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Abstract

Preoperative Partial Breast Irradiation with a Novel Breast-Specific Stereotactic Radiotherapy (BSRT) Device: Projected Improvements in Cosmetic Outcomes over Volumetric Modulated Arc Therapy (VMAT)

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Objectives: Accelerated Partial Breast Irradiation (APBI) has reduced logistical burdens and normal tissue exposure associated with breast radiotherapy. Three-dimensional conformal radiotherapy (3D-CRT) has been the most widely employed method of APBI. Unfortunately, 3D-CRT APBI has been linked with high rates of fair to poor cosmesis, which have been correlated with volumes of normal breast receiving low, intermediate, and high percentages of the prescribed dose (Vx%). Efforts have focused on improving dose conformality and reducing treatment volumes such as through preoperative, VMAT. At our institution, a novel BSRT device has been developed with 2 main components: 1)a negative-pressure breast immobilization system; 2)a delivery system with 36 non-coplanar, Co-60 beams which rotate around isocenter as the patient is translated in the prone position to dynamically dose-paint the target. We hypothesized that this BSRT device would demonstrate significant improvements over VMAT in normal breast tissue and critical organ sparing based on clinically validated dosimetric parameters which predict for poor cosmesis.

Methods: On an IRB-approved protocol, 15 previously treated patients underwent CT simulation in the BSRT immobilization system. Setup accuracy has been previously validated at less than 2mm. To simulate a neoadjuvant approach, a gross tumor volume (GTV) was delineated as a sphere with diameter equal to the patient's original tumor, within the lumpectomy bed. Expansions for clinical target volume (CTV_15mm) and planning target volume (PTV_10mm) were made per the NSABP B-39 protocol. An additional PTV_3mm was generated to account for improved immobilization in the breast cup. Plans were assessed based on PTV_eval. Two medical dosimetrists, blinded to BSRT planning, generated VMAT PTV_10mm plans utilizing a 2-arc technique with avoidance angles for the contralateral lung/breast and the ipsilateral arm. Conformality of dose to the target and reduction of normal breast tissue irradiated were highly prioritized. Two trained BSRT planners (physicist/physician) generated BSRT plans for both PTV_10mm and PTV_3mm. Plans were assessed primarily based on Vx% of normal breast tissue.

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Results: The BSRT device produced substantial reductions in dose to normal structures as compared with VMAT. Taking into account physical limitations of the BSRT device, 14 patients were eligible for planning with the large PTV_10mm expansion, while 1 additional patient was eligible with PTV_3mm. Doses to the ipsilateral, uninvolved breast tissue with PTV_10mm were significantly reduced with BSRT by a relative 5.3%, 31.0%, 34.1%, 30.8%, and 30.5% for V5%, V20%, V50%, V80%, and V100% ($P<0.05$). The V15% and V40% of the breast skin (most superficial 5mm of breast tissue) were reduced by 23.0% and 20.2% ($P=0.05$). With PTV_3mm, further reductions in breast dose were achieved: V5% 31.0%, V20% 57.8%, V50% 62.4%, V80% 63.4%, and V100% 65.9% ($P<0.001$). The skin dose also fell: V15% 58.3% and V40% 59.5% ($P<0.005$). Dose to the lung and heart were also significantly reduced at several levels ($P<0.05$).

Conclusions: This BSRT device affords setup margin reductions and dose conformality improvements that are substantial even compared to VMAT. The device is particularly well suited to delivering neoadjuvant therapy with the potential for expansion to definitive, ablative approaches. Clinical trials will start this year using this device.