentix E<sup>TM</sup>, E-speed<sup>TM</sup> and Insight<sup>TM</sup>, when either manually processed using Prograd or Kodak liquids, or automatically processed using Kodak liquid. The analysis of the figures demonstrated that Dentix E<sup>TM</sup> and E-speed<sup>TM</sup> presented superposed curves in all processing conditions. Those curves were more to the right of the graph in comparison to Insight<sup>TM</sup>, indicating that Dentix E<sup>TM</sup> film presented similar behavior as E-speed<sup>TM</sup> film for Kodak.

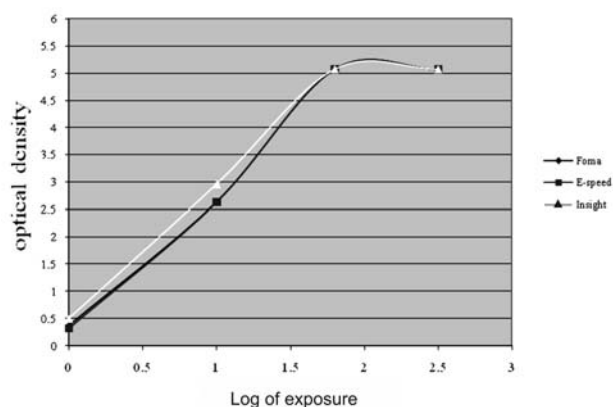


Figure 2 - Characteristic curves of Dentix E<sup>TM</sup>, E-speed<sup>TM</sup>, and Insight<sup>TM</sup> films, manually processed with Prograd liquid

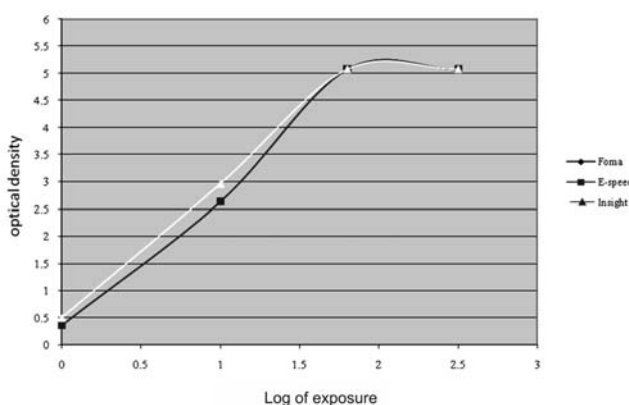


Figure 3 - Characteristic curves of Dentix E<sup>TM</sup>, E-speed<sup>TM</sup>, and Insight<sup>TM</sup> films, manually processed with Kodak liquid

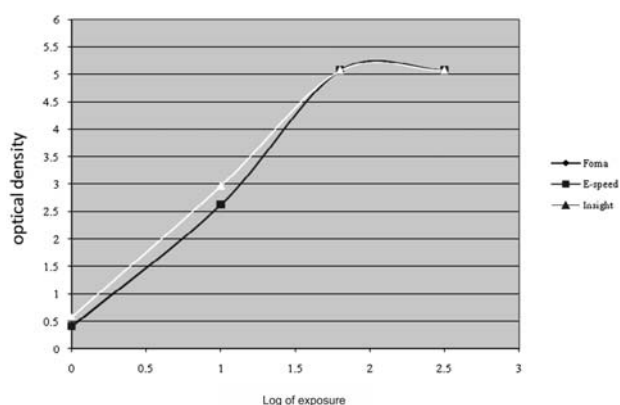


Figure 4 - Characteristic curves of Dentix E<sup>TM</sup>, E-speed<sup>TM</sup>, and Insight<sup>TM</sup> films, automatically processed with Kodak liquid

Table 1 brings the sensitometric property values obtained for Dentix E<sup>TM</sup>, E-speed<sup>TM</sup>, and Insight<sup>TM</sup> films processed under different conditions. Those properties confirm the results from the characteristic curves, where Dentix E<sup>TM</sup> showed sensibility, contrast, and latitude values similar to the values of E-speed<sup>TM</sup> film, regardless of the different processing conditions tested.

Table 1 - Contrast, sensibility, and latitude values for the radiographs obtained with Dentix E<sup>TM</sup>, E-speed<sup>TM</sup>, and Insight<sup>TM</sup> films, processed under different conditions

| Property    | Processing        | Dentix E <sup>TM</sup> | Film E-speed <sup>TM</sup> | F-speed <sup>TM</sup> |
|-------------|-------------------|------------------------|----------------------------|-----------------------|
| Contrast    | Manual / Prograd  | 2.14                   | 2.12                       | 2.50                  |
|             | Manual / Kodak    | 2.11                   | 2.11                       | 2.50                  |
|             | Automatic / Kodak | 2.11                   | 2.12                       | 2.54                  |
| Sensibility | Manual / Prograd  | 0.038                  | 0.040                      | 0.032                 |
|             | Manual / Kodak    | 0.039                  | 0.039                      | 0.032                 |
|             | Automatic / Kodak | 0.038                  | 0.038                      | 0.031                 |
| Latitude    | Manual / Prograd  | 0.45                   | 0.43                       | 0.41                  |
|             | Manual / Kodak    | 0.45                   | 0.45                       | 0.41                  |
|             | Automatic / Kodak | 0.42                   | 0.46                       | 0.42                  |

## Discussion

Diagnostic decision is based on available information regarding the actual condition of patients, and in Radiology that information is obtained from the radiographs. However, one radiograph will only provide the necessary diagnostic information if it presents good image quality. Moreover, radiographs are considered documentation, once they record patients' conditions prior, during, and after dental treatment. A radiograph, in order to present legal value must present good image quality. The process of obtaining radiographs with good image quality depends on a series of factors, such as processing and film type. Those two factors were studied in the present research, which evaluated Dentix E<sup>TM</sup> films using different processing liquids and under different conditions.

According to Dentix E<sup>TM</sup> characteristic curve provided by the manufacturer<sup>13</sup> in the product cata-

log, it should present 0.95 of contrast, 0.140 of indicative value of sensibility, and 0.30 of latitude. Those values of sensitometric properties presented by the manufacturer differ from the values obtained in the present study within all tested processing conditions. The contrast, indicative value of sensibility, and latitude obtained in the present study were superior to the values determined by Foma Bohemia. Although it is pointed out in the catalog that for Dentix E<sup>TM</sup> processing, the use of Prograd liquids is recommended in order to obtain better results and to accept the usage of other brand liquids, there is no information available regarding which liquid they used to build the characteristic curve. The fact that the manufacturer indicates using Prograd liquids to obtain better results agrees with the results from the present study, since Dentix E<sup>TM</sup> film presented similar behavior when processed with either Prograd or Kodak liquids.

Regarding diagnostic capability, Svenson and Petersson<sup>19</sup> (1990), Horner et al.<sup>20</sup> (1995), and Svenson et al.<sup>21</sup> (1997) showed no differences between film E and D-speed, in terms of contrast, lifetime, processing, and accuracy in diagnosis. Films that are more sensitive or faster should always be favored to perform radiographic procedures by minimizing the radiation dose received by patients, thus reducing the radiobiological risks<sup>22</sup>.

In studies of Platin et al.<sup>23</sup> (1999) and Price<sup>24</sup> (1995) film speed is reduced by 40-50% of the radiation dose needed to obtain a radiographic image with the same quality of D-speed films, and the E-speed<sup>TM</sup> film recommended for dental practices.

This research allowed determining that the sensitometric properties of Dentix E<sup>TM</sup> were similar to those presented by E-speed<sup>TM</sup>, and both presented lower contrast, lower indicative value of sensibility, and higher latitude values than F-speed. These results support the findings that Dentix E<sup>TM</sup> presents similar behavior to E sensibility films, confirming the manufacture's information<sup>13</sup>.

## Conclusion

It was observed that the position of Dentix E<sup>TM</sup> characteristic curves and the values of sensitometric properties were similar to E-speed<sup>TM</sup> characteristic curves, regardless of processing. This indicates that Dentix E<sup>TM</sup> film presents contrast, sensibility, and latitude compatible to films classified as E sensibility.

Quality control is justified at any time in carrying out a radiographic examination. Through it, we can reduce the time of patient care and therefore the cost of the exam, and avoid repetitions, which is one way to protect the patient from repeated exposures to radiation. A large number of methods can evaluate the quality of a film. A more objective and detailed representation of the quality of a radiogra-

ph may be obtained from sensitometric parameters such as sensitivity, contrast, and latitude.

## Resumo

*Objetivo: O conhecimento das propriedades de novos filmes radiográficos é de fundamental importância, pois dessa avaliação dependerá o aprendizado sobre esses filmes, implicando diretamente na dose de radiação recebida pelo paciente na execução de exames radiográficos. Assim, o objetivo com este estudo foi avaliar as propriedades sensitométricas do novo filme radiográfico Dentix E®, comparativamente aos filmes E-speed® e Insight®, processado com diferentes líquidos e sob diferentes condições. Métodos: Para tanto, os filmes foram expostos a tempos predeterminados e processados manualmente pelo método temperatura/tempo, com líquidos pronto uso, da Kodak e da Prograd, e automaticamente com líquidos da Kodak. Após, foi mensurada a densidade dessas radiografias e construídas curvas características para a obtenção das propriedades sensitométricas de contraste, valor indicativo de sensibilidade e latitude. Os valores das propriedades foram avaliados pela inclinação das curvas nos gráficos e por estatística descritiva. Resultados: Foi possível observar que o filme Dentix E® mostrou curvas características e propriedades sensitométricas semelhantes ao filme E-speed®, independentemente do processamento. Conclusão: Este resultado indica que o filme Dentix E® apresenta contraste, sensibilidade e latitude compatível com filmes de sensibilidade do grupo E.*

*Palavras-chave: Filmes para raios X. Processamento. Densitometria.*

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**Endereço para correspondência:**

Mateus Ericson Flores  
 Rua Cesario Rosseto, 414  
 99074-210 Passo Fundo-RS  
 Phone/Fax: 55 54 3316 8403  
 E-Mail: mef@upf.br

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