QUALITY CONTROL OF MEGA VOLTAGE PORTAL IMAGING SYSTEM

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INTRODUCTION

The Electronic Portal Imaging Device (EPID) is a system used to verify either the correct positioning of the patient during radiotherapy treatment or the linear accelerator beam parameters. The correct position of the patient corresponds to the position at which the patient was scanned at the CT simulator and according to which the therapy plan was made and optimized. Regarding this, besides the advanced treatment planning system and optimized treatment planning techniques [1], the day-to-day reproduction of simulated conditions is of great importance for the treatment outcome. Therefore, to verify the patient set-up portal imaging should be applied [2] prior to the first treatment session and repeated according to treatment prescriptions during the treatment.

In order to achieve full functionality and precision of the EPID, it must be included in radiotherapy Quality Control (QC) programme. Regarding this, a set of procedures dealing with different parameters of the system should be defined and periodically performed. Also, the treatment conditions should be simulated using anthropomorphic phantoms and dose distributions for particular EPID protocols should be measured.

Procedures for quality control of the portal imaging system developed and implemented at University Hospital (UH) Rijeka will be presented in this paper.

MATERIALS AND METHODS

The University Hospital Rijeka is equipped with two Siemens linear accelerators, the Oncor Expression and the Oncor Impression, that have Mega Voltage EPID Siemens Optivue 1640-S (matrix size 1024 × 1024) and 1640-M (matrix size 512 × 512), respectively. Both flat panel detectors are fabricated using thin film technology based on amorphous silicon on glass panels.

The Oncor Expression linear accelerator has the possibility of acquiring both 2D and 3D images of the patient, while the Oncor Impression can give only 2D information. The classical portal imaging system generates planar images that can be compared with reference images acquired via digitally reconstructed radiographs (DRR). At our department it is used to acquire two orthogonal portal images that allow verification and correction of the patient position. EPID with Mega Voltage Cone Beam Computed Tomography (MV CBCT) module has ability to acquire a set of 2D projection images made in a gantry angle range from 270 to 110 degree that are used to compute a 3D imaging volume of the patient that is going to be compared with the scans acquired at the CT simulator. Regarding this the MV CBCT module can improve patient positioning accuracy by using a 3D space.

The QC of the portal imaging system was separated in two parts. In the first, the QC of the detector parameters should be performed using tools which are regularly used in performance of periodic QC routines at UH Rijeka [3]. Tests include flat panel alignment QC, analysis of electronic portal imaging device parameters and light/radiation field alignment. At the beginning, the alignment of radiation field and EPID centres should be verified using images with a reticle with for the radiation non-transparent crosshairs. The evaluation could be performed using programme packages for image analysis.

The QC3 test phantom should be used to check detector parameters, along with the Portal Image Processing System program (PIPSpro) package for data analysis. The results show the relative modulation transfer function (RMTF) for the images, the Contrast to Noise Ratio (CNR) and the Noise value. Resolution is evaluated comparing frequencies at 50 %, 40 % and 30 % of the RMTF with the frequencies of the MTF obtained using the analytical edge spread function technique. The analysis of light and radiation field alignment using EPID is performed with the FC2 phantoms [4]. The results show the radiation/light field displacement value in both x and y directions as well as the detected x and y sizes of radiation field.

The second part of the QC of the linear accelerator's portal imaging system should include the QC of the MV CBCT. For this purpose two different phantoms should be used, one for the geometry calibration and the other for the image quality evaluation [5]. Projection images of the phantom were acquired and used to compute projection matrices that map the 3D imaging volume to the 2D flat panel imager plane. The MV CBCT image

QC aimed at the evaluation of the spatial resolution and low contrast resolution, noise and artefacts should be performed using the Image Quality (IQ) phantom. Spatial resolution and low contrast sensitivity was checked with 3 different MV CBCT acquisition protocols: Cone Beam 8MU, 15 MU and 60MU.

The QC protocol of the portal imaging system should include procedures to control EPID performance in treatment conditions. For this purpose two anthropomorphic phantoms CIRS Thorax and CIRS Head&Neck (CIRS Inc., Norfolk, VA) should be used (Figure 1). The phantoms have a body made of plastic water, with appropriate inhomogeneities. A single beam plan should be made separately for every phantom and both 8MU classical portal imaging acquisition and CBCT with scans at 8MU, 15MU and 60MU should be used. Doses should be measured in 7 points inside the CIRC Thorax phantom, and in 5 points inside the CIRS H&N using the Farmer ionization chamber.

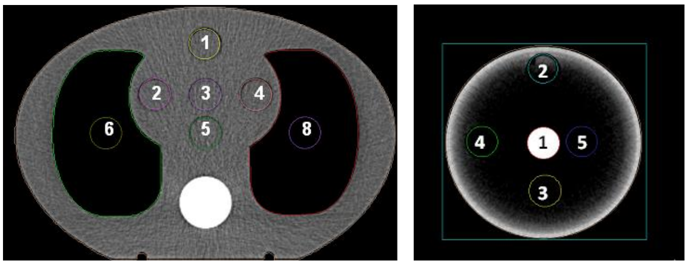

Figure 1: CIRS Thorax phantom and CIRS Head&Neck phantom.

RESULTS

The portal image alignment has been checked inspecting images using the Coherence Therapist tools (tolerance: ±1 mm). Measurements of field size for both flat panels have shown agreement inside 1 mm, while radiation/light field displacement has not been larger than 1 mm. The detector parameters results for both flat panels have been compared. The results are shown in Table 1. Caution and reject levels for CNR and f50 are values suggested by the manufacturer.

A set of predefined manufacturers' tests has been done to check the geometry correctness and the image quality of the reconstructed images of the MV CBCT. All results are within acceptance criteria. It is interesting to notice that the geometry calibration can also be completed successfully when the phantom is not correctly positioned. Changing position in longitudinal or lateral direction separately, no error is detected. Only in cases when both coordinates were changed geometry calibration failed.

Table 1. Detector parameters results for both flat panel detectors of UH Rijeka.

For 6 MV Acquisition	Siemens Optivue 1640-S			Siemens Optivue 1640-M		
	Result	Caution Level	Reject Level	Result	Caution Level	Reject Level
Contrast/Noise	776.2	380	360	817	740	720
f50 level	0.47	0.42	0.41	0.41	0.34	0.33

Spatial resolution and low contrast results show minor differences in the image quality between 8MU and 15MU CBCT protocols, while the 60MU CBCT protocol gives better images but with a significant dose increase.

At the end, treatment conditions have been simulated and the dose has been measured inside two anthropomorphic phantoms using classical portal imaging 2D acquisition and different CBCT protocols. Dose values for 8MU PI 2D acquisition are 8.1 cGy in point 5 of CIRS Thorax and 6.5 cGy in point 1 of CIRS H&N. CBCT results of measured dose in CIRS Thorax phantom and in CIRS Head&Neck phantom are presented in Table 2.

Table 2. Measured dose in anthropomorphic phantoms.

CIRS Thorax	**Dose** / cGy						
	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 8
CB 15 MU	15.8	13.91	13.75	14.35	12.93	13.61	14.35
CB 60 MU	62.10	53.49	54.04	56.40	50.82	53.49	56.40
CB 8 MU	9.78	8.61	8.51	8.88	8.0	8.42	8.88

CIRS H&N	**Dose** / cGy				
	Point 1	Point 2	Point 3	Point 4	Point 5
CB 15 MU	13.9	16.5	13.0	14.0	15.1
CB 60 MU	54.7	64.93	51.16	55.09	59.42
CB 8 MU	7.47	8.87	6.99	7.52	8.11

Results for CBCT scans show expected dose value because of the arc mode used in CBCT. The dose measurements and IQ results should be considered in deciding which CBCT protocol have to be used and what CBCT frequency for patient set-up verification have to be applied. Also minor dose differences between 2D protocol and low MU 3D protocol suggested that even in cases where the strict dose volume constraints should be fulfilled 3D verification could be performed. The results obtained at the UH Rijeka suggested that the CBCT 8MU protocol is a good compromise between image quality and dose released.

CONCLUSION

The Portal Imaging system is of great importance to verify the correct positioning of the patient during radiotherapy treatment. QC of the EPID is essential to ensure the functionality of the system and to reduce set-up uncertainties and errors [2]. The understanding of the EPID properties and limitations is necessary to know what are EPID possibilities.

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