Materials/Methods: The appropriate anatomical structures were identified in a 3T MR sequence. Prescription doses and target selection for each treatment type were identified from previously published work. GK treatment was simulated with 4- or 8-mm collimator. VMAT treatment was simulated using MLC-based virtual cone approach previously developed to replicate spherical GK dose profile. Plans were reviewed for acceptability by the multidisciplinary team. Gradient, V12Gy, and mean brain dose were compared for each case between the 2 delivery systems.

Results: For each case, the linear accelerator approach was able to generate a plan nearly dosimetrically equivalent to its GK counterpart, and to metrics previously reported in the literature. Individual plan quality metrics are provided in Table 1.

Conclusion: Coneless MLC-based VMAT on the linear accelerator is a feasible option for SRS of functional neurological conditions.


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Dosimetry for Spatially Fractionated Synchrotron Radiation Therapy
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Purpose/Objective(s): Microbeam and minibeam radiation therapies (MRT and MBRT, respectively) are preclinical radiation therapy modalities being developed at several biomedical synchrotron beamlines and involve the collimation of synchrotron x-ray beams into an array of spatially fractionated quasi-parallel beams. Spatial fractionation exploits the dose-volume effect, where the threshold dose for damage to normal tissues increases as the volume of irradiated tissue decreases. Very large doses of fractionated quasiparallel beams. Spatial fractionation exploits the dose-volume effect, where the threshold dose for damage to normal tissues increases as the volume of irradiated tissue decreases. Very large doses of radiation can be delivered to a tumor while sparing surrounding normal tissues, thereby satisfying the clinical goal. A robust dosimetry protocol is at the core of quality assurance for any radiation therapy technique. The characteristics of synchrotron X rays that offer desirable outcomes for radiation therapy present significant challenges to dosimetric measurements. The narrow beam widths—typically 25-50 μm for MRT and 500-600 μm for MBRT—require a detector with submillimetric dimensions to accurately measure peak doses and scattered dose between the beams (valley). The detector should also exhibit tissue equivalence in kilovoltage x-ray spectra and have a linear response with dose rate.

Materials/Methods: A synthetic single crystal diamond detector (SSCD) designed specifically for dosimetry in small fields has been studied to investigate its potential as a high-resolution dosimeter for quality assurance measurements in spatially fractionated synchrotron radiation therapy. The energy dependence was characterized for energies 30-120 keV by comparing the response of the detector to reference ionization chambers. The dose rate dependence was also studied over the range 1-700 Gy/s. High-resolution measurements of mini- and microbeam array profiles were performed and peak to valley dose ratio (PVDR) at various depths was calculated and compared to gafchromic film.

Results: The detector exhibited an energy response but this has been characterized and beam quality correction factors are now known. Over the dose rate range 1-700 Gy/s the response of the detector was independent of dose rate. Microbeam and microbeam array profiles showed less noise than film profiles, and PVDRs calculated from the diamond detector and film were in agreement.

Conclusion: The diamond detector studied is a promising candidate to be used in a dosimetry protocol for spatially fractionated synchrotron radiation therapy.


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Effects of Continuous Positive Airway Pressure (CPAP) Used for Respiratory Motion Management In Patients Receiving Chest Radiation to the Heart: An Analysis of Size, Position, and Motion
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Purpose/Objective(s): CPAP used during radiation treatment reduces tumor motion and expands lung volume. CPAP’s effect on the size, position, and motion of the heart has not been reported previously. We hypothesized that the physiologic effects seen with use of CPAP—expansion of the thoracic cavity caused by reduction of motion and flattening of the diaphragm as well as decreased venous return to the heart— affects cardiac parameters important for radiation treatment. We measured the effects of CPAP on the heart in a cohort of patients receiving radiation therapy for lung tumors.

Materials/Methods: IRB approval was given in December 2013. Patients with primary or secondary lung tumors underwent 4-dimensional computed tomography (4DCT) simulation twice using identical positioning with free breathing and with CPAP. The heart was contoured according to RTOG guidelines on all 3D and 4D CT imaging studies. The Boolean operator function on the treatment planning system (TPS) was used to combine contours from all 10 respiratory phases of the 4D scans to create a maximal heart volume (MHV). The TPS was used to coregister all scans using the vertebral bodies for fusion and to measure and compare changes in the size, center of mass, and excursion of the heart and lung. A Wilcoxon signed-rank test was used to assess differences between variables. Spearman rho coefficient was used to assess correlations between changes in lung volume and measured heart parameters.

Results: Studies were reviewed from 9 patients. CPAP use decreased mean heart size on 3D and 4D scans by 6% (95% CI: 2%-8.5%, P<0.008) and 13% (95% CI: 9%-16%, P<0.008), respectively. CPAP decreased change in MHV by 46% (95% CI: 26%-65%, P<0.01). CPAP shifted the mean center of mass caudally on 3D and 4D images by 1 cm (95% CI: 0.7 cm-1.4 cm, P<0.01) and 1.1 cm (95% CI: 0.8 cm-1.5 cm, P<0.01), respectively. Positional shifts in other directions were NS. CPAP reduced the mean excursion vector on 3D and 4D images by 4% (95% CI: 3%-6%, P<0.01) and 6% (95% CI: 5%-7%, P<0.01), respectively. Use of CPAP decreased the change in mean excursion by 36% (95% CI: 4%-67%, P=0.01). Spearman correlation coefficient for increase in lung volume and caudal change in heart position and reduced heart excursion were 0.83 (P<0.005) and 0.87 (P<0.003), respectively. Correlation with change in heart size was NS.

Conclusion: The use of CPAP decreased heart size, shifted heart position caudally, reduced heart motion, and increased total lung volume. The increase in total lung volume was correlated with the changes observed in position and motion of the heart. CPAP should be evaluated further as a novel cardiac motion management strategy to reduce heart exposure when offering radiation therapy.

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Jaw Tracking Impacts on Treatment Plan Quality in Small Volumetric Modulated Arc Therapy Fields: A Dosimetric Verification
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Purpose/Objective(s): Jaw tracking is essential to ensure optimal coverage of the tumor and to spare surrounding structures. The effects of jaw tracking on the resulting dose distributions were evaluated using Monte Carlo simulations for 2 different jaw-tracking methods: step-and-shoot (SAS) and jaw-tracking (JT). The impact of jaw tracking on the dose distributions was evaluated in terms of dose delivered to the target volume and organs at risk (OARs). The dose delivered to the target volume was compared with the planning target volume (PTV) dose, and the dose delivered to OARs was compared with the constraints specified in the radiation oncology protocol.

Materials/Methods: The simulations were performed using the Eclipse treatment planning system (Varian Medical Systems, Palo Alto, CA). The dose distributions were generated for a 60-Gy PTV and a 66.67-Gy PTV, corresponding to a 100% and 101% isodose line, respectively. The dose distributions were compared with the planning dose distributions, which were generated using a 20-mm margin around the isocenter. The dose distributions were also compared with the dose distributions generated using the approved jaw-tracking method (JT). The dose distributions were evaluated using the gamma index, which is a measure of the agreement between the planning dose distributions and the dose distributions generated using the approved jaw-tracking method (JT). The dose distributions were also evaluated using the dose-volume histogram (DVH), which is a graphical representation of the dose delivered to different volumes. The dose-volume histograms were compared with the DVHs generated using the approved jaw-tracking method (JT).

Results: The gamma index for the dose distributions generated using the approved jaw-tracking method (JT) was 99.9% for the 60-Gy PTV and 99.9% for the 66.67-Gy PTV. The DVHs for the dose distributions generated using the approved jaw-tracking method (JT) were in agreement with the DVHs generated using the approved jaw-tracking method (JT) for all OARs. The dose delivered to the target volume was within the planned dose range of 60-66.67 Gy for all PTVs.

Conclusion: The use of jaw tracking significantly improves the dose distribution in small Volumetric Modulated Arc Therapy (VMAT) fields. The gamma index and DVHs for the dose distributions generated using the approved jaw-tracking method (JT) were in agreement with the DVHs generated using the approved jaw-tracking method (JT) for all OARs. The dose delivered to the target volume was within the planned dose range of 60-66.67 Gy for all PTVs.