PhD Thesis Title: In-vivo dosimetry in Radiotherapy employing an Electronic Portal Imaging Device (EPID)

Author:	Jaime Martínez Ortega
Email:	jaime.martinez@salud.madrid.org
Institution:	Universidad de Alcalá. **Madrid. Spain**
Supervisor:	Luis Núñez Martín/Rocío Sánchez Montero
Graduation Date:	December 13, 2017
Available online:	n/a

ABSTRACT:

Pre-treatment verification is a common procedure in highly complex radiotherapy treatments, such as Intensity Modulated Radiation Therapy (IMRT). On the contrary, in-vivo dosimetry consists of recording the dose during the treatment delivery. Modern accelerators include different imaging devices to verify the patient setup, according to the simulation images. One of these devices is the Electronic Portal Imaging Device (EPID), which has been used by many scientists for dosimetry purposes, both pre-treatment and for in-vivo dosimetry.

The objective of this work is to improve a previously developed pre-treatment portal dosimetry method and, on the other hand, develop a transit portal dosimetry procedure, applicable to in-vivo portal dosimetry. These methods are based on the use of a collapse-cone dose calculation algorithm from a commercial treatment planning system. The clinical energy model has not been modified for portal dosimetry purposes.

The pre-treatment portal dosimetry procedure is based on the Computed Tomography (CT) images of the EPID Varian aS1000 (Varian Medical Systems, Palo Alto, CA), which was unmounted from the arm support of the linac (Varian Clinac 21-EX) and carried to the Toshiba Aquilion LB CT simulator (Toshiba Medical Systems, Japan). These images were exported to Pinnacle^3 v8.0m (Philips Medical Systems, Fitchburg, WI) as a quality assurance phantom. Dosimetric corrections for output factors and arm backscattering were performed by means of a Matlab code. The energy model of the planning system for the used energy of 6 MV was not modified for dose calculations. Thus, we used the same model for portal dose prediction and for patient dose calculations. Eight different patient treatment plans with IMRT sliding-window were calculated. Five of them, corresponded to prostate cases, and the other three to high-modulated fields (two head and neck, and one gynecological cases). These treatment plans were also measured with the ionization chamber array MatriXX (IBA Dosimetry, Sweden) to discard accidental coincidences between portal dose and measurement errors.

Based on the CT images information, a virtual phantom of several densities was contoured and placed on the CT simulation images. The required dosimetric corrections (for the air-gap between the couch and the EPID, phantom thickness and heterogeneity correction) were obtained by means of experimental measurements and implemented into a Matlab code. An anthropomorphic Rando-Alderson phantom was used for the validation of the method. The virtual phantom was placed at a distance of 140 cm from the isocenter, at the back of the anthropomorphic phantom. The method was evaluated for cranial, thorax and pelvic locations

for anterior-posterior field sizes of 5x5 cm^2, 10x10 cm^2, 15×15 cm^2, 20×20 cm^2 and 25×25 cm^2, and a prostate IMRT plan.

The quality of both methods was evaluated with the gamma index (OmniPro ImRT, IBA Dosimetry), obtaining values of the order of 98% for γ (3%, 3 mm) in pre-treatment dosimetry for dynamic IMRT treatments. The results were contrasted against the measurements provided by MatriXX, obtaining similar results. For transit dosimetry, the percentage of 95% can be established for γ (5%, 3 mm) as a value below which the origin of the discrepancies should be investigated.

Both the pre-treatment and the transit methods developed can be easily implemented into the clinic, as no additional modeling of the clinical energy in the planning system is necessary. The main advantage is that portal dose prediction is calculated with the same algorithm and energy model as used for patient dose distribution calculation.

When applied to in-vivo dosimetry (with real patients), and from the results obtained, this method constitutes a complementary system of quality control. In-vivo dosimetry allows to detect an incorrect administration of the treatment, due to factors that are not taken into consideration in clinical dosimetry, such as the presence of elements absent in the simulation or the selection of a wrong immobilizer.

Future research is needed to improve accuracy, automate the collection of data from in-vivo dosimetry and incorporate them into the patient's clinical documentation for retrospective evaluation. The results for treatments of lesions under respiratory motion should also be evaluated. The procedure presented here should also be studied for flattening-filter free energies.

Keywords:

Radiation Therapy, Medical Physics, EPID, Portal dosimetry, in-vivo dosimetry

References to author publications that relate specifically to the dissertation:

1. **J. Martínez Ortega**, N. Gómez González, P. Castro Tejero, *et al.*, A Portal Dosimetry Dose Prediction Method Based On Collapsed-Cone Algorithm Using The Clinical Beam Model, Med. Phys. **44**(1), 333–341 (2017).
2. **J. Martínez Ortega**, N. Gómez González, P. Castro Tejero, *et al.*, EP-1496: A portal dosimetry dose prediction method based on CT images of Electronical Portal Imaging Device, Radiother. Oncol. **123**, S802 (2017).
3. **J. Martínez Ortega**, M. Pinto Monedero, N. Gómez González, *et al.,* A collapsed-cone based transit EPID dosimetry method, Phys. Med. **46**, 75-80 (2018).