Validation of motion-tracked prostate SBRT treatments with a transmission detector

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Introduction

Our clinic started treating prostate cancer with an SBRT approach in 2013. With the use of IMRT being a standard approach for these cases, a patient-specific plan validation is done prior to the start of treatment , with the assumption that the plan delivery does not change between the time of the QA and the final treatment.

With the low number of treatments with hypofractionated regimens, deviations in the quality of the delivered plan can have serious repercussions on the eventual control of the disease and/or potential co-morbidities that need to be managed. Adaptive radiotherapy has been one approach to solve one side of this problem by accounting for changes in dose distribution due to changes in patient anatomy. However the basic assumption that the plan delivered by the machine stays constant still stands.

In order to get a full picture of the plan delivered on the patient, this assumption needs to also be verified. The Delta^4 Discover from Scandidos (Uppsala, Sweden) is a relatively new transmission detector meant to answer this exact question.

This project presents data for one of our prostate SBRT patients where the Discover was used during pre-treatment QA and for each treatment fraction, allowing us to verify the machine performance as the treatment progressed.

Methods and Materials

The Discover unit mounts to the gantry head (Figure 1) during patient treatment to measure the fluence delivered throughout each treatment fraction.

When used by itself, the Discover can point out errors in MLC leaf, gantry and collimator positions by comparing measurements to what was planned. However, if the Discover is used in conjunction with the Delta4 Phantom at pre-treatment QA time, then a correlation can be made between the signal level of in the Discover and the doses measured in the phantom. This correlation can then be used during patient treatment fractions to predict a dose distribution in the phantom for that fraction. This, in turn, can then be used to calculate the dose in the patient CT to provide feedback to the user on the clinical relevance of any deviation detected in the quality of the plan.

This approach was used for this patient, where immediate feedback was available after the treatment delivery for each fraction with a predicted dose distribution in the phantom and the associated gamma passrate. This phantom dose was then used to calculate the dose in the patient.

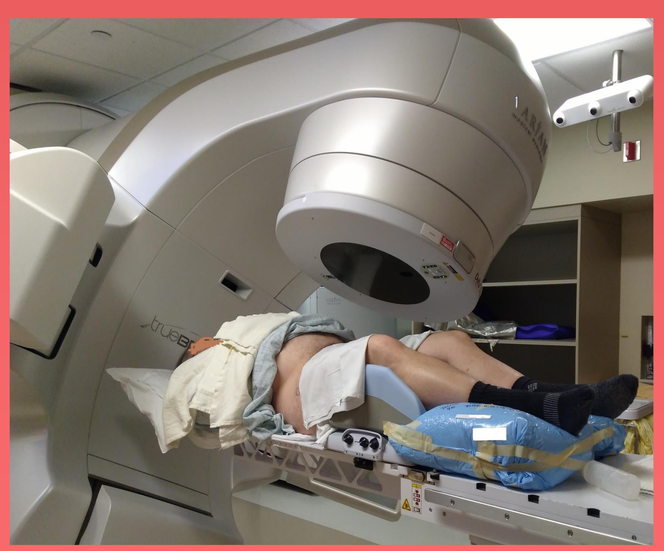

Figure 1 – The Discover mounted on the gantry head for patient treatment

Results and Discussions

After each treatment delivery, the dose distribution calculated in the phantom resulted in a gamma distribution that was passed our clinical criterion (>75% of points with gamma ≤ 1 for a 2%,2mm criterion). The ongoing summation of doses predicted from all delivered fractions also showed that total dose delivered met the same criterion.

A closer look at the gamma pass-rates, however, showed that, while the value at pre-treatment QA was around 97%, it had dropped down to close to 75% (our clinical criterion) at fraction 3. This is shown in Figure 2. By fraction 4, the pass-rate went back to 92%. This behavior prompted an investigation which showed that the Discover was actually capturing the change in daily output over the first three days of treatment as also shown in Figure 2.

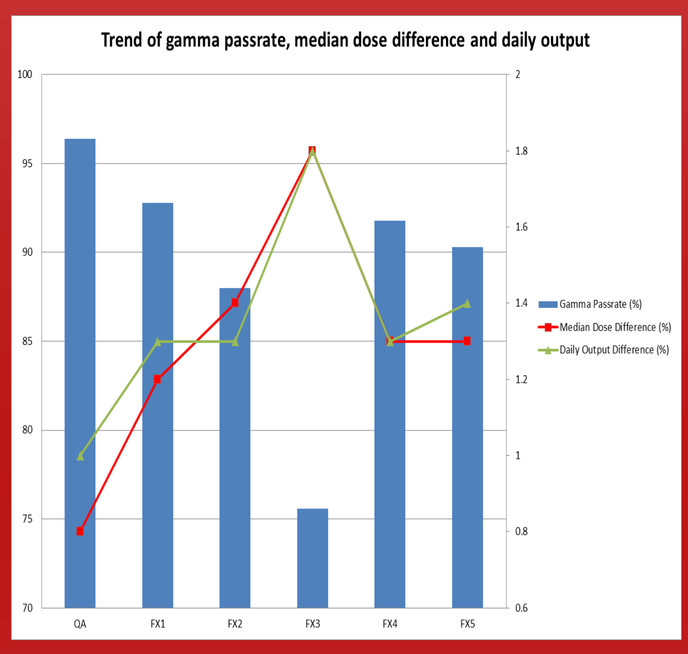

Figure 2 : The height of the columns shows the gamma (2%/2mm) pass-rate for QA and each fraction. The line charts show the median dose deviation predicted from Discover (red) and the dose output measured by our daily output check device (green)

It should be pointed out that the daily output variation was well within acceptable limits but, given the gamma dose criterion being used is 2%, the fact that the dose output was getting close to that criterion explains why more points were failing the gamma requirements, lowering the pass-rate.

With the current workflow used in most clinics where QA is only performed once, prior to delivery, these changes are not necessarily recognized easily. However, with a transmission detector such as the one investigated here, immediate feedback is provided for each fraction so that the treating team can make informed decisions on how to proceed with treatment, especially for hypofractionated regimens where even small deviations can have large consequences due the higher fractional dose.

Conclusion

This project investigates the use of a transmission detector to characterize the quality of the delivered plan for every treatment fraction. The case presented here clearly shows that the plan quality does change for each treatment due to changes in machine output or small differences in leaf position. This information can prove invaluable to the treating team in determining how to proceed with treatment when non-ideal treatment delivery quality is observed.

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Physics track: Basic dosimetry and phantom and detector development

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