Predicting isocenter shift due to prostate motion and selecting patient specific posterior margin for IGRT of prostate

Introduction: The motion of the prostate gland manifested as an isocenter shift (isoshift) in the left-right (LR), superior-inferior (SI) and anterio-posterior (AP) directions is a well known problem in prostate irradiation. Due to the apparent random nature of the motion, predicting the isoshift appears to be futile. Thus IGRT of prostate cancer is generally performed for the entire treatment course, requiring significant resources. In this study, we present our clinical data which demonstrate the predictive nature of the iso-shift. Using this predictive nature, it is possible to design a patient specific treatment margin with 95% confidence limit for more than 90% of the patients.

Materials and methods: A total of 2670 shift data from 1350 CT scans for 100 consecutive patients are reviewed and analyzed in this study. IGRT for prostate irradiation in our department is performed using a Siemens Primatom by image fusion of the Primatom CT images with the planning CT. In the first phase of treatment, each patient received 10-15 IGRT fractions. The iso-shift is reviewed every 5 fractions and an 'average' isoshift is determined for patient setup in the next 5 IGRT fractions. After all 10-15 IGRT fractions had been delivered, a final isoshift and a patient specific posterior margin are determined for the second phase of the irradiation. The accuracy of the isoshift is verified weekly by a CT scan (isocheck). To show the effect of the patient adjustment as a result of IGRT, the shift data for each patient is 'un-shifted' relative to the initial treatment isocenter. The frequency distributions (FD) of the 'un-shifted' and shifted data sets in the LR and AP directions are compared. The shift data from isochecks is also compared.

Results: The FD of the un-shifted data in the LR and AP directions follow that of a normal distribution, indicating the random nature of the prostate motion. The normalized FD of the un-shifted data in the AP direction (mean=0.18mm, SD=5.1mm) is shown in Fig. 1. The 2SD width (10mm) coincides with the posterior margin traditionally used in 3D planning. The shifted data superimposed on the un-shifted curve also shows a normal distribution (mean=-0.12mm, SD=4.1mm), validating an improvement in setup accuracy. Further improvement in setup accuracy is demonstrated in the isochecks (AP: mean=0.28mm, SD=3.4mm). The AP margin in the second phase of treatment is in the range 5-8mm for 90% of patients.

Conclusion: Despite the apparent random nature of prostate motion, we have used a simple method to predict the iso-shift and determine a specific margin to account for the prostate motion. The patient subgroup that lies outside of the 2SD range may indicate that a daily IGRT is needed for these patients.