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Original research article

Comparison of individual and composite field analysis using array detector for Intensity Modulated Radiotherapy dose verification☆

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ABSTRACT

Aim: To compare the measured and calculated individual and composite field planar dose distribution of Intensity Modulated Radiotherapy plans.

Materials and methods: The measurements were performed in Clinac DHX linear accelerator with 6 MV photons using Matrixx device and a solid water phantom. The 20 brain tumor patients were selected for this study. The IMRT plan was carried out for all the patients using Eclipse treatment planning system. The verification plan was produced for every original plan using CT scan of Matrixx embedded in the phantom. Every verification field was measured by the Matrixx. The TPS calculated and measured dose distributions were compared for individual and composite fields.

Results and discussion: The percentage of gamma pixel match for the dose distribution patterns were evaluated using gamma histogram. The gamma pixel match was 95–98% for 41 fields (39%) and 98% for 59 fields (61%) with individual fields. The percentage of gamma pixel match was 95–98% for 5 patients and 98% for other 12 patients with composite fields. Three patients showed a gamma pixel match of less than 95%. The comparison of percentage gamma pixel match for individual and composite fields showed more than 2.5% variation for 6 patients, more than 1% variation for 4 patients, while the remaining 10 patients showed less than 1% variation.

Conclusion: The individual and composite field measurements showed good agreement with TPS calculated dose distribution for the studied patients. The measurement and data analysis for individual fields is a time consuming process, the composite field analysis may be sufficient enough for smaller field dose distribution analysis with array detectors.

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1. Background

Intensity modulated fields have the potential to deliver optimum dose distributions which results in a greater dose uniformity in the target and lower doses to the neighboring critical organs and normal healthy structures as compared to conventional external beams employing wedges and cerroband blocks.[1] The clinical implementation of Intensity Modulated Radiotherapy (IMRT) requires special commissioning procedures including machine and patient-related routine quality assurance (QA).[2–8] The IMRT has made a considerable impact on both clinical and physical aspects of radiotherapy. The IMRT patient specific QA procedures have been emphasized and the clinical requirements for IMRT implementation have been the driving force behind many medical physics research activities. A major difficulty with designing IMRT QA procedures for treatment delivery units, treatment planning system (TPS) and patient-specific QA was that the likely failures for this new treatment technique were not known. On the other hand, traditionally used methods and equipment designed for dose verification in uniform intensity beams were becoming obsolete. For example, point dose measurements were replaced or supplemented with two-dimensional measurements.[9,10] Another example is monitor unit (MU) verification procedures, as empirical methods for dose calculation[11] cannot be applied or extended to IMRT in any straightforward manner. Due to the lack of efficient tools for patient-specific QA, routine dosimetric methods are still commonly used to verify IMRT treatment plans.[12] The European Society for Therapeutic Radiation Oncology (ESTRO) have started the QUASIMODO (QUality ASsurance of Intensity MODulated radiation Oncology) network between fifteen European centers.[13] They suggest that the verification of a composite plan is of utmost importance for the actual patient treatment. Agazaryan et al.[14] compared the measured single field and composite field IMRT planar dose with TPS computed values.

2. Aim

The patient specific IMRT QA of brain tumor patients were carried out using a 2-D ion chamber array detector. The planar dose distribution measured by the array detector for individual and composite field were compared with the TPS calculated dose distribution.

3. Materials and methods

The Matrixx (Matrixx, IBA Dosimetry GmbH, Schwarzenbruck, Germany) device consists of 1020 vented ion chamber array detectors, arranged in 32 × 32 grid. Eeach chamber volume is 0.08 cm^3 with the height of 5 mm and diameter of 4.5 mm. The detecting system can measure the dose distribution for the dose rate ranging from 0.1 Gy/min to 5 Gy/min.[15] The bias voltage required for the Matrixx system is 500 ± 30 V. The equivalent absorber thickness on the front side of the matrix is 3.6 mm. The maximum field of view is 24 × 24 cm^2. Before the measurement, the device requires 15 min of warm-up time. The device runs with two separate counters to avoid dead time, the minimum sampling period is 20 ms. The Matrixx device can be directly connected to PC via standard ethernet interface to acquire the measured charge.

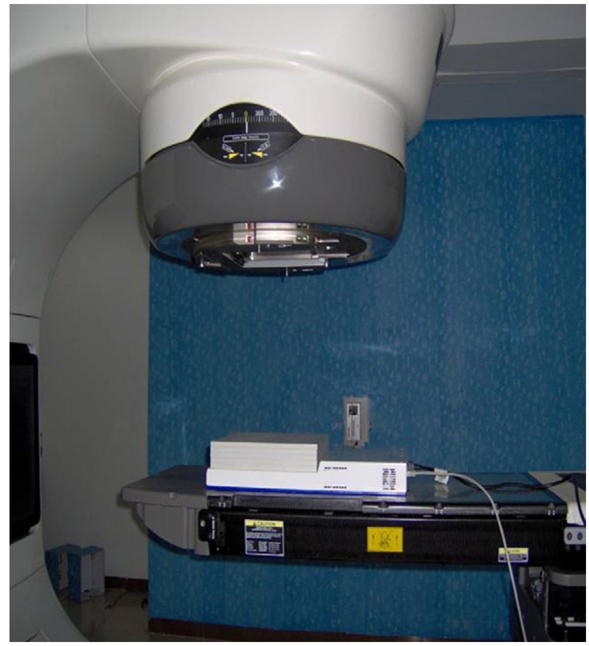

Fig. 1 – Matrixx along with slap phantom.

The measurements were performed on Clinac DHX linear accelerator with 6 MV photon beams using Matrixx device and a RW3 solid water phantom. The Millennium multileaf collimator (MLC) is an accessory attached to the treatment head below the secondary jaws as tertiary collimator. The Millennium MLC contains 120 leaves designed with 5 mm leaf width projected at isocenter the middle 20 cm of the treatment field and 10 mm leaf width projected over the peripheral 10 cm on each side of the treatment field. The leaf movements are controlled by the stepper motors through MLC controller workstation (Millennium MLC user guide, P/N 100011548). The MLC is capable of producing irregular shaped fields and dynamic motion. It is possible to achieve dose dynamic and arc dynamic IMRT treatments with dynamic MLC motion. The Matrixx device with a 5 cm solid water phantom positioned above and below was scanned with 2 mm CT slice thickness. The CT scan data was imported to TPS for 3-D reconstruction and planning. Twenty brain tumor patients were selected for this study. The IMRT treatment plan was carried out for all the patients using the sliding window technique with Eclipse treatment planning system (Varian Medical systems, USA). The 5 equally spaced beam angles were selected for each plan at an interval of 72° for all the brain tumor patients. The Anistrophic analytical algorithm (AAA) was used with the calculation grid size of 2.5 mm for dose computation. The IMRT optimization was carried out using Dose Volume Optimizer (DVO) algorithm within the Eclipse treatment planning system. In order to verify an IMRT plan a verification plan with the gantry and collimator angles set at 0 degrees was produced for every original plan using CT scan data of Matrixx device. The CT data of the measurement system was used to estimate the dose distribution at depth for these verification plans. The