TPS Accuracy at 1 Meter Extended-Distance for a Novel TBI Technique

Shealynn Burgess [1*], David Delaney [1*], and Stefano Peca [2]
1 Suffolk University, Boston, MA
2 Beth Israel Deaconess Medical Center, Boston, MA
* Authors contributed equally to the work

Beth Israel Lahey Health
Beth Israel Deaconess Medical Center

INTRODUCTION

Total Body Irradiation (TBI) aims to deliver a uniform dose to the entire body, with a uniformity goal of ± 10% [1].

Indication: for hematological malignancies, to suppress the immune system before the patient receives a transplant of bone marrow or hematopoietic stem cells.

Non-CT-based arc-TBI is simple, robust, and can be done with a standard linac [2]. However, due to the target volume size, it is difficult to fully characterize and optimize (e.g. energy, field size, arc segment weighting) using measurements alone.

Here we quantify the dosimetric accuracy of a clinical Treatment Planning System (TPS) in multiple conditions, 1-1.5 m away from isocenter, to justify the use of the TPS to guide parameters for future arc-TBI plans.

AIM

To test the accuracy of Varian Eclipse TPS calculations at extended SSDs below isocenter.

- Determine the effect on dose calculation accuracy of X-ray **energy** and **field size** across different **depths.**
- Quantify the impact of a **spoiler plate** on dose, and the accuracy of the TPS in modelling it.

METHOD

Measured and calculated doses were compared using the percent difference from the measured value.

A. Dose Accuracy 1 Meter Below Isocenter

Solid water phantoms (30x30x20 cm^3) were placed 90 cm below the level of isocenter in two locations: directly below isocenter (SSD 190 cm), and 90 cm laterally in the plane of gantry rotation (along gantry angle of 318°). At each location, ion chamber measurements were recorded at depths of 1 cm, 3 cm, and 10 cm, for static fields of three field sizes (20x40 cm, 30x40 cm, 40x40 cm) and two energies (6 MV, 10 MV).
This setup was replicated in Eclipse. TPS phantoms were generated to match the dimensions of the physical solid water. The density was set to that of water (1 g/cm^3).

B. Dose Calculation and Measurement with Beam Spoiler

The same setup was used with the presence of a 1.3 cm-thick, acrylic spoiler plate. Only measurements at gantry 0° were taken. The spoiler was set at an SSD of 157.5 cm, approximately 31 cm above the solid water.
Measurements were taken at depths of 1 cm and 3 cm with the same field sizes and energies listed above
The setup was again replicated in Eclipse. The generated spoiler plate phantom was set to a density of 1.19 g/cm^3.

RESULTS (A): Dose Accuracy 1 Meter Below Isocenter

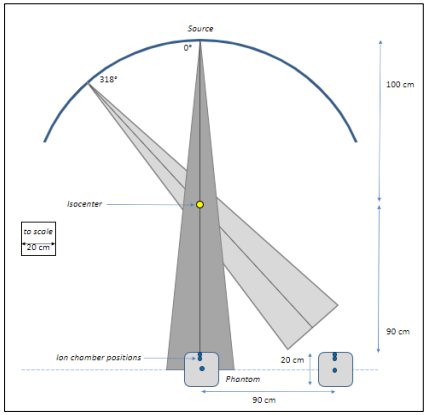

Figure 1 *– Setup for the physical measurements. Phantom location 1 is at 190 cm SSD, location 2 is 90 cm lateral*

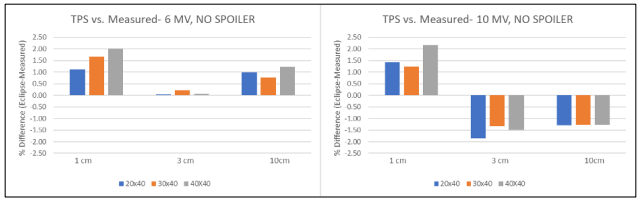

Figure 2 *– Dose percent difference (Eclipse-Physical) for gantry at 0° **(phantom location 1)***

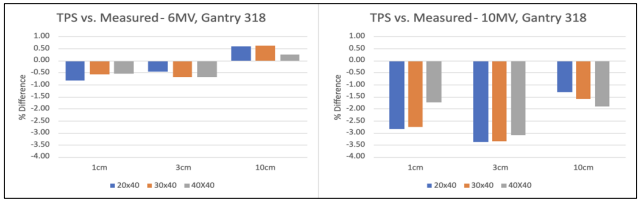

Figure 3 *– Dose percent difference (Eclipse-Physical) for gantry at 318° **(phantom location 2)***

RESULTS (B): Dose Calculation and Measurement with Beam Spoiler

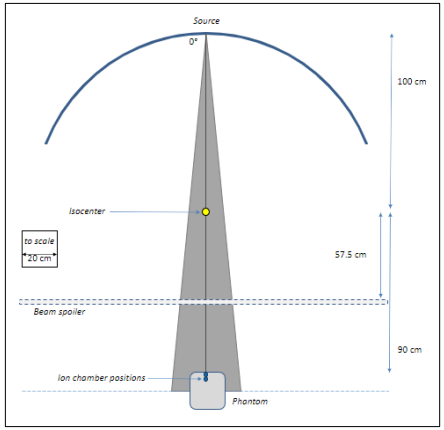

Figure 4 *– Setup for physical measurements with a beam spoiler*

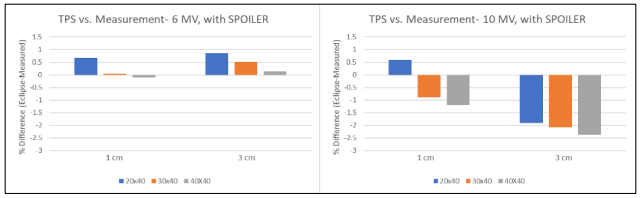

Figure 5 *– Dose percent difference (Eclipse-Physical) with beam spoiler*

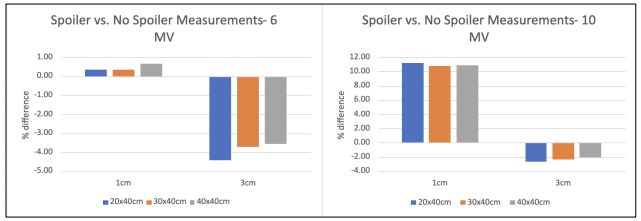

Figure 6 *– Actual effect of spoiler plate: Dose percent difference (Spoiler measurement - No Spoiler measurement)*

CONCLUSIONS

Under all conditions, the TPS-calculated dose was within 5% of the measured dose. Eclipse can accurately model dose at extended distances below isocenter for various energies, field sizes, and depths with or without a spoiler plate. This justifies the use of TPS calculations in determining the optimal parameters (energy, field size, weights) for future arc-TBI research.

In addition, we confirmed the need for a beam spoiler plate to provide adequate surface dose if using 10 MV. At a depth of 1 cm (buildup region) approximately 10% of the 10 MV dose comes from the spoiler (from secondary electrons). At 3 cm depth, on the other hand, the dominant effect is the additional attenuation (for both energies).

LIMITATIONS

We did not take physical measurements at 90 cm lateral distance in the presence of the spoiler plate due to setup limitations.

Higher energies such as 15 MV were not available.

FUTURE WORK

This work is essential for creating sweeping-arc plans for TBI patients using Eclipse. Further research will be needed to quantify the homogeneity of dose distributions of such plans, and thus their clinical feasibility.

A 'library' of arc-TBI plans could be created on various-sized anthropomorphic phantoms to model different patient sizes and shapes. Such '**TPS-optimized Arc-TBI**' has the potential to provide high-quality treatments while maintaining efficiency and simplicity for the clinic.

REFERENCES

[1] Van Dyk J, et al. AAPM Rpt.17 of TG-29: The Physical Aspects of Total and Half Body Photon Irradiation.; *1986.*
[2] Jahnke A, et al. Arc therapy for total body irradiation - A robust novel treatment technique for standard treatment rooms. *Radiother Oncol. 2014;110(3):553-557.*

CONTACT INFORMATION

shealynn.burgess@su.suffolk.edu, david.delaney@su.suffolk.edu, speca@bidmc.harvard.edu