Quantitative changes on CT imaging after stereotactic body radiation therapy to non-spine bone metastases

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Introduction

- Stereotactic Body Radiation Therapy (SBRT) is a precise and high-dose method of radiation therapy that is used commonly for treating non-spine bone metastases
- Not many studies have described the radiological changes after SBRT treatment
- The purpose of this study is to examine SBRT-induced changes on the metastatic site to seek out trends in tumor response.
- Change in mean CT number of a volumetric [2] contour after SBRT treatment may be an effective measure to monitor tumor response in our patients.
- Lytic lesions show a response to treatment from bone remineralization and sclerotic lesions respond by demineralization or maintaining stability.
- Past studies have used a point measurement on the metastatic lesion to monitor the changing CT density value. [1]

Methods

- This study was approved by the research ethics board at Sunnybrook Health Sciences Centre
- Between November 2011 to April 2014, a retrospective review was conducted for patients treated with SBRT to non-spine bone metastases at Sunnybrook Health Sciences Centre
- All patients underwent at least one CT scan prior and one scan after start of treatment
- Two contouring experts determined the lesion volume, one drawing the lesion volume and the other reviewing and approving the contours (Figure 1)
- One musculoskeletal radiologist classified lesions as lytic, sclerotic, or mixed
- A custom graphical user interface of MATLAB software was used for texture analysis of the CT data
- CT follow-up to CT baseline ratio for each patient were binned into months 1 to 3, 4 to 6,7 to 9 and 10 to 12

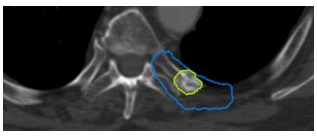

Figure 1. Radiological image showing a treatment contour with the bony region of interest in yellow

Results

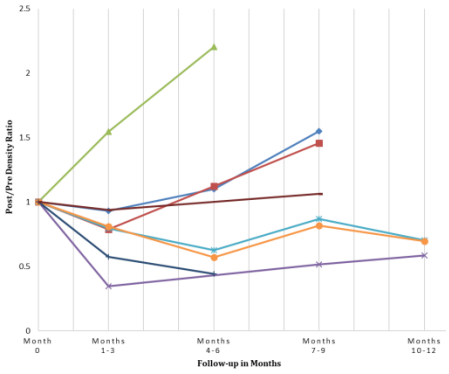

Figure 2. Posttreatment/pretreatment ratio for lytic lesions. The primary cancer being renal cell carcinoma.

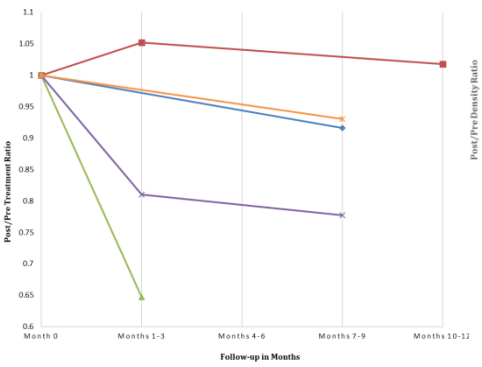

Figure 3. Posttreatment/pretreatment ratio for all sclerotic lesions ,and one mixed lesion (orange), from prostate carcinoma.

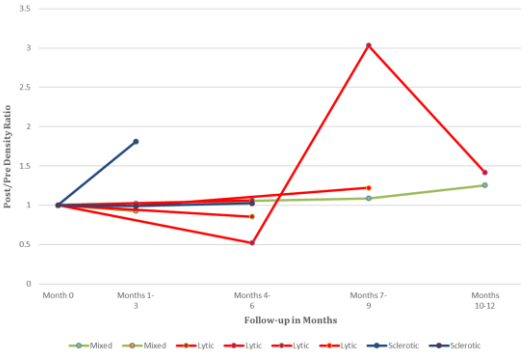

Figure 4. Postreatment/pretreatment ratio for all lesions from lung cancer.

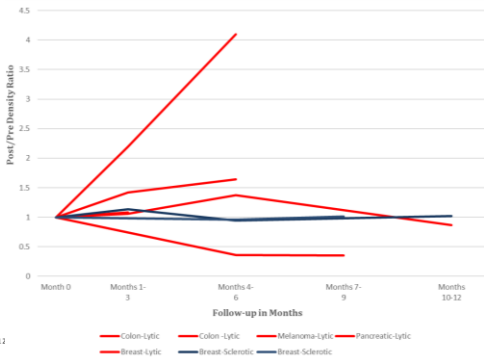

Figure 5. Posttreatment/pretreatment ratio for all lesions from other primary cancers.

- Patients with sclerotic lesions appear to have an early response to treatment (within 1-2 months) than the patients with lytic lesions (Figure 3)
- The patients with lytic lesions from renal cell carcinoma experienced a delayed response to treatment (1-6 months, Figure 2)
- Lesions arising from lung cancer had a smaller response to treatment (Figure 4)

Months	1-3	4-6	7-9	10-12
Renal Cell	0.84	1.01	1.05	0.66
Prostate	0.84	n/a	0.88	1.02
Lung	1.15	0.87	1.78	1.34
Other	1.38	1.56	0.68	0.95

Table 1. Average post/pre ratios for each primary cancer

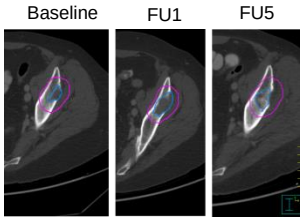

Figure 6. Lytic lesion from renal cell carcinoma. Baseline was imaging taken 2 months before treatment. The images for follow-ups one and five were taken 2 and 7 months after treatment respectfully.

- Lytic lesion follows a common trend of continued bone resorption post-radiation before bone remineralization takes into effect (Figure 6)

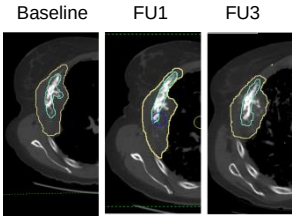

Figure 7. Sclerotic lesion from breast cancer. Baseline imaging was taken 1 month before treatment and follow-ups one and three done 2 and 6 months post-treatment respectfully.

- Changes in mean CT number for the sclerotic lesions in the study suggested a response over time although the radiological images only suggest subtle or indistinguishable changes (Figure 7)

Discussion and Conclusions

- After SBRT treatment, response patterns and recovery times follow identifiable trends
- Limitations include the size of the patient population, confounding treatments such as chemotherapy, inter- and intra- observer variability for target delineation and classification (i.e. lytic, sclerotic, mixed)
- The results in this study indicate that SBRT can effectively initiate remineralization of lytic lesions and demineralization sclerotic lesions
- Future studies will include other parameters such as skew, kurtosis, and standard deviation to further understand the changing nature of bone metastases.
- Established trends in response to SBRT will help to optimize follow-up times and dates of retreatment
- Monitoring mean CT density changes may improve the evaluation of a patient's disease status and allow a more effective and personalized treatment
- The volumetric contour method shown here is less sensitive to positional errors and observer bias compared to the point-based assessment when monitoring CT density

References

1. McDonald R, Probyn L, Poon I, et al. Computed tomography evaluation of density following stereotactic body radiation therapy of nonspine bone metastases. *Technol Cancer Res Treat.* 2016;15(5):683-688.
2. Chua D, Sham J, Kwong D, et al. Volumetric analysis of tumor extent in nasopharyngeal carcinoma and correlation with treatment outcome. *Int J Radiat Oncol Biol Phys*. 1997;39(3):711-719.

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