Conclusion: All three generations of MLC are found to be highly stable with a significant improvement in stability for each generation. Thus, it is possible to make a highly accurate and precise calibration of the Elekta MLCs if an adequate calibration procedure is available.

PO-0945
Modeling and simulation of simultaneous using of two superficial hyperthermia antennas
A. Di Dia1, S. Depalma2, S. Bresciani1, A. Maggio1, A. Miranti1, M. Poli1, P. Gabriele3, E. Garibaldi1, M. Stasi1
1Istituto di Radiologia- IRCCS, Medical Physics, Candiolo, Italy
2Politecnico di Torino, Dipartimento di Elettronica e tele comunicazioni, Torino, Italy
3Istituto di Radiologia- IRCCS, Radiotherapy Department, Candiolo, Italy

Purpose or Objective: Hyperthermia is a powerful radiosensitizer for treatment of superficial tumors. The purpose of this study is the 3D-modeling and simulation of the simultaneous using of two antennas of our equipment. In particular, geometric and functional characterization of the antennas as a function of various tissues characteristics (skin, fat and muscle) were investigated.

Material and Methods: The hyperthermia device is equipped with double arms, operating at a radiofrequency of 434 MHz, with a water automatic superficial cooling device. For temperature measures, it is equipped with an integrated Multichannel thermometer. The antennas are designed to cover areas from 7.2 × 19.7 cm² up to 20.7 × 28.7 cm². The applicators geometry have been reproduced in the CAD environment with a professional software based on the FDTD processing methods. In order to identify the distribution of specific absorption power rate in different types of tissues, several simulations have been performed, varying the relative thicknesses of a model consisting of skin, fat and muscle. Working incident power has been set equal to 100 watt. Water bolus temperature is assumed to be equal to 38 °C.

Results: The numerical model of the applicator has been coupled to various models of tissue, the incident maximum power of 100W for 60 minutes, with a thickness of waterbolus equal to 10 mm. In particular, as the fat thickness is gradually increased, muscle layer temperatures decrease of about 0.04 °C per mm of fat layer. Setting the skin thickness, as the fat thickness increases, the maximum temperature and the penetration depth reached in the muscle decrease; increasing skin thickness, if the fat thickness increases, consequently the maximum temperatures reached in the muscle and the depth of penetration decrease. In particular, increasing the fat thickness, temperatures in the underlying muscles were gradually reduced (approximately 0.2 °C for 5 mm fat raise). In the underlying muscle layer, maps were more homogeneous, with an approximately uniform power intensity decrease on the section plane. By varying waterbolus thickness, from 10 to 20 mm, the adaptation of the applicator coupled to tissue model undergoes small changes of the reflected power and, at the operating frequency, the model with thickness 17.5 mm showed to have the best reflection coefficient (-31.35 dB). The simultaneous use of the two antennas showed that only the 10% isoSAR are overlapping, and it demonstrates that it is possible to use both antennas in safety without possibility of hot spots in the tissue, varying also the thickness of the bolus.

Conclusion: The numerical simulation allows to know in detail the temperature distribution to different levels of depth, in particular it demonstrate that it is possible the simultaneous using of two antennas to treat more lesion in the same hyperthermia treatment session without hot spot in the tissue.

PO-0946
A new liquid fiducial marker formulation for image-guided pencil beam scanning proton radiotherapy
1Rigshospitalet, Oncology, Copenhagen, Denmark
2Paul Scherrer Institut, Center for Proton Therapy, Villigen, Switzerland
3DTU Nanotech, Dept of Micro and Nanotechnology, Copenhagen, Denmark
4Rigshospitalet, Department of Pulmonary Medicine, Copenhagen, Denmark

Purpose or Objective: The purpose of this work was to test the dosimetric impact of using a novel liquid fiducial marker (BioXmark®) in a proton spot scanned system.

Material and Methods: In order to test the clinical applicability of the new fiducial marker for proton therapy we measured the relative proton stopping power (RSP) of the liquid fiducial marker. Second, we measured the dose perturbation of a clinical pencil beam scanning proton beam of the liquid fiducial marker and three other commercially available solid markers for comparison by introducing them in a gelatin phantom. Dose perturbation was measured for several proton energies between 90 and 101 MeV at several distances after the markers in order to evaluate potential dose perturbation directly behind the markers, in the Bragg peak and after the Bragg peak. Finally, we created proton therapy plans on five patients with locally advanced lung cancer and with the liquid fiducial marker implanted. Each treatment plans had 3-4 intensity modulated proton (IMPT) beams. We examined the markers impact on the dose distribution caused by the fiducial markers. This was done by first calculating the dose with no marker correction, secondly by matching the RSP of the fiducial marker with the theoretical, respectively. The dose perturbation of the liquid fiducial marker and three other commercially available solid markers for comparison by introducing them in a gelatin phantom. Dose perturbation was measured for several proton energies between 90 and 101 MeV at several distances after the markers in order to evaluate potential dose perturbation directly behind the markers, in the Bragg peak and after the Bragg peak. Finally, we created proton therapy plans on five patients with locally advanced lung cancer and with the liquid fiducial marker implanted. Each treatment plans had 3-4 intensity modulated proton (IMPT) beams. We examined the markers impact on the dose distribution caused by the fiducial markers. This was done by first calculating the dose with no marker correction, secondly by matching the RSP of the fiducial marker with the experimental results, and subsequently with the RSP matching soft tissue and comparing changes in the dose distributions.

Results: The RSP of the liquid fiducial marker was determined to be 1.164 and 1.174 experimentally and theoretically, respectively. The dose perturbation of the liquid fiducial marker showed no effect directly after the marker itself and only had an effect on the proton range (Figure 1). By introducing the fiducial markers, we estimated a median range deviation of 1.2 (range: 0.7-1.9 mm) of the proton beam as compared to soft tissue. On the clinical lung cancer IMPT plans with the correct RSP manually introduced, the spinal cord max dose, lung V20, PTV V95, CTV V95 and GTV V95 were all modified by less than 1% by introducing the markers.

| Material and Methods: | The numerical simulation allows to know in detail the temperature distribution to different levels of depth, in particular it demonstrate that it is possible the simultaneous using of two antennas to treat more lesion in the same hyperthermia treatment session without hot spot in the tissue. |
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| Material and Methods: | In order to test the clinical applicability of the new fiducial marker for proton therapy we measured the relative proton stopping power (RSP) of the liquid fiducial marker. Second, we measured the dose perturbation of a clinical pencil beam scanning proton beam of the liquid fiducial marker and three other commercially available solid markers for comparison by introducing them in a gelatin phantom. Dose perturbation was measured for several proton energies between 90 and 101 MeV at several distances after the markers in order to evaluate potential dose perturbation directly behind the markers, in the Bragg peak and after the Bragg peak. Finally, we created proton therapy plans on five patients with locally advanced lung cancer and with the liquid fiducial marker implanted. Each treatment plans had 3-4 intensity modulated proton (IMPT) beams. We examined the markers impact on the dose distribution caused by the fiducial markers. This was done by first calculating the dose with no marker correction, secondly by matching the RSP of the fiducial marker with the experimental results, and subsequently with the RSP matching soft tissue and comparing changes in the dose distributions. |
| Results: | The RSP of the liquid fiducial marker was determined to be 1.164 and 1.174 experimentally and theoretically, respectively. The dose perturbation of the liquid fiducial marker showed no effect directly after the marker itself and only had an effect on the proton range (Figure 1). By introducing the fiducial markers, we estimated a median range deviation of 1.2 (range: 0.7-1.9 mm) of the proton beam as compared to soft tissue. On the clinical lung cancer IMPT plans with the correct RSP manually introduced, the spinal cord max dose, lung V20, PTV V95, CTV V95 and GTV V95 were all modified by less than 1% by introducing the markers. |
Conclusion: The experimentally determined RSP of the liquid fiducial marker was in good agreement (within 1%) of the theoretical calculation. The investigated liquid fiducial marker introduced smaller dose perturbation than the solid fiducial markers. The liquid fiducial marker shows promise for use in image-guided proton therapy of locally advanced lung cancer, as the risk of altering the clinical dose distribution is minimal.

PO-0947
VMAT-based grid for spatially fractionated radiation therapy
S. Gholami1, M. Severgnini2, H.A. Nedaie3, F. Longo4, A. S. Meiroomi5
1Tehran University of Medical Sciences, Department of Medical Physics and Biomedical Engineering, Tehran, Islamic Republic of Iran
2A.O.U. Ospedali Riuniti, Department of Medical Physics, Trieste, Italy
3Tehran University of Medical Sciences, Radiation Oncology Department- Cancer Institute, Tehran, Iran Islamic Republic
4University of Trieste and INFN Trieste, Department of Physics, Trieste, Italy
5Comprehensive Cancer Centers of Nevada, Las Vegas-Nevada, USA

Purpose or Objective: The purpose of this study is to investigate about feasibility of using volumetric modulated arc therapy (VMAT) technique to provide a Grid dose distribution with the therapeutic ratio (TR) advantage similar to the block-based Grid.

Material and Methods: A series of cylinders with hole diameters of 1.3 cm and 1 cm height was created in a phantom as the boost volume within a larger volume target. The Monaco® 5 treatment planning system was used to plan the VMAT and block-based Grids. Four arcs, with collimator angles at 00 and 180º were used. The cost functions were defined to deliver 17 Gy dose to the boost volume and 6 Gy dose to the target volume. A dose profile from treatment plan was utilized to calculate TR for the VMAT-based Grid. In addition, for an available Grid block in our department the TR value was calculated from dose profile using EBT Gafchromic film. The Hug–Kellerer (H-K) radiobiological model (Equation 1) was used to calculate the TR for the VMAT-based Grid. In addition, for an available Grid block in our department the TR value was calculated from dose profile using EBT Gafchromic film. The Hug–Kellerer (H-K) radiobiological model (Equation 1) which is more appropriate at doses higher than 12 Gy was used to calculate survival fraction of cell lines under a single hole of the both Grids. The values of α/β ratios for tumor cells and normal cells were considered to be 10 Gy and 2.5 Gy, respectively.

Equation 1:
\[ TR = \frac{\sum V_i e^{(-k_1 D_i) + k_2 (1-\exp(-k_3 D_i))}}{\sum V_i} \]

Figure 1 shows a 2D dose distribution of VMAT-based and block-based Grids at the center of the phantom. The VMAT plan generated a highly spatially modulated dose distribution in the volumes. D95% and D50% for the cylinders and the target in Gy were 16.5, 17 and 6, 10 respectively. The valley to peak ratio of the VMAT-based and block-based Grid was 19% and 22% respectively. The Therapeutic ratio for VMAT-based and block-based Grid was obtained 1.25 and 1.38 respectively.

PO-0948
A comprehensive evaluation of intracranial SRS treatment accuracy
T.A. Van de Water1, P. Remeijer1, F. Wittkämper1, C. Schneider1, M. Frantzen-Steneker1, E. Damen1, C. Panneman1, J. Geuze1, J. Kaas1, R. Van Schie1, A.M. Van Mourik1
1The Netherlands Cancer Institute, Department of Radiation Oncology, Amsterdam, The Netherlands

Purpose or Objective: This study provides a comprehensive overview of our geometric accuracy of frameless, linac-based intracranial SRS treatments. It is currently used to evaluate and further improve SRS treatment accuracy at our institute. Moreover, for other institutes, the overview may be used as reference material to supplement the more coarsely defined tolerance limits available in guidelines. To our knowledge, this is the first study that presents an overview of MRI/CT-to-RT treatment accuracies in such detail, combining regular QA data with clinical data, for a specific treatment.

Material and Methods: Our intracranial SRS treatments are based on a non-coplanar dual arc VMAT technique (table 0º and ±90º), in combination with an extensive online IGRT protocol with table correction verification and a post treatment CBCT. We systematically evaluated precision of the main elements of this SRS chain. We gathered patient set up data and image registration data, evaluated the imaging, treatment planning and QA protocols that were used, measured small fields (≤3 cm²) and compared this data with the TPS beam fit, and analysed QA data of the last couple of