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Original research article

EPID-based daily verification of reproducibility of patients' irradiation with IMRT plans

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ARTICLE INFO

Article history:
Received 23 August 2017
Accepted 5 May 2018

Keywords:
EPID
Fluency map
Treatment repeatability
IMRT

ABSTRACT

Aim: The aim of the work was to catch potential errors with daily EPID measurements of repeatability of the dose distribution during irradiation of IMRT patients.
Materials and methods: In the first stage, measurements were made using an anthropomorphic phantom in which the method of collecting data with an EPID device and the possibility of detecting errors in positioning were developed. Next, for 23 patients, the pelvis (P) and head and neck (H&N) regions, images were collected with an EPID device for each IMRT subfield daily and compared to reference images using the gamma method (DTA 3 mm, DD 3%). Finally, the dependencies between treatment plan parameters, pre-verification results and repeatability of collected images were evaluated.
Results: The anthropomorphic phantom study has shown what kind of effects we can expect with EPID measured at potential shifts during radiotherapy. For the clinical case, score results were obtained for individual tumor regions as below: (P) 0.786 ± 1.046, (H&N) 0.720 ± 1.552. For most evaluated cases, score values were below 1%: (P) 75.5% and (H&N) 83.9% of analyzed fields. 95% of all evaluated data was with the score below: (P) 2.86% and (H&N) 3.40%. The relationship between the results of the analysis of daily collected images and the results of pre-verification, field size and irradiation time was shown.
Conclusions: The EPID-based daily verification can provide extra information about day-to-day repeatability of treatment, without additional dose.

1. Introduction

The dynamic techniques, such as IMRT (intensity modulated radiotherapy) and VMAT, have become very popular in the clinical routine of radiotherapy in recent years. This can offer substantial benefits to the patient, both in terms of better dose distribution in the target volume and improved sparing of the surrounding normal tissues and critical organs.[7–9] Since these techniques are much more complex than conventional open-field 3DCRT (3D conformal radiotherapy), more advanced and precise quality control of treatment should be implemented.[1–3]

In present clinical procedures, the pre-treatment dosimetry verification of IMRT plan is used at the hospital as

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https://doi.org/10.1016/j.rpor.2018.05.003
1507-1367/

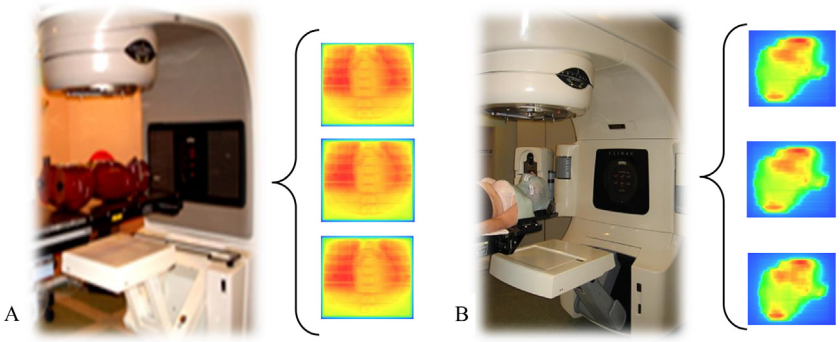

Fig. 1 – The picture of principle of (A) phantom measurement (B) daily measurement and examples of collected fluency map using an EPID.

a standard for dynamic techniques before treatment and patient's geometric verification (MV, OBI: kV, CBCT) is also performed.[4] QA of the linac is performed periodically according to the national and international reports and the government recommendations, but still not daily, for each fraction and each patient. In the pre-treatment dosimetry verification, it is checked that the linac is capable of achieving the planned dose distribution prior to initiation of therapy, after which no information is available on the correct dose distribution during irradiation. Patient's geometric verification gives information about patient position, but, usually, it is not performed daily and it relates to additional doses from imaging. Machine QA (especially MLC tests are important for IMRT/VMAT techniques.) are conducted weekly, monthly or even less often, so, in general, unexpected errors in beam delivery are hard to catch with conventional QA. It is more often said that QA for more sophisticated techniques should be performed daily or for every patient and each fraction.[2,5,6]

During the whole treatment, there are many things which can change: patient's anatomy, patient position, linac settings: MLC, output or geometry. To ensure that the patient is adequately irradiated, dosimetry verification should be performed daily, throughout the entire therapy.

There are some dosimetric tools for daily verification of dynamic techniques, such as Dolphin®, IBA Dosimetry), PerFraction® (Sun Nuclear), DAVID® (PTW), or recently very popular the transit dosimetry method.[1,2,5,6] These tools give some information about daily delivery of the treatment. However, they are quite expensive or there is limited availability (for example one tool at the hospital for many linacs), so it is important (especially for developing countries) to find a more available method or use a simple method for additional verification of patient treatment.

This is possible through the use of an electronic portal imaging device (EPID). This device is an integral part of most available treatment machines in radiotherapy, so there is no additional cost. In recent years, EPID has gained new importance and usefulness in radiotherapy: it can be used not only for geometric verification of patient position or for pre-verification dosimetry but also as a useful tool for QA of linac: verification of output, geometry or MLCs.[3,4] There is also interest in transit dosimetry and patient dose reconstruction based on measurement fluency map collected during treatment.[2,6] It is easy to use and can be placed under treatment couch with patients lying on it. This device can be used to collect daily fluency for patients during IMRT. The EPID-based method is cost-effective, integrated and involves no additional doses to the patient.

The aim of the work was to catch potential errors with daily EPID measurements of repeatability of the dose distribution during irradiation of IMRT patients, to verify the developed method on an anthropomorphic phantom with simple test plan and to determine the impact of the treatment plan parameters on the reproducibility of irradiation.

2. Material and methods

In our hospital, for dynamic techniques (IMRT/VMAT) quality control is carried out according to established procedures. For this study, a therapeutic line vendor by Varian was used: TPS Eclipse, Clinac (6 and 20 MV), imaging system: MV, OBI (kV, CBCT). For this study, to assess repeatability of irradiation, the fluency maps were collected with EPID aS500, which was placed under treatment couch (SDD 140 cm) with a phantom/patient placed on it (Fig. 1). All measured images were related to a reference map using the gamma evaluation method with definition created by Low at al. with considerate criteria: DTA 3 mm, DD 3% of maximum dose. Score value was defined as the ratio of points that do not meet the gamma criteria to all analyzed points:

$$\text{Score} = \frac{\text{number of points which not pass criteria}}{\text{total number of analyzed points}} \times 100\%$$

Finally, the data was analyzed statistically using the Spearman correlation ($p < 0.05$ is statistical significance).

In the first part of the study, anthropomorphic phantom (phantom case) was used, in the second, repeatability of 23 patient (clinical case) was assessed.

2.1. *Phantom case*

In the first stage, measurements were done for an anthropomorphic phantom (Alderson Radiation Therapy Phantom) irradiated with a homogeneous static field. The method of