The Dynamic Tumor Bed Volume and Image-Guided Breast Irradiation

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Summary

With the increased use of external beam accelerated partial breast irradiation (EB APBI), technical advancements are needed to ensure accurate delivery of targeted radiation therapy (RT) to the tumor bed. Inaccurate treatment not only can lead to overtreatment of normal tissues, thus enhancing short-term and long-term toxicities, it can also compromise long-term oncologic care if the subclinical disease is not adequately addressed. The optimal strategy in determining the EB APBI treating volume is through understanding factors that would influence seroma development and change after breast-conserving surgery and utilizing on treatment imaging to evaluate tumor bed change during breast irradiation (**Chapter 1**).

This thesis demonstrated the following significant results and contributed to the field of breast radiation oncology in various ways:

- First, in **Chapter 2** this thesis showed that the lumpectomy cavity volume is dynamic after surgery and stabilizes approximately 8 weeks post-operatively. Radiotherapy was found to hinder seroma reduction. These results suggest that redefining target volumes and modifying treatment plans are needed during breast irradiation, especially for EB APBI, to appropriately determine the post-operative target volume. The change in the post-operative cavity can significantly impact the target volume for EB APBI, leading to risk of overtreatment of normal tissue causing long-term toxicities, such as fibrosis.
- Second, in **Chapter 3** this thesis showed that cone-beam computed tomography (CBCT) could be used in place of CT in detecting seroma reduction. Seroma clarity can influence an observer's ability to contour seroma; however, this effect was equally observed on both CT and CBCT. The results included in this thesis suggest that CBCT is a good clinical surrogate for CT in monitoring seroma reduction during breast RT, especially for patients with seroma scoring 3 or higher in clarity on CBCT. Therefore, for patients undergoing EB APBI, CBCT can be used and should be recommended to monitor tumor bed changes. If significant volume change is observed during EB APBI, then the treatment plan should be modified to reflect the change to allow for most accurate treatment delivery.
- Third, in **Chapter 4** this thesis demonstrated the dosimetric impact of the shrinking tumor bed in the breast conserving therapy setting (whole breast irradiation with boost). These results showed that a significant change in the tumor bed volume can lead to excessive irradiation of normal breast tissue during EB APBI, which reflects the importance of monitoring seroma reduction during RT.
- Fourth, since CBCT may not always be available as an image-guided radiation therapy (IGRT) modality for EB APBI in all institutions, feasibility of two-dimensional IGRT with on-board kilovoltage (2D-kV) x-rays using external landmarks outside of the lumpectomy cavity, such as the thoracic spine and boney structures, was investigated in **Chapter 5**. It was found that when registered with treatment planning CT, 2D-kV orthogonal images used for patient setups for thoracic spine irradiation resulted in the small differences of 0.2 ± 1.6mm in translation -0.7 ± 1.1° in rotation. The promising results demonstrated in chapter 5 have led to the development of a pilot study at the Memorial Sloan Kettering Cancer Center for breast irradiation.
- Lastly, **Chapter 6** describes a thorough literature review in the optimal target definition of EB APBI. These investigations made a cohesive argument for the importance of understanding and

monitoring tumor bed change after surgery in the setting of EB APBI, utilizing landmark outside the lumpectomy cavity for IGRT delivery, and a strong recommendation in better defining the target volume for future studies.