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Development of an object test to dental image verification

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ABSTRACT

An object test was developed to verify the dental images best quality in relation to the exposition time. It consists of high purity perforated aluminum plates, with different thickness and dimensions of 3×4 cm. The plates were covered by acrylic, making its total thickness of 3.0 mm. It was irradiated together with the film from 0.1 to 0.5 s. The irradiation of 0.2 s showed the best image, reducing the regular time exposition by 0.3 s.

1. Introduction

Quality assurance programs in diagnostic radiology have increased in the last years due to the fact that the extensive use of X-rays in medicine for diagnosis of injuries and diseases represents the largest man-made source of public exposure to ionizing radiation (Bushong, 1997). Many international organizations have published documents with radiation protection recommendations, including for dental practice (SEFM, 2002; EC, 2004; NCRP, 2003). The main objective of those publications is to provide methods and procedures for radiation protection in the use of X-rays in order to eliminate unnecessary radiation exposure to patients and to ensure that exposures are within recommended limits and are keeping as low as reasonably achievable (IAEA, 1996). To meet the goals the assessment and control of the image quality is an essential part of a quality assurance program.

The Brazilian Health Ministry Regulation 453, published in June 1998, established basic lines of radiological protection in medical and dental diagnostic radiology, in order to guarantee the health of patients, workers and of the public (Brazilian Health Ministry, 1998). In dental area, one of the recommendations of this regulation is the evaluation of the radiographic image quality by an object test (standard phantom) in relation to contrast, clearness and sensibility. Several studies have been carried out in order to evaluate the performance of radiographic systems through the image quality (Yakomakis et al., 2001; Kunzel et al., 2003; Servomaa, 1993; Doyle and Finney, 2006; Hayakawa et al., 2000).

The objective of this work is the development of an object test in order to verify the best quality of the image in relation to the smaller exposition time in dental diagnostic radiology systems. It would be applied in dental clinics, in order to achieve an improvement in the radiological image qualities and the patient dose reduction.

2. Materials and methods

To simulate a medium tooth high purity aluminum plates ($>99.9\%$), with thickness varying from 0.05 to 1 mm, with the same lateral dimension as the dental X-ray films, 3×4 cm, was used. The plates were overlapped and perforated using a dental engine with holes from 0.05 to 0.7 mm of depth. After that, the plates were covered by an acrylic plate. The perforated plates can be seen in Fig. 1.

The holes diameter was varied from 0.25 to 1.0 mm. The aluminum plates together have 1.5 mm of thickness and were covered by an aluminum plate of 1.5 mm thickness. Its total thickness is 3.0 mm, as can be seen in Fig. 2.

The measurements were carried out in a dental X-rays machine, Dabi Atlante, model Spectro 70X Seletronic. Its characteristics were: 70 kVp of tube voltage, 8 mA of tube current, inherent filtration of 0.51 mmAl, additional filtration of 1.4 mm and focus–film distance of 20 cm.

3. Results

The film characteristic curve describes its optical density (blackening level) as a function of exposure time. In this work this curve was obtained by films irradiated with exposure times from 0.1 to 1.5 s, using the dental 70 kVp X-ray machine described below. They were processed according to manufacturer instructions. The result is shown in Fig. 3. According to this curve the maximum optical density is obtained with 0.5 s of exposure time.

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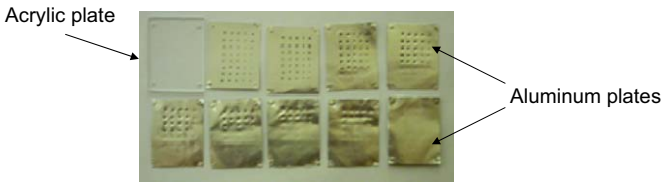

Fig. 1. Acrylic plate, perforated aluminum plates and the aluminum base.

Fig. 2. (a) Acrylic, aluminum and dental X-ray film. (b) Mounted object test.

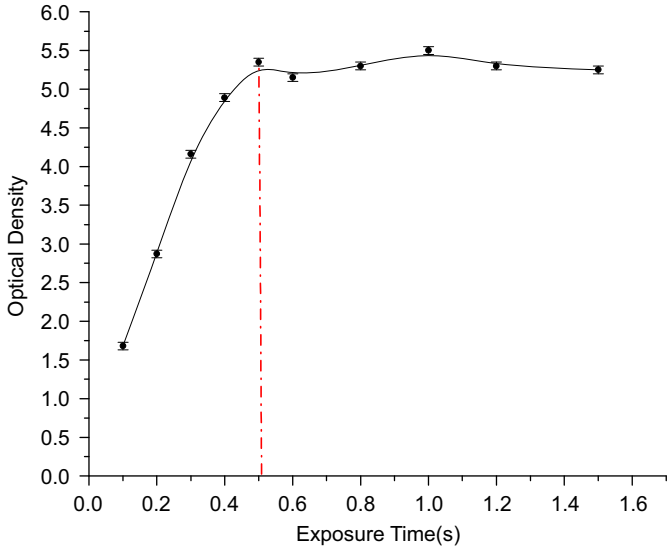

Fig. 3. Kodak Ektaspeed film characteristic curve.

The next step was the irradiation of the object test and the Kodak Ektaspeed film together using the exposure time selected to provide the optical density of the image in the dental X-ray film high contrast range, obtained by its characteristic curve. The exposure time interval was from 0.1 to 0.5 s, using the same dental 70 kVp X-ray machine. To verify the variability, five films were irradiated to each exposure time.

The films were conventionally processed and three observers evaluated them, one oral radiologist and two medical physicists, using a negatoscope. In all cases the films irradiated with 0.2 s showed the highest number of eye observed holes, as can be seen in Fig. 4. The use of this object allowed the reduction of the exposition time from 0.5 s, the maximum value of the linear region of the characteristic curve, to 0.2 s.

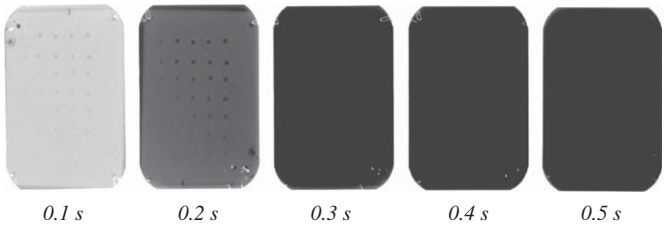

Fig. 4. The object test images to different exposure times.

4. Conclusions

The importance of the quality control in dental diagnostic radiology systems is essential due to the constant use of X radiation in dental clinics. The PF453 recommends the frequency of at least two years for the constancy tests. However, it is suggested that the professional, surgeon-dentist, should be responsible for the internal control of the image quality obtained from the X-rays device. This can be done through periodic exposures of the object test developed in this work.

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