A comparative study of detectors and media for relative dose measurements in kilovoltage small beams

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Purpose/Objective: The XRAD225Cx is a small animal radiotherapy device using a medium energy beam (225 kVp) and small circular fields. In addition to the half-value layers and the absolute dose rate, measurement accuracy depends on spatial resolution in depth of the detector. Therefore, PinPoint chamber was not used. Plane ionization chamber and film measurements were performed at 20, 15, 10, 8, 5, and 2.5 mm in diameter. OfS, PDDs, and TMRs were also computed with the Monte Carlo model.

Results: Measured and simulated PDDs were similar in water and RW3. Regardless of media and detectors, simulated and measured OFs showed no differences down to a diameter of beam 5 mm. For the smallest beam (2.5 mm), ionization chambers yielded large discrepancies (up to -22%) compared to SFD and EBT2 measurements and Monte Carlo simulations. This is due to the size of the sensitive volume of chambers compared to beam diameter. For PDDs and TMRs, measurement accuracy depends on spatial resolution in depth of the detector. Therefore, PinPoint chamber was not used. Plane ionization chamber and film measurements were closed to Monte Carlo computed results. SFD diode results showed significant discrepancies (up to 9%) due to the important variation in the relative energy response of the diode at 225 kVp.

Conclusions: For relative measurements, RW3 can be used instead of water at 225 kVp for convenient considerations. For OFs, all studied detectors may be used down to a beam diameter of 5 mm. For smaller beams, measurements should be performed with the SFD diode or Gafchomic films. For PDDs and TMRs, plane ionization chamber can be used down to a beam diameter of 5 mm. Gafchromic films are suitable whatever the beam diameter.

Sensitivity of three commercial dosimeters to delivery errors in helical tomotherapy

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Purpose/Objective: To assess the sensitivity of three different commercially available dosimetry systems in detecting treatment delivery errors during helical tomotherapy pre-treatment verification.

Materials and Methods: Three dosimeters 1) MatriXX Evolution (IBA) with OmniPro-IMRT software 2) ArcCheck (Sun Nuclear®) with SNC Patient software 3) EDR-2 film with cheese phantom and RIT software were used to measure delivered doses. Dose optimization was performed with the HT treatment planning system. Doses were calculated for selected points in the central lung (11 TLDs) and in eye, heart, kidney (4 TLDs) in an anthropomorphic phantom. The target dose was 12 Gy to the skeletal bone. A dose of 2 Gy was delivered 6 times. We compared the calculated dose to the measured dose.

Results: For each dosimetric point, the measured value was averaged and corrected by the MVCT scan value and converted according to the calibration factors. The mean difference between the measured and calculated dose for the bone TLDs was 1.2% (with a range of -4.2% to +5.0%) for individual detectors included in this group), indicating that the measured dose was higher than the calculated dose. For the lung-TLD group of detectors, the corresponding difference was -1.9% (range, -9.0% to +7.6%). At 11 points, the measured dose was lower than the calculated dose, with the largest differences observed in the region located in the kidney (-9.2%) and lungs (-9.0%).

Table 1: Gamma pass rates for each dosimeter and plan. Pass criteria used was 3%/3 mm, +10% b/ehind.

<table>
<thead>
<tr>
<th>Plan/ERROR plan</th>
<th>% Gamma passing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MatriXX Evolution</td>
</tr>
<tr>
<td>Original</td>
<td>97.6%</td>
</tr>
<tr>
<td>Couch speed 2%</td>
<td>92.34%</td>
</tr>
<tr>
<td>Couch speed 4%</td>
<td>73.07%</td>
</tr>
<tr>
<td>Gantry speed 4%</td>
<td>91.7%</td>
</tr>
<tr>
<td>Start Gantry angle 2%</td>
<td>93.07%</td>
</tr>
<tr>
<td>Start Gantry angle 4%</td>
<td>82.61%</td>
</tr>
<tr>
<td>Projection line 2%</td>
<td>73.67%</td>
</tr>
<tr>
<td>Projection line 4%</td>
<td>54.80%</td>
</tr>
</tbody>
</table>

Conclusions: All three dosimetry systems were sensitive to each introduced error. Additional work is underway to assess the impact of these errors on treatment plans and to include systematic/random error in MLC and jaw position. This work will also help to establish meaningful tolerance levels for quality assurance.

PO-0780
Dosemetric verification of dose calculation algorithm during Total Marrow Irradiation with helical tomotherapy

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Purpose/Objective: To evaluate the accuracy of the dose calculation algorithm for the target (bones) and some sensitive structures (lungs, eyes, heart, kidneys) in total marrow irradiation (TMI) performed with helical tomotherapy (HT).

Materials and Methods: Thermoluminescent detectors (TLDs) were used to measure delivered doses. Dose optimization was performed with the HT treatment planning system. Doses were calculated for selected points in the target - bones (9 TLDs), in the central lung (11 TLDs) and in eye, heart, kidney (4 TLDs) in an anthropomorphic phantom. The target dose was 12 Gy to the skeletal bone. A dose of 2 Gy was delivered 6 times. We compared the calculated dose to the measured dose.

Results: For each dosimetric point, the measured value was averaged and corrected by the MVCT scan value and converted according to the calibration factors. The mean difference between the measured and calculated dose for the bone TLDs was 1.2% (with a range of -4.2% to +5.0%) for individual detectors included in this group), indicating that the measured dose was higher than the calculated dose. For the lung-TLD group of detectors, the corresponding difference was -1.9% (range, -9.0% to +7.6%). At 11 points, the measured dose was lower than the calculated dose, with the largest differences observed in the region located in the kidney (-9.2%) and lungs (-9.0%).
Conclusions: The mean measured dose to the lungs was only 6.02 Gy, whereas most studies of TBI have reported a range of 8-10 Gy. TMI-HT delivers lower doses vs. conventional total body irradiation, thus backscatter correction by calculating the maximum rel. difference of profiles in the flat field region (80% area within field limits) and (iii) PD image) of the central axis dose values, (ii) beam profile correction, while not all field sizes (4 x 4 cm² and 5 x 5 cm²) met the ±1.5% limit for the backscatter correction. Conclusions: The use of generic configuration data appears to be feasible for the Varian PD solution allowing for a simplified configuration process and the easy implementation of essential improvements. Further data at high beam energies as well as for dynamic MLC fields (IMRT and VMAT) are required to support the promising results obtained in this preliminary study.

PO-0782
VMAT pre-treatment QA for Flattening Filter Free beams with GLAaS algorithm for portal dosimetry
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Purpose/Objective: To evaluate the possibility to use an amorphus silicon portal imager as pre-treatment quality assurance of RapidArc plans with flattening filter free (FFF) beams.

Materials and Methods: The backscatter effect is field size dependent, thus implementing the backscatter correction using calibration data required a trade-off: Good performance for small to medium (clinically more relevant) field sizes versus reduced performance for larger field sizes. The PD solution was configured on 11 Varian systems (3 Unique, 8 Clinac) at 9 different sites for beam energies of 6 MV (n=8), 15 MV (n=2) and 18MV (n=3) using the generic PD configuration package. Pre-treatment quality assurance of RapidArc plans with FFF beams. The GLAaS algorithm was originally developed to convert portal imager integrated readings into absorbed dose to water, and was validated for IMRT and RapidArc (the Varian VMAT) pre-treatment quality assurance for standard flattened beams. The algorithm was adapted to FFF beams and validated for open as well as for modulated beams. In this study it was used to evaluate RapidArc pre-treatment acquisitions. Five different clinical FFF RapidArc plans were selected and recalculated for both 6 and 10 MV FFF. The maximum dose rate was set for each energy. Dose prescriptions ranged from 7 to18 Gy/fraction. Pre-treatment QA deliveries were performed on four different TrueBeam machines (two equipped with a high-definition MLC, HD-120MLC, and two with a standard Millennium 120-MLC). QA evaluation was based on gamma index, using distance to agreement and dose difference criteria of 3mm/3% and 2mm/2%. 2D dose maps were evaluated also through profiles.

Results: The percentage of points passing the gamma criteria (gamma agreement index GAI) were collected for all deliveries. For 3mm/3% criteria, GAI evaluated on the field area was 97.9±2.5% and 98.6±1.6% for 6 and 10 MV FFF respectively. For 2mm/2% criteria, GAI evaluated on the field area was 92.0±3.5% and 96.6±4.3% for 6 and 10 MV FFF respectively.

Conclusions: The use of Portal Vision as pre-treatment QA for RapidArc for FFF beams gives advantages that can be summarised in three points: 1) verification of absorbed dose calculation, 2) fast acquisition, 3) improved resolution at SD=150 cm, particularly interesting in hyperfractionated treatment, where small fields are mostly used. Gamma results presented fully satisfactory results in line with standard flattened beams.