TECHNICAL NOTE

The characteristics of Fuji IP Cassette Type PII and application for radiotherapy quality assurance tests and portal imaging

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Abstract

The advancement of digital imaging has prompted more medical institutions to go filmless. The computed radiography (CR) system is becoming an important tool not only in diagnostic imaging, but also in radiation oncology. A new CR system that was specially designed for the use in radiation oncology, Fuji IP cassette type PII has been introduced to the market in the middle of year 2006. This project aimed to study some basic physical characteristics of this new type of cassette and explore its application for performing quality assurance (QA) tests and portal imaging in radiotherapy. All the images were read by FCR 5000 Plus reader. The image was found to reach its saturation value of 1023 (due to the image was stored in 10 bits data) by depending on the sensitivity value being adjusted. The uniformity test gave the result of 0.12%. The cassette was used to perform the QA tests which are previously performed by using film. All the results met the specification as stated in AAPM Task Group 40. The comparison for the portal images of PortalVision™ contrast-detail phantom showed that the spatial resolution of the images obtained by CR system (Fujifilm Co., Ltd., Tokyo, Japan) were better than the EPID (Varian Medical Systems, Inc., Palo Alto, USA) and film system (Eastman Kodak Co., New York, USA). The IP cassette type PII was found to be suitable as an alternative QA test tool and portal imaging in radiotherapy.

Key words computed radiography, radiation oncology, electronic portal imaging device, imaging plate

Introduction

With the introduction of Picture Archiving and Communication System (PACS) and Radiological Information System (RIS), radiological imaging is becoming filmless. Hardcopy images have been replaced by digital images which are archived in digital storage media such as compact disc, magnetic optic disc, DAT tape etc. The application of computed radiography (CR) system in digital imaging is well established. Transition to filmless technologies offered potential for improved workflow and increased productivity3. It also enables improvement in data storage and management.

Imaging in radiation oncology is going filmless due to the complexity of radiotherapy technique such as Intensity Modulated Radiation Therapy (IMRT) and Image-Guided Radiation Therapy (IGRT) which involve a big number of images. CR systems are currently used for portal imaging2.

The new Fuji IP cassette type PII was introduced for the applications in radiation oncology. This paper aims to investigate some characteristics of the cassette, focused on the sensitivity and uniformity response of this new type of cassette. The authors also explore its application in performing quality assurance (QA) tests and portal imaging in radiotherapy.

Methods and materials

Physical characteristics of Fuji IP Cassette Type PII

The size of the Fuji IP cassette type PII used in this study was 35.4 cm x 43.2 cm. For this type of cassette, a compression plate was added to the back of the cassette to place the imaging plate (IP) in contact with the lead cassette front during exposures. It is possible to stick the imaging plate to the front surface simply with the sliding button which is on cassette back. The compression mechanism was developed to maintain contact between the cassette front and IP during exposure to ensure maximum resolution and contrast. All the images obtained in this study were read by the Fuji Computed Radiography (FCR) 5000 Plus reader.

The sensitivity (S) value is used as the guide that roughly represents relative sensitivity. The Fuji-based
The characteristics of Fuji IP Cassette Type PII

**Figure 1. Calibration curve with pixel intensity versus monitor unit at different sensitivity values.**

The system is calibrated to correspond to a 200 Screen-Film system. For example, an IP irradiated at an exposure of 1 mili Roentgen generates an S value of 200. A very high S value reveals a very low dose to the IP per patient. The correlation between the image pixel intensity values and the monitor unit readings was investigated at different sensitivity values being adjusted on the reader. Five exposures with different monitor unit were made on the same IP. In this test, the field size was set to 10 cm x 10 cm. Image was saved in DICOM format and analyzed using the ImageJ analysis software. The mean pixel value was obtained by selecting the region of interest (ROI). A graph was plotted for the pixel value against the monitor unit for different sensitivity values.

Uniformity test also had been carried out to evaluate the uniformity response of the cassette. The exposure was repeated for eight different positions on the same cassette.

**The use of Fuji IP Cassette Type PII for QA tests**

To check the isocentre for gantry, couch and collimator, all the procedures to obtain the images by using CR were similar to those using conventional film. The procedures were mentioned in Khan. By using Osiris 4 (University Hospital of Geneva, Switzerland) software, lines were drawn through the middle of the slit images to define more clearly the intersection point of the slit images. To check the coincidence between the light field and radiation field, a square light field size (15 cm x 15 cm) was indicated by placing four coins at each of the four edge of the light field. The IP was exposed with 1 MU. The Osiris 4 software was used to measure the alignment between the x-ray beam edges and the light beam marks.

**Qualitative assessment of portal image quality**

In this study, a PortalVision™ (Varian Medical Systems, Inc., Palo Alto, USA) contrast-detail phantom was used. It is an aluminium block with holes of various depths and diameters. Visualizing a certain hole implies a specific resolution for a given linear accelerator beam.

The portal images obtained were inspected visually by ten observers to identify the smallest circles that can be visualized. The observers consisted of radiation therapists and physicists who were familiar with the portal images. For the images obtained by using liquid chamber array EPID (Varian Medical Systems, Inc., Palo Alto, USA) and CR, observers were requested to adjust the contrast level of the portal images on the monitor screen to their satisfaction level. For the portal films (Eastman Kodak Co., New York, USA), observers observed the images at the view box to identify the smallest circles that can be visualized. During the observations, film masking is essential for preserving the perceived radiographic contrast. The ambient light intensity in the reading room should be low to eliminate the reflections from the film and to improve the perceived radiographic contrast. A form was prepared for data collection purposes as shown in Appendix A.

Besides using the PortalVision™ contrast-detail phantom, a clinical testing was performed to obtain images in order to compare the images obtained by using EPID with those obtained by using Fuji IP cassette Type PII. A patient with Nasopharyngeal Carcinoma (NPC) was exposed before the treatment to obtain portal images by using Fuji IP cassette type PII and EPID (Varian Medical Systems, Inc., Palo Alto, USA). Two views were obtained, which were the lateral and anterior posterior (AP). An observation study was conducted to compare the clinical efficacy of CR versus EPID. Eight landmarks were selected as typically used by radiation oncologists for portal verification. The ratings were classified in six grades, i.e.: insufficient (1), deficient (2), adequate (3), satisfactory (4), good (5) and very good (6).

**Results and discussion**

**Physical characteristics of Fuji IP Cassette Type PII**

For the sensitivity response, Figure 1 showed that image will reach its saturation value of 1023 (due to image
The characteristics of Fuji IP Cassette Type PII

Diameter of the minimal visible hole (mm) versus Object Contrast (%) for
6MV Photon Beam

![Graph showing the relationship between diameter of minimal visible hole and object contrast for 6MV photon beam.](image)

**Figure 2. Low-contrast spatial resolution of the three imaging systems for photon energies of 6 MV obtained by exposing the PortalVision™ contrast-detail phantom.**

was stored in 10 bits data) by depending on the sensitivity value being adjusted. Based on the data collected, the IP cassette was ideally to be used for lower dose exposure up to 10 cGy by applying the lower sensitivity value.

For uniformity test, ImageJ (Watne Rasband, National Institute of Health, USA) software was used to obtain the pixel value for region of interest. The mean pixel value for each of the eight exposed region was obtained by using the equation as stated by Zullo et al:

\[
\text{Uniformity} = \frac{(\text{Maximum value} - \text{Minimum value})}{\text{Average value}}
\]

The overall uniformity response of the cassette was found to be 0.12%. The uniformity for each exposed region was also calculated by using the same equation. The maximum, minimum and average pixel values were that measured in that particular region of interest (ROI). The uniformity response for each ROI had been found to be in the range of 0.06% to 0.09%. From the results, it was evident that the imaging plate had a good uniformity response with the Fuji IP cassette type PII.

**The use of Fuji IP Cassette Type PII for QA tests**

For the radiation isocentre checking of gantry, couch and collimator, the diameter of the intersection points was in the range of 1.12 - 1.13 mm. In light and radiation field coincidence test, the deviations between the light field and radiation field were all within 2 mm. The results met the required acceptable specification of the Task Group 40. Thus, it is feasible to use CR for all functions that are typically done with conventional films in radiotherapy. The film imaging is time consuming and labour intensive. It can only be handled in the dark room and chemical development is needed. But, the IP can be loaded in day light with no development needed. Besides, the plates are reusable and it is cheaper for long term consideration in performing QA tests.

**Qualitative assessment of portal image quality**

Based on the three phantom images per beam energy and per imaging system, the most frequent value of the smallest certainly recognizable diameter of a hole was determined for all depths of the holes.

For 6 MV photon beam, the results were shown in Figure 2. It showed that the CR system had the highest low-contrast spatial resolution when evaluated by the images of the contrast-detail phantom. The images obtained by using EPID and Kodak EC-L film showed a slightly lower low-contrast spatial resolution than the CR system. The visibility of the holes differed maximally by only one diameter value.

For 10 MV photon beam, the results were shown in Figure 3. CR system also showed the highest low-contrast spatial resolution when evaluated by the images of the contrast-detail phantom. The images obtained by using EPID and Kodak EC-L film showed an identical resolution but slightly lower than the CR system. The visibility of the holes differed maximally by only one diameter value.

The visible circles for portal image obtained using CR for 6 MV was up to 1 mm which represents contrast value of 1.75%. For 10 MV photon beam, the visible circles was also up to 1 mm but with the contrast value of 1.33%. Higher photon beam tends to reduce the object contrast. Scattering photon will affect the visibility of small objects (1mm) but does not affect much on the visibility of large objects (15 mm). The results showed that CR system is a possible alternative to EPID and Kodak EC-L film.

For the clinical testing, the images of the head and neck from the lateral and AP view were shown in Figure 4. Both the right images were obtained by using EPID while the left images were obtained by using CR. The mean score for the eight landmarks of subjective visual image quality which directly compares the two different types of portal images is shown in Figure 5. In general, the anatomical landmarks were more easily visible in the processed CR images if compared with those obtained by using EPID.
The characteristics of Fuji IP Cassette Type PII

Figure 3. Low-contrast spatial resolution of the three imaging systems for photon energies of 10 MV obtained by exposing the PortalVision™ contrast-detail phantom.

Figure 4. Top row showing lateral view of post-nasal cavity portal images as taken by (a) CR and (b) EPID. Bottom row showing anterior view of post-nasal cavity portal images as taken by (c) CR and (d) EPID.

Conclusions

The Fuji IP cassette type PII showed promising results in the preliminary tests carried out in this study. This type of cassette has been designed for more practical use in radiation oncology. It gave good uniformity responses which enabled suitable applications such as QA tests and portal imaging. The QA tests performed by using this new
The characteristics of Fuji IP Cassette Type PII

Mean Ratings for Anatomical Landmark Visibility

<table>
<thead>
<tr>
<th>Anatomical Landmarks</th>
<th>Rating Score</th>
<th>CR</th>
<th>EPID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bones of the skull</td>
<td>5.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base of the skull</td>
<td>4.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sella Turcica</td>
<td>3.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft palate</td>
<td>3.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard palate</td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandible</td>
<td>2.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxillary Sinus</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sinus</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 5.** Mean ratings for the different landmarks of subjective visual image quality (mean ± 1 standard deviation).

The qualitative assessment for the portal image quality showed that the images obtained using this type of cassette had the highest low-contrast spatial resolution compared with those images obtained using EPID and Kodak EC-L film. The advantages of digital image enabled integration of the CR system into a hospital wide computer network.

**Acknowledgements**

We would like to thank Fujifilm (M) Sdn. Bhd. for providing the Fuji IP cassette type PII used in this study.

**Appendix A**

Observation form for Low-Contrast Resolution Test of PortalVision™ Contrast-Detail Phantom

Date: ______________

Modality: CR / EPID / EC-L Film

Instruction: Please kindly help to mark the visible circles with a cross.

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**References**