Measuring Radiation Isocenter Performance Using Conically-Shaped Scintillator Screen Imaging Device

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Introduction

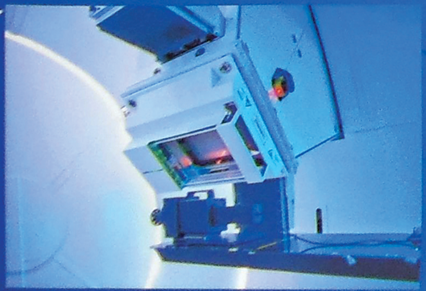
Due to the size, weight and therefore flexing of typical proton therapy gantries, the mechanical isocenter alone is not often relied upon solely for treatment isocentricity. The goal of this study is to investigate the use of a commercially available device, primarily utilized in Cyperknife facilities, as a tool for quantifying the position of the radiation isocenter. Radiation isocenter is indicated by the central axis proton pencil beam. The study quantifies the radiation isocenter as a function of gantry rotation for both commissioning and quality assurance.

Materials and Methods

Logos XRV-100

The ***XRV-100*** consists of a 60 degree cone laminated with an X-ray scintillator phosphor. As a single proton pencil beam passes through the cone, two spots of visible light are formed by Compton scattering at the entry and exit points of the beam. The two spots define a path of the radiation in three-dimensional space.

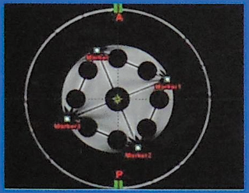
BeamWorks, the XRV-100 software, uses the entry and exit point data, known geometry of the detector, and basic fitting algorithms to determine the coincidence of the pencil beam with the isocenter and the angle of entry relative to room. This data may be exported in several formats, such as text or Microsoft Excel files, for further in-house analysis.



Methodology

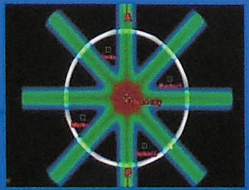
The methodology for data acquisition is similar to an end-to-end system test. That methodology is as follows:

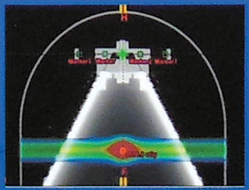
- A computed tomography (CT) image of the XRV-100 is acquired at the CT simulator. That image is imported to the treatment planning system, and serves as the basic image for the alignment and delivery systems.
- A treatment plan with a single spot at eight gantry angles is created. The planning isocenter corresponds to a certain X, Y, Z location relative to the fiducials embedded in the conical scintillator.
- Then, the XRV-100 is aligned in the treatment room using orthogonal x-ray positioning system as compared to digitally reconstructed radiographs (DRR) and embedded fiducials.



Four fiducials embedded in detector for detector alignment. Fiducials are precisely machined, at known locations relative to conical scintillator geometry.

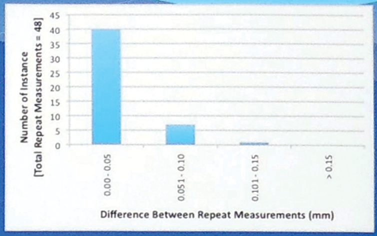
- Once aligned, a single spot at 200MeV is delivered at each of the eight planned gantry angles.



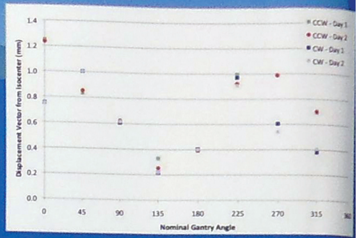


For part of the study, each angle was approached clockwise (CW) and counter clockwise (CCW). Additionally, data was repeated on subsequent days to assess reproducibility.

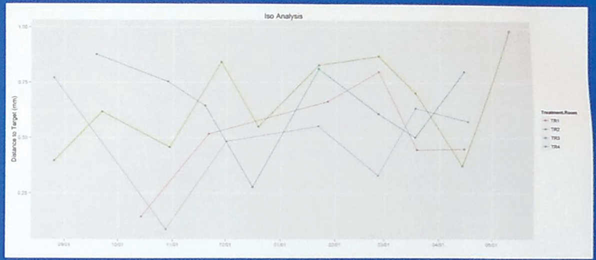
Results



For the given study, the reproducibility of the entire system (gantry + detector + methodology) is better than 0.2mm.



For Clockwise (CW) versus Counter-Clockwise (CCW), the isocenter coincidence it, at worst, 0.4mm, with the majority of the same-angle points within 0.2mm.



The overall trueness of the systems' data is still being evaluated. The system is, of course, limited by the ability to align the detector to the DRRs. Generally, aligning to better than 0.25mm is difficult. This institutes an overall 0.25+mm accuracy limit.

Also, in a 9 month period across four treatment rooms, the trend analysis indicates the imaging-proton coincidence remains within 1.0mm. There is a potential for up to 0.75mm magnitude drifts in the isocenter position coincidence. However, this requires further study.

Conclusion

The XRV-100 is a very valuable tool in quantifying the imaging and proton beam isocenter coincidence. It has large efficiency benefits over standard methods, such as Winston-Lutz. Eight gantry angles can be verified in less than 30 minutes. The system methodology is reproducible and accurate. Further study is warranted in determining the absolute accuracy limit, especially as it relates to detector alignment, inter-user variability and comparison to other techniques.

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