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Evaluation of application of EPID for rapid QC testing of linear accelerator

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ABSTRACT

Aim: Evaluation of application of EPID for rapid QC testing of linear accelerator.
Background: Quality control of a linear accelerator device is a time and energy intensive process. In this study, attempts have been made to perform the linear accelerator quality control using electronic portal imaging device (EPID), which is mounted on most accelerators.
Materials and methods: First, quality control and dosimetry parameters of the device were determined and measured based on standard protocols to ensure full calibration of the accelerator. Then, various features of EPID including spatial resolution and contrast resolution, the effect of buildup region, dose response and image uniformity were evaluated. In the next step, consistent with the parameters of linear accelerator quality control including field size, field flatness and symmetry, the light field coincidence with X-ray field, mechanical stability and multileaf collimator position accuracy test, the output images of device were obtained.

After feeding images to the MATLAB software, their pixel content was analyzed. All measurements of the three photon beams were repeated three times.
Results: The EPID image had a desirable resolution, contrast and uniformity and displayed high sensitivity to dose changes with linear dose response. Seven qualitative parameters of the linear accelerator were then controlled by EPID.
Conclusions: The results of the linear accelerator quality control using the EPID were consistent with practice. Quality control using the EPID was more convenient and faster than conventional methods.

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1. Background

Radiation therapy is a multistep process. To ensure treatment quality and accurate dose delivery, each step has its unique standards and quality control programs. One of the equipment used to enhance the precision of the treatment is EPID which is composed of a two-dimensional array of small dosimeters that are capable of acquiring images of megavoltage radiation beams. The system output is a digital image of DICOM format and its pixel content can be analyzed. The main application of these systems is to control the position of the patient and the treatment area prior to radiation therapy by means of imaging and comparing images with the reference digital reconstructed radiograph image (DRR).[1]

In recent years, the utilization of EPID images to perform quality control test for linear accelerator devices,[2,3] evaluate the performance of multileaf collimator[4,5] and dose distribution in the treatment area[6,7] have been investigated in a growing number of studies.

2. Aim

Since quality control tests and dosimetry of linear accelerator devices based on standard protocols, such as AAPM (TG 51) protocol,[8] is time consuming and requires prolonged exposure time and use of special equipment, such as a water phantom and various dosimeters, this study was designed to explore the application of EPID for rapid quality control testing of accelerators.

3. Materials and methods

In this study, Elekta linear accelerator (Precise model) was used. The device is equipped with multileaf collimators consisting of 80 leaves (the leaf width in the isocenter is 1 cm) and electronic portal imaging device. In the photon mode, there are three energy (8, 10 and 15 MV) and in the electron mode there are five energy (6, 8, 10, 15 and 18 MeV) states. The linear accelerator calibration was performed according to AAPM (TG-51) protocol.[8]

Distance between the source and the detector was fixed (157 cm). The light sensitive layer had 1024×1024 pixels with a pixel size of $0.4 \times 0.4\,mm^2$. Thus, the EPID size was $409.6 \times 409.6\,mm^2$. Each pixel was 0.25 mm in isocenter with a maximum imaging field of $25.9 \times 25.9\,cm^2$ in the isocenter. In this paper, all measurements except for dose linearity test, were performed at 10 MU with a dose rate of 400 MU/min. Before any measurement, equipment was calibrated to increase the accuracy of calculations and allows comparison of measurements. To confirm the reproducibility, each measurement was repeated 3 times. Images were analyzed in MATLAB software (Ver 2014Ra) using image processing toolbox to implement M-file functions and then graphical user interface toolbox to facilitate quality control testing.

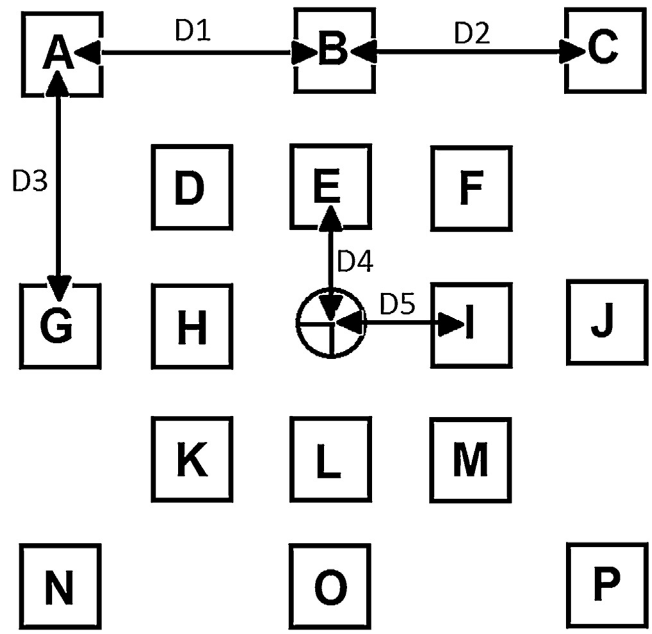

Fig. 1 – The selected area to check uniformity.

3.1. *Image quality*

To determine the spatial resolution and contrast resolution, the Las Vegas Phantom was placed on the treatment table and the irradiation was performed at SSD = 100 cm and field size = $15 \times 15\,cm^2$. The quality of the images was evaluated according to AAPM TG-58.[9] This process was carried out for all three photon energies.

3.2. *Dose linearity*

Dose linearity of linear accelerator was verified using scanditronix wellhofer dosimetry system including water phantom and Farmer ion chamber. To check the dose response linearity of EPID, images were captured in an open field of $10 \times 10\,cm^2$ with monitor units of 10, 20, 50, 100 and 150 at dose rates of 200 MU/min and 400 MU/min. The average value of pixels in a 40×40 pixel square at the center of each image was obtained. Pixel value versus MU was plotted. This test was conducted for 6, 10 and 15 MV energies as well.

3.3. *Pixel uniformity response*

EPID system calibrates images using Flood Field (FF) and Dark Field (DF) images. This removes the off axis effect and bad pixels and produces image uniformity. However, it is necessary to evaluate the image uniformity. For this purpose, using the method proposed by Kavuma et al.,[10] images with a field size of $20 \times 20\,cm^2$ were prepared for three photon energies of 6, 10 and 15 MV. According to Fig. 1, in 16 regions and center of the image, squares with a pixel size of 40×40 were selected and then a comparison was drawn between average pixel count in all 16 regions and average pixel count at the center. D1_D2 and D3_D4 distances were 7 cm and D4_D5 were 4 cm.