IMPLEMENTATION OF PORTAL DOSIMETRY WITH AN AMORPHOUS SILICON EPID

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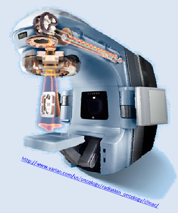
Introduction

Electronic portal imaging devices (EPIDs) were originally developed for the purpose of patient setup verification over a protracted course of radiation therapy. Recently, the use of EPID has been expanded as a useful tool for radiotherapy dosimetry and periodic quality assurance (QA) of the linear accelerator. The interest in electronic portal imaging devices (EPIDs) dosimetry has been accelerated due to its ability to acquire a large two-dimensional array of digitized x-ray data in real-time with a high resolution. Compared with conventional QA methods EPIDs have the advantages of reducing both costs and setup time.



Purpose

The first aim of the present study was to investigate the EPID performance in terms of image quality based on contrast resolution, spatial resolution, uniformity, noise and contrast to noise ratio (CNR). Also the dosimetric characteristics of the detector, such as linearity with MU and dose rate, and field size dependence were investigated.

Materials and Methods

The EPID used in this study is a commercial available amorphous silicon (aSI) imaging device (aS500, Varian Medical Systems), mounted on a Clinac 2100 c/D (photon energies of 6 and 15MV).
The EPID system consists of an image detector unit (IDU), image acquisition system (ISA2) and PortalVision workstation.
EPID characteristics: 512 x 384 pixels; 0,784 mm absolute spatial resolution ; 40 x 30 cm^2 active imaging area.

EPID Characterization

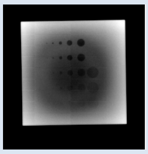
Images acquired for the EPID characterization resulted from the irradiation with 6 and 15MV photon energies, 300 MU/minute dose rate and high quality acquisition mode. EPID was set at 100 cm source EPID distance (SED). A total of 10 images were used for each test and the mean value recorded.

Contrast Resolution

A contrast detail aluminium phantom with holes of depths 0.25, 0.50, 1.0, 2.0 and 3.0 mm arranged in 5 rows provided by Varian was used. The phantom was placed directly on the top of the plastic house. The contrast resolution was found using the equation:

$$CR(\%) = 100 \cdot \frac{I_o - I_b}{I_o + I_b}$$

where I_o is the intensity of the object (hole) and I_b the intensity of the background.



Uniformity

Images of an open field were taken. The uniformity was given as the highest mean value of pixels for the 4 quadrants and the central area of the image relatively to the whole image.

Noise

Images of an open field were taken. Noise was assessed by the determination of the variance of the intensity in a ROI of the whole image.

Contrast to Noise Ratio

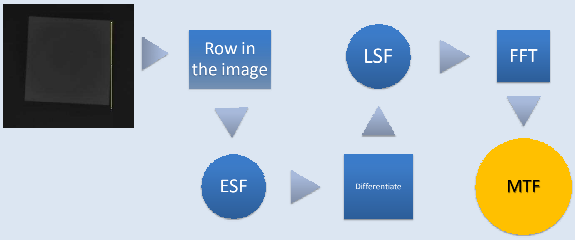
A metallic object placed on EPID surface was used. The CNR was defined by the equation:

$$CNR = \frac{I_o - I_b}{\sigma_b}$$

where I_o is the intensity of the object, I_b the intensity of the background and σ_b the standard deviation of the background.

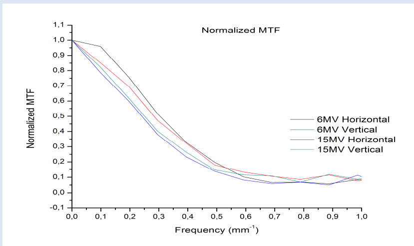
Spatial Resolution

The edge spread function (ESF) of a solid metallic block image placed directly on EPID surface and tilted 3° to detector axis was measured. In order to reduce noise, a total of 10 rows were chosen from each image and displaced to give the mean value of ESF. The ESF was differentiated with a kernel (-0.5 0 0.5). The resulting line spread function (LSF) was Fourier transformed resulting in the modulation transfer function (MTF). The f_{50} parameter was defined as the resolution (mm^{-1}) at 50% of the normalized MTF (horizontal and vertical), quantifying the resolution of the system.



Results

Contrast Resolution		
	Object Contrast (%)	
Hole depth (mm)	6MV	15MV
3	1.36 ± 0.05	0.90 ± 0.04
2	0.83 ± 0.03	0.60 ± 0.03
1	0.45 ±0.03	0.28 ± 0.02
0.5	0.21 ±0.04	0.14 ± 0.03
0.25	0.12 ± 0.06	0.11 ± 0.05



Spatial Resolution		
	f_{50} (mm^{-1})	
	6MV	15MV
Horizontal	0.303 ± 0.006	0.240 ± 0.009
Vertical	0.282 ± 0.009	0.248 ± 0.013

	Uniformity (%)	Noise	CNR
6MV	0.45 ± 0.10	162.2 ± 10.15	7.11 ± 1.40
15MV	0.16 ± 0.09	46.66 ± 13.18	2.15 ± 0.79

Dosimetric Characteristics

Measurements were performed with both 6 and 15MV photons energy, a constant dose rate of 300MU/minute and integrated acquisition mode. No extra buildup was added for the EPID measurements. The pixels values at the center of the field in a 9x9 pixel region were recorded and multiplied by the number of frames acquired for each image. Measurements were also performed with an ionization chamber (PTW, type 31010, 0.125 cm^3) in a solid water phantom at 8 mm depth for comparison.

Linearity with MU

To evaluate the dose response the portal cassette was irradiated with 3 field sizes: 3x3 cm^2, 10x10 cm^2, 25x25 cm^2 with monitor units (MU) ranging from 3 to 500 MU. EPID was set at 100cm SED.

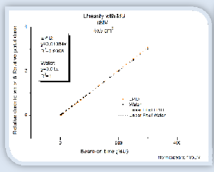
Dose rate linearity

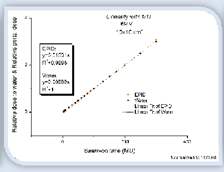
To modify the dose rate the SED was varied by varying the distances below the isocentre from 100 to 150 cm SED. At each distance a dose of 100 MU was delivered to a 10x10 cm^2 open field.

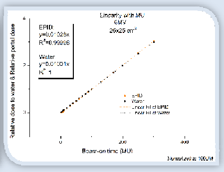
Field size dependence

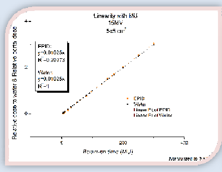
The field size dependence of the detector was assessed for field sizes ranging from 3x3 to 25x25 cm^2. The EPID was set at 100cm SED. A dose of 100 MU was delivered.

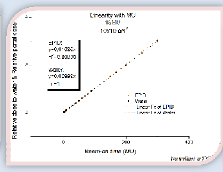
Results

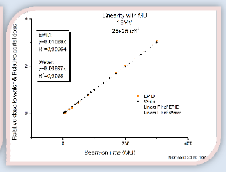


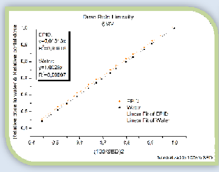


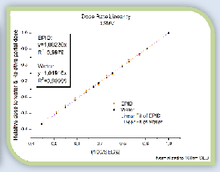




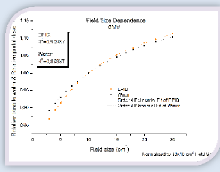


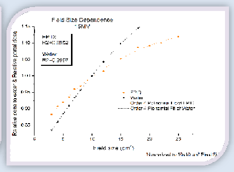






Dose rate linearity results are consistent with the ionization chamber measurements with a maximum deviation of 3.7% in the 6MV energy and 2.2% in the 15MV energy for the SED of 140 cm.





Field size dependence results are consistent with the ionization chamber measurements with a maximum deviation of 2.7% in the 6MV energy for the 3x3 cm^2 field and 8.4% in the 15MV energy for the 25x25 cm^2 field.

Conclusions

Results regarding the contrast resolution and the spatial resolution are low comparing with literature although they are consistent in that higher energy deliveries yield worse imaging results (with the exception for the uniformity and noise tests). The mean values and standard deviation resulting from this study will serve as bases to the implementation of a quality control tool to evaluate variation in EPID over time. The signal response is linear with exposure time and inverse square law behavior, and proportional to open field size. Although behavior of the EPID is not equivalent to a dose to water measurement is consistent and reproducible. For future work the use of EPID for linac specific quality assurance will be studied, e.g., monitoring leaf calibration and wedge factors, beam flatness and symmetry measurements, verifying jaws calibration, light and radiation fields coincidence, and radiation isocentre starspot test.

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