IBAC Fluence to Film Dose FWHM Comparison

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Introduction

The CyberKnife Iris collimator shapes the radiation beam into a dodecagon that approximates a circle and is capable of 12 different beam diameters: 5, 7.5, 10, 12.5, 15, 20, 25, 30, 35, 40, 50, and 60 mm. Measurement of these beams is typically performed at 800 mm SAD using film, scanner, and third-party software. The goal of this study was to determine if X-ray beam fluence measured near the Iris collimator beam exit (400 mm) can be used to reliably predict Full Width Half Maximum (FWHM) film dose diameters at 800 mm SAD.

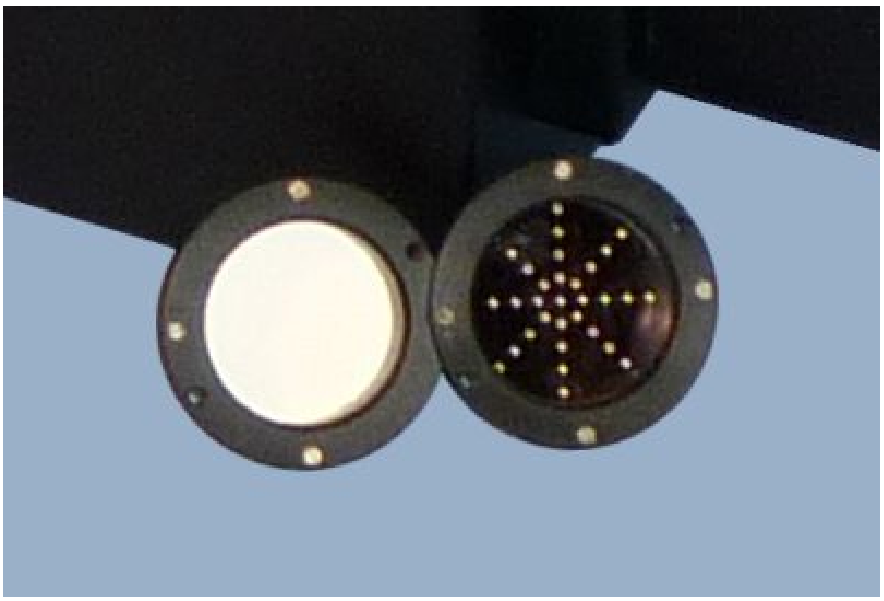

Figure 1 – The IBAC converts X-ray beam fluence to visible light using the scintillator module shown on the left. The calibration module on the right is used by the software to convert pixels distances into millimeters. Visible light from these modules is reflected off a mirror and directed to a CCD camera connected to a computer.

Materials and Methods

A camera/scintillator system (Iris Beam Aperture Caliper – Logos Systems) was connected to the CyberKnife such that either the scintillator or the calibration module could be inserted within a millimeter of the collimator lower surface. This surface is located 400 mm from the linear accelerator beam source.

X-ray fluence images were captured for the 12 Iris apertures. The IBAC software measured 72 FWHM diameters at 5 degree intervals on each beam spot in order to develop the average.

Figure 2 – The IBAC is shown attached to the CyberKnife Iris with the scintillator module access door open.

EDR2 film was used to capture beam images of the 12 aperture sizes at 800 mm SAD. Each exposure used 200 MU and was made with 15 mm of tissue equivalent build-up and 82 mm of back scatter material.

A Vidar scanner was used to scan the film and the images were brought into RIT software to measure FWHM dose diameters for each beam. In addition, the film images were input into the IBAC software and agreement was verified between the IBAC and RIT image processing algorithms with a maximum delta of 0.06 mm and an average delta of 0.03 mm (standard deviation 0.01 mm).

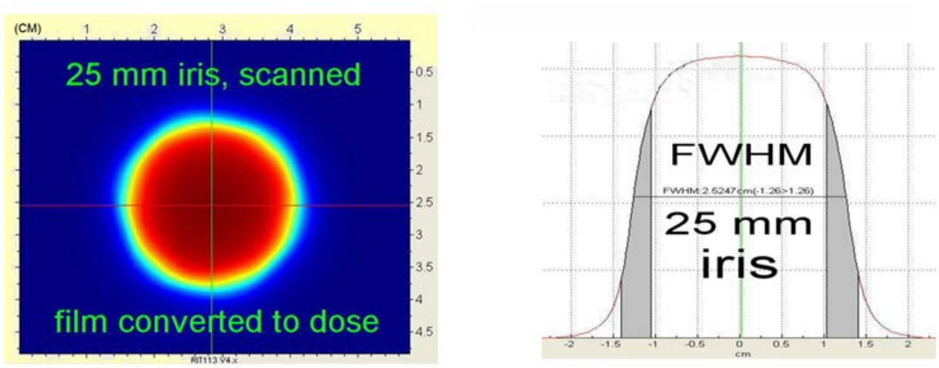

Figure 3 – RIT user interface output for the Iris 25 mm measurement

Test Results and Analysis

Since the IBAC measurements were made at 401 mm and the film measurements at 800 mm SAD, all IBAC FWHM measurements were multiplied by a factor of 800/401 before comparing them to film.

Iris Aperture (mm)	IBAC FWHM (mm)	Film - RIT FWHM (mm)	Delta IBAC vs Film (mm)	Absolute Value Delta IBAC vs Film (mm)
5	5.29	5.62	-0.33	0.33
7.5	8.46	8.34	0.12	0.12
10	10.89	10.64	0.25	0.25
12.5	13.29	12.97	0.32	0.32
15	15.74	15.42	0.32	0.32
20	20.59	20.25	0.34	0.34
25	25.48	25.22	0.26	0.26
30	30.44	30.23	0.21	0.21
35	35.11	34.93	0.18	0.18
40	39.96	39.78	0.18	0.18
50	49.78	49.57	0.21	0.21
60	59.61	59.42	0.19	0.19
			Average	**0.24**
			Std. Dev.	**0.07**

Figure 4 – FWHM Comparison Results

The IBAC fluence diameters when projected from 401 to 800 mm SAD were equivalent to the film dose measurements with an average delta of 0.24 mm (standard deviation 0.07 mm). The eleven largest apertures showed a consistent trend with IBAC fluence measurements being larger than film by 0.2 to 0.3 mm. difference between the projected fluence beam widths and the expected 5 mm to 40 mm dose beam width at 80 cm.

The exception to this pattern was the 5 mm Iris aperture. Closer inspection with the IBAC showed that gap asymmetry between the lower collimator leaves causes the beam spot to be less circular at 400 mm.

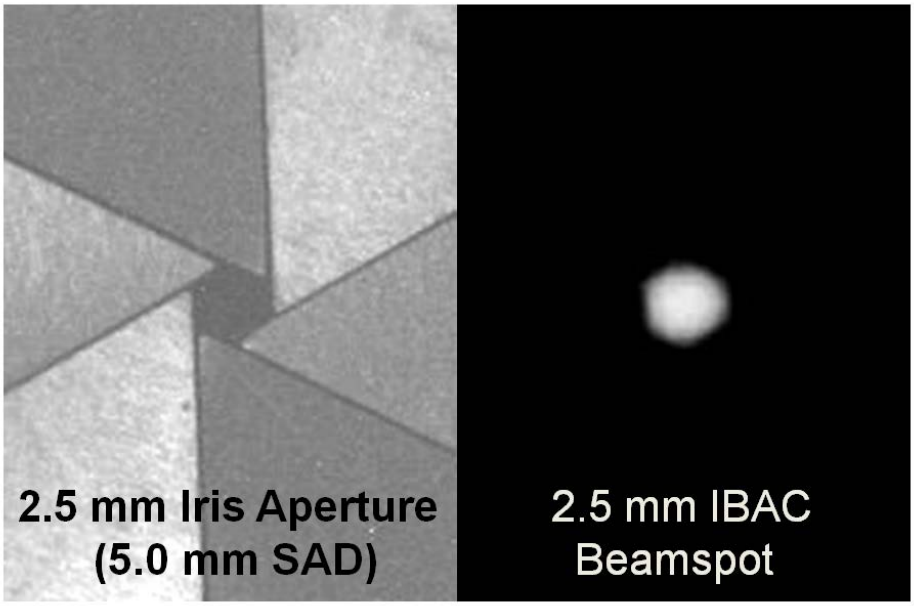

Figure 5 – Asymmetry of smallest Iris aperture and beam as imaged with the IBAC

The time required to perform the IBAC measurements was 20 minutes while the time needed to expose, scan, and measure the film was 2 hours.

Conclusion

This work indicates that the IBAC system can be used to produce fluence FWHM measurements that closely correlate with the result of conventional film based systems. Since no film is used and the total amount of time saved is more than 1.5 hours, measuring the fluence at the collimator source with the IBAC can be seen as an effective Iris QA alternative, having a lower incremental cost per measurement.

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