Preliminary 2D and 3D Gamma calculation comparison using PRESAGE®

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Introduction:

To move from 2D dosimetry to 3D dosimetry in anthropomorphic phantoms, comparable pass/fail criteria need to be investigated. It has been suggested from Monte Carlo studies that 3D gamma pass rates are up to 2.9% higher than 2D counterparts [1]. Appropriate criteria need to be defined to allow for quality assurance pass rates to be of clinical value.

Methods and Materials:

An IROC Houston (RPC) head and neck phantom was irradiated with a 9 beam IMRT plan using two inserts: a TLD and film insert and a PRESAGE® insert seen in figure 1. Both inserts were irradiated 3 times for a total of 6 irradiations. The relative doses measured with film and PRESAGE® were scaled to the absolute dose measured with TLD. 2D gamma calculations were made in the axial and sagittal planes bisecting the primary target, as shown in figure 2. 3D gamma measurements were taken within the PRESAGE® dosimeter volume covering the entire volume, excluding optical artifacts at the dosimeter edge. Gamma constraints of 3%/3mm distance to agreement (DTA), 5%/3mm DTA and 7%/4mm DTA were used in the study. The 3 irradiations for each insert were averaged together for comparison.

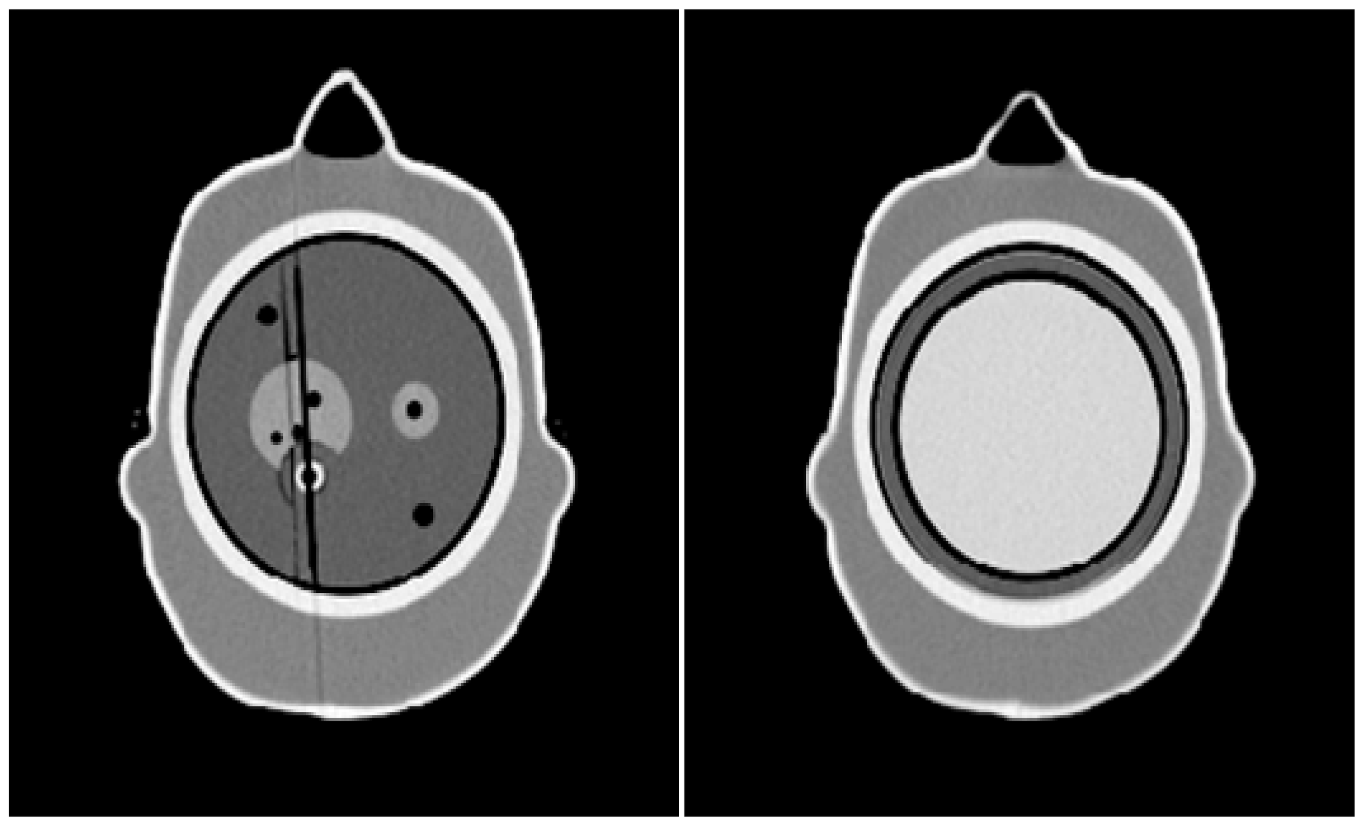

Figure 1: CT slice of the head phantom with the imaging insert (left) and the PRESAGE® insert (right)

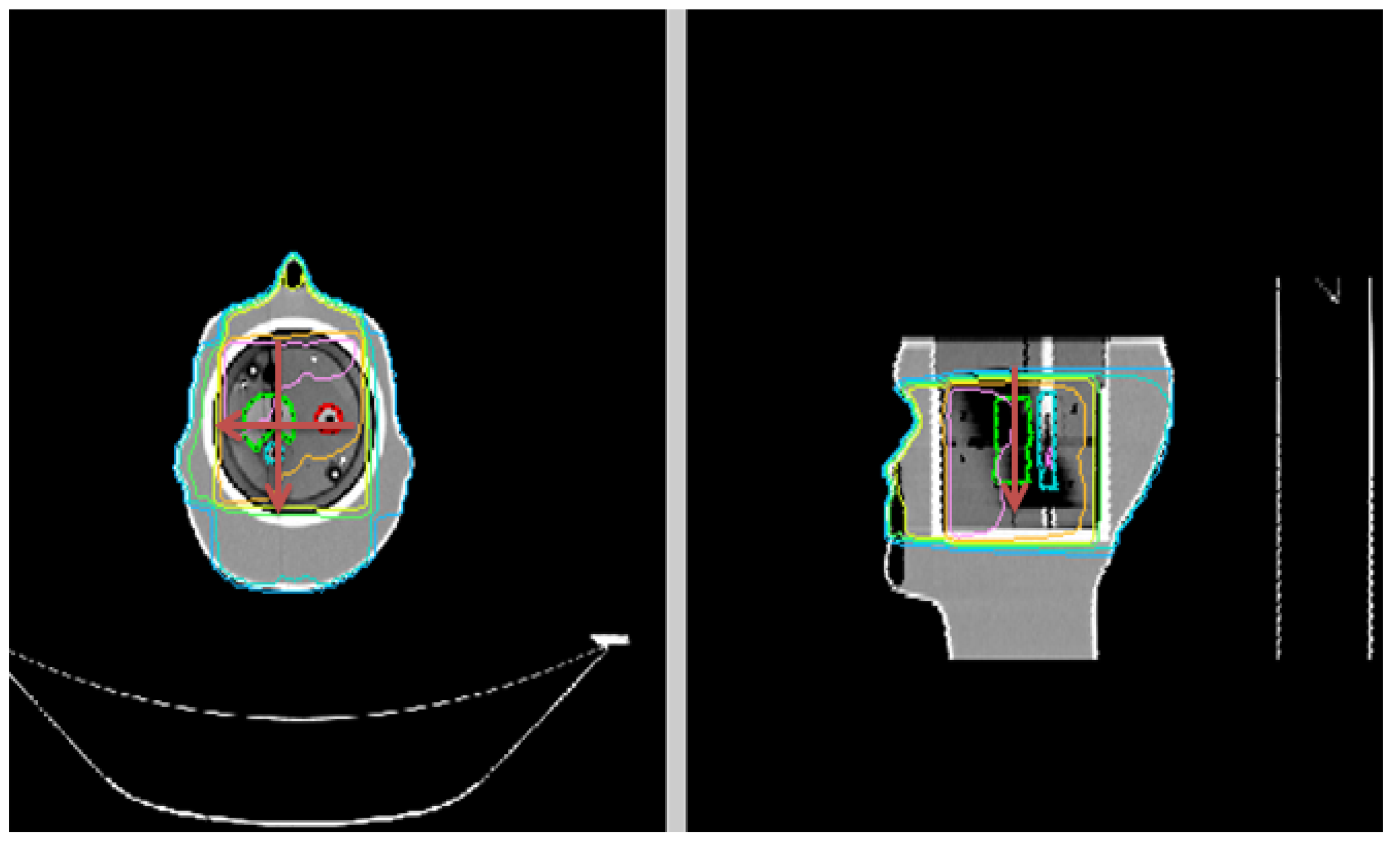

Figure 2: Treatment plan with arrows to indicate the direction of the planes used for 2D gamma calculations

Results:

A 2D gamma analysis of the film measurements showed 85% pixels passing at 3%/3mm in both planes. The 5%/3 mm constraint had 93% and 90% passing in the two planes. The 7%/4mm constraint yielded 99% passing in both planes. The PRESAGE 2D gamma passed 66% and 61% of pixels in the two planes at 3%/3mm. At 5%/3mm, 86% and 82% passed. For 7%/4mm, 94% of pixels passed in both planes. In contrast, a 3D gamma analysis resulted in a pass rate of 90% at 3%/3mm, 95% at 5%/3mm, and 99% at 7%/4mm.

	Contraints	Film	PRESAGE®
Axial Plane	3%/3mm	85%	66%
	5%/3mm	93%	86%
	7%/4mm	99%	93%
Sagittal Plane	3%/3mm	85%	61%
	5%/3mm	90%	82%
	7%/4mm	99%	91%

Table 1: Percentage of passing pixels from 2D gamma calculations

Constraints	PRESAGE®
3%/3mm	90%
5%/3mm	95%
7%/4mm	99%

Table 2: Percentage of passing pixels from 3D gamma calculations over the 3D dosimeter minus the edge effects

Discussion:

The results from 2D and 3D gamma analyses of both film and PRESAGE® dosimeters are listed in tables 1 and 2. The comparison showed PRESAGE® had a greater sensitivity to 2D gamma results. All of the 3D gamma results had a pass rate no less than 90%. Using only a 2D calculation with PRESAGE® showed a sensitivity that needs to be investigated further. As of now, 2D PRESAGE® evaluations using criteria more strict than 7%/4mm criteria appear too demanding. 3D gamma calculations showed pass rates within 5% compared to film but above the 2.9% difference found by Pulliam *et.al.* This is most likely due to the difference in dosimeter and evaluation techniques between film and PRESAGE®. The preliminary data show the differences in gamma measurements and the large difference with PRESAGE® itself from 2D to 3D calculations create a need for further investigation for a pass/fail criteria using a true 3D dosimeter in phantom measurements.

Conclusion:

2D gamma pass rates using film showed a higher pass rate than PRESAGE using the same criteria in the same planes. This may be due to poor registration of the PRESAGE® data with the treatment plan compared to the 2D film registration system. The 3D gamma results had a higher pass rate (> 90% pass rate) possibly because many more pixels were sampled in noncritical volumes thus diluting the percent of pixels passing. 3D constraints should be more restrictive to be comparable to 2D results.

References:
1.Pulliam, K. B., *et. al.* (2014). Comparison of 2D and 3D gamma analyses. *Med Phys, 41*(2),