Improving Patient-Specific Pre-Treatment Quality Assurance

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Rapid technology innovation in radiation therapy has lead to many advanced treatment techniques. A `side effect' of this development is that they have also introduced new sources of error that sometimes make radiation therapy treatment more fragile. As a result, the role of pre-treatment patient-specific QA in ensuring the quality of treatment and safety of patients has become more important than ever.

This dissertation presents the effort to improve the process of pre-treatment patient-specific dose QA. Conventionally, patient-specific QA is performed by comparing the planned and measured phantom dose, and action levels are based on the Gamma passing rate that is generated from this comparison. We started by exploring the question `Is Gamma passing rate correlated to clinically relevant patient dose errors'. Through a correlation study based on a virtual QA simulation scheme, we found only weak to moderate correlation between the planar QA passing rate and patient DVH errors. We then went on to perform similar study on 3D Gamma passing rate, both in phantom and in-patient, and determined the conventional QA lacks predictive power to clinically important patient dose error. Many false negative and false positive cases could be created during conventional Gamma-based QA.

In the second part of this dissertation, we aimed to explore new methods and metrics. We first evaluated a commercially available QA system that is capable of predicting the delivered patient dose from conventional QA measurement. The predicted patient dose was shown to be accurate, which opens the possibility of patient dose prediction based QA. We then explored the use of TCP and NTCP models as metrics for this new QA scheme. Through QA simulation under various types of induced errors, we have shown that ΔTCP and ΔNTCP are potentially good metrics for patient-specific QA. Using these new metrics will allow one to pass false positives and allow one to concentrate on errors that have potentially a large clinical impact. Through this process we have also demonstrated the potential use of these radiobiological models to evaluate the robustness of treatment plans to perturbation introduced by various sources of error.