

Comprehensive assessment of uncertainties and errors in [^{18}F]NaF PET imaging

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Quantitative PET imaging is increasingly being used as a tool for treatment response assessment of various types of cancers, supplementing the conventional qualitative anatomical imaging. [^{18}F]NaF is a radiotracer used for imaging of metastatic bone lesions and provides a means of visualizing and quantifying metabolic activity. [^{18}F]NaF PET images provide better sensitivity and quantitative response assessment of the bone lesions compared to the $^{99\text{m}}\text{Tc}$ which is currently the clinical standard. Nevertheless, for accurate and reliable use of [^{18}F]NaF PET for response assessment of metastatic bone lesions, many factors need to be thoroughly understood. These include the understanding of the uncertainties and errors associated with quantitative [^{18}F]NaF PET imaging and how these uncertainties and errors impact treatment response assessment. Additionally, the reproducibility of [^{18}F]NaF PET imaging metrics need to be assessed to determine their value as quantitative biomarkers for response assessment.

This thesis work comprehensively characterized the uncertainties and errors in quantitative [^{18}F]NaF PET imaging and investigated the impact of these uncertainties and errors on absolute and relative quantitative PET measures used in treatment response assessment. The lesions within the patients were evaluated globally and individually to understand both inter-patient and intra-patient variations. Additionally, the reproducibility of [^{18}F]NaF PET imaging metrics such as SUV and textural features was evaluated. All these studies were performed on a

multi-center clinical trial data set that used [^{18}F]NaF PET/CT to assess treatment efficacy of metastatic bone lesions. We found that [^{18}F]NaF PET imaging is highly reproducible; however it is affected by many uncertainties which translate to uncertainties and errors in response assessment and these need to be taken into consideration in clinical practice. We also developed and tested a methodology to quantitatively harmonize the data from the different PET/CT scanners used in the trial to increase accuracy of [^{18}F]NaF PET/CT data. The methodology included both phantom-based and patient-based harmonization of the PET data.