Purpose: To evaluate radiation treatment effects on mammary carcinoma cells, quantitative photon radiance were monitored to track light-emitting cancer cells and metastasis using in vivo bioluminescence imaging.

Methods: Eight female BALB/c mice aged 8 weeks were orthotopically injected with 5x10^4/cc 4T1 tumor cells into the abdominal mammary gland. The firefly luciferase-based bioluminescence images were acquired every 2-3 days for 1 month. Bioluminescent intensity was analyzed in average surface radiance (photons/sec/cm^2/sr) taken in 3-dimensional bioluminescence tomography (BLT). After 1 week, single-radiation dose of 20 Gy was delivered by orthovoltage X-rays. Variation of detected bioluminescence signals emitted from molecular cancer cells was depicted on BLT images. To delineate tumor volumes according to bioluminescence intensity on anatomical images for radiation therapy, BLT images were registered with the micro computed tomography (CT) images using surface-constrained warping.

Results: Multispectral BLT images elaborated on early detection of cancer cells, characteristics of tumor growth, and metastasis for more accurate determination of internal bioluminescent sources. The radiation-treated mice having only primary tumor volumes showed 67% decrease in bioluminescent signals, while the mice with metastatic cancer cells suggested 88% reduction, as compared to the control group. Registration of BLT with CT images guided molecular cancer cells on anatomical coordinates.

Conclusions: The BLT imaging was a useful tool to localize cancer cells and to quantify radiation response. Application of BLT led to more accurate definition of tumor volumes including molecular probe-based microscopic cancer cells. Monitoring of bioluminescence signals enables to diagnose real-time metastatic behavior of cancer cells and determine optimal radiation treatment strategies adapted to tumor characteristics.