Film-Based Commissioning of Valencia Skin Applicators – the Sutter Experience

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ABSTRACT

Purpose: To report clinical experience in commissioning Valencia surface applicators by applying published guidance and using fully film-based methods to assess source positioning, flatness/symmetry, depth dose, and output verification.

Methods: Commissioning of the 2-cm and 3-cm diameter Valencia applicators was performed using the Varian Bravos afterloader, Gafchromic EBT3 and EBT4 film calibrated with a 6 MV TrueBeam linear accelerator, and an EPSON 10000XL scanner using RIT for film analysis. Film batches were calibrated with doses ranging from 0-1000 cGy for purposes of absolute dose confirmation. Flatness and symmetry measurements were performed using film in solid water at a depth of 3 mm. Depth dose measurements were assessed using two different film orientations.

Results: For both the 2-cm and 3-cm diameter Valencia applicators, positioning the source 1 mm back from the applicator tip resulted in flatness and symmetry within +/-5% in both directions. Absolute dose measurements using the first film batch initially showed a systematic under-response relative to the planned dose. Subsequent measurements using a new film batch showed deviations of 4-7%, which is within the expected uncertainty. Depth dose values were largely within published specifications. One depth dose point initially exceeded tolerance when measured with the film oriented perpendicular to the applicator face. However, a spot check using film oriented parallel to the applicator face yielded agreement within 0.5%, and further measurements are ongoing to assess orientation-dependent effects. During end-to-end testing, improper applicator cap seating produced pronounced asymmetry ranging from -29% to 56%.

Conclusion: This clinical experience demonstrates that a fully film-based commissioning approach for Valencia applicators provides reliable data for quantifying source position, flatness, symmetry, depth dose, and output verification. It also reinforces the importance of accurate applicator assembly by highlighting the sensitivity of dose distribution to applicator cap seating.

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INTRODUCTION

Initially, superficial HDR brachytherapy treatments at our clinic were performed using a surface applicator set in which the single dwell source was oriented perpendicular to the treatment surface.

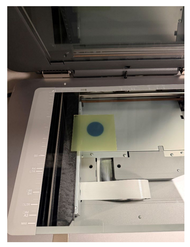
To improve dose uniformity, we pursued implementation of the Valencia applicator (Figure 1). Its design incorporates an internal flattening filter with the source positioned parallel to the treatment surface, providing a more desirable dose distribution.

Figure 1. Valencia Schematic [7]

Clinical deployment within a reasonable time frame required an efficient commissioning approach using resources readily available in our department. Therefore, we elected to apply published guidance to develop a fully film-based approach for evaluation of source positioning, flatness/symmetry, percent depth dose, and direct output verification. [1-6]

METHODS AND MATERIALS

Commissioning of the 2-cm and 3-cm diameter Valencia applicators was performed using the Varian Bravos afterloader and Gafchromic EBT3 and EBT4 film calibrated with a 6 MV TrueBeam linear accelerator. The film analysis was performed with an EPSON 10000XL flatbed scanner and RIT Classic Version 6.11 software. Approximately, 1”x 8” strips of film were cut and exposed to a 10x10cm field with doses ranging from 0-1000 cGy for purposes of absolute dosimetry.[1] Films were marked for consistent orientation and scanned in individually with a resolution of 72 dpi.

The first step was to determine at what dwell position the source aligned with the flattening filter to provide the best flatness/symmetry.

Then, for flatness/symmetry and absolute dose measurements, the film was oriented in a plane perpendicular to the axis of the radiation beam and positioned between solid water slabs at 3 mm depth (a typical clinical Rx depth). A dose of 700 cGy was planned and delivered using the calculation worksheets (Figure 2)[7]. Although 700 cGy is not the typical Rx dose, higher doses were recommended in the literature if performing absolute film dosimetry.[4]

Valencia In-House Calculation Worksheet
SUTTER CANCER CENTERS RADIATION ONCOLOGY SERVICES - HDR

Today's Date:	3/4/2024
Patient Name:	Val Valencia
EPIC #:	
Physician:	Select a Physician
Physicist:	JSG
Treatment Site:	
Dose/Fraction (cGy):	700
Treatment Depth (mm):	3
DD (%):	100
Valencia Applicator Diameter (cm):	2
Applicator Output Factor (cGy/(hr*U)):	0.2215
Reference Air Kerma Rate for 10 CI (mGy*cm²/hr):	40.7
Calculated Treatment Time =	**279.53**

$$\frac{T_f}{[s]} = \frac{D_{prescr.f}}{[Gy]} \cdot \frac{1}{\frac{DD}{[\%]} \cdot \frac{OF}{[cGy\,h^{-1}\,U^{-1}]} \cdot \frac{RAKR}{[mGy\,h^{-1}]}} \cdot 3.6 \cdot 10^4$$

$1\ U = 1\ \mu Gy\ m^2 h^{-1} = 1\ cGy\ cm^2\ h^{-1}$

Valencia In-House Calculation Worksheet
SUTTER CANCER CENTERS RADIATION ONCOLOGY SERVICES - HDR

Today's Date:	3/4/2024
Patient Name:	Val Valencia
EPIC #:	
Physician:	Select a Physician
Physicist:	JSG
Treatment Site:	
Dose/Fraction (cGy):	700
Treatment Depth (mm):	3
DD (%):	100
Valencia Applicator Diameter (cm):	3
Applicator Output Factor (cGy/(hr*U)):	0.1733
Reference Air Kerma Rate for 10 CI (mGy*cm²/hr):	40.7
Calculated Treatment Time =	**357.28**

$$\frac{T_f}{[s]} = \frac{D_{prescr.f}}{[Gy]} \cdot \frac{1}{\frac{DD}{[\%]} \cdot \frac{OF}{[cGy\,h^{-1}\,U^{-1}]} \cdot \frac{RAKR}{[mGy\,h^{-1}]}} \cdot 3.6 \cdot 10^4$$

$1\ U = 1\ \mu Gy\ m^2 h^{-1} = 1\ cGy\ cm^2\ h^{-1}$

Figure 2.

Depth dose measurements were assessed using two different film orientations: (1) With the film oriented perpendicular to the plane of the applicator face & (2) With the film oriented parallel to the plane of the applicator face.

RESULTS/DISCUSSION

For both the 2-cm and 3-cm diameter applicators, positioning the tip of the source wire 1 mm back from the end of the applicator lumen resulted in flatness and symmetry values within +/-4% in both directions. (Green plots are in in direction of source travel.)

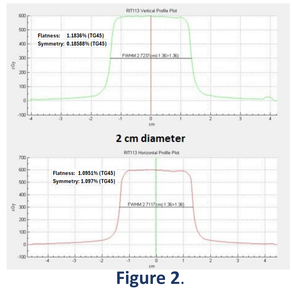


Figure 2.

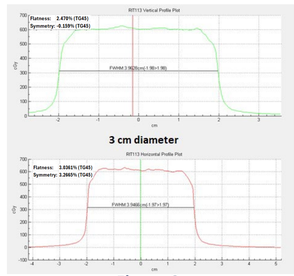


Figure 3.

However, absolute dose measurements yielded approximately 600 cGy (Figures 2 and 3) instead of the expected dose of 700 cGy. To try to resolve this issue, measurements were repeated with a new film batch. The thought was perhaps this discrepancy was due to the original film batch being close to its expiration.

In Figures 4 and 5, with the new film batch, the flatness and symmetry were still within +/-4%, but now the absolute doses were also within +/-2-5% of 700 cGy.

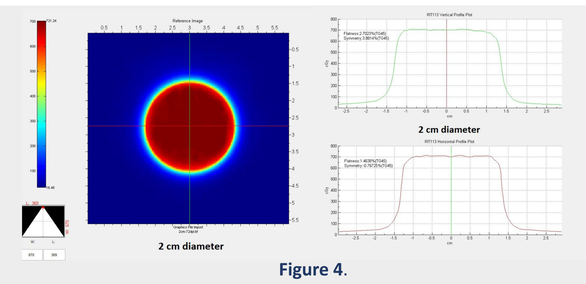


Figure 4.

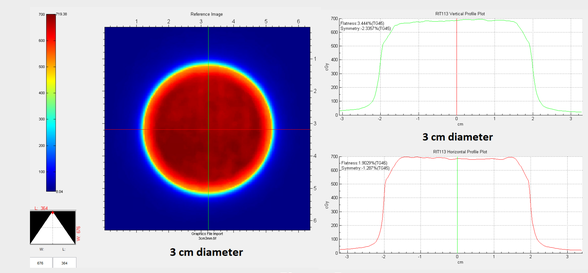
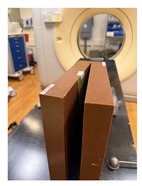
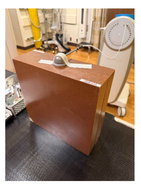
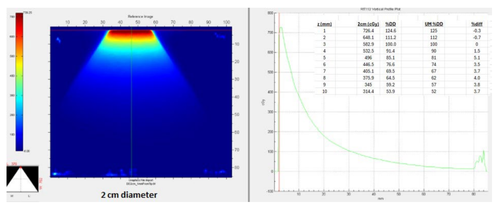
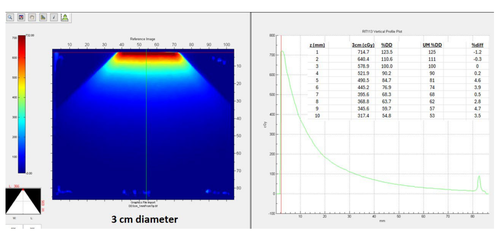


Figure 5.

To confirm the depth doses that are published in the Valencia User Manual[7], two setups were utilized.

Setup 1:

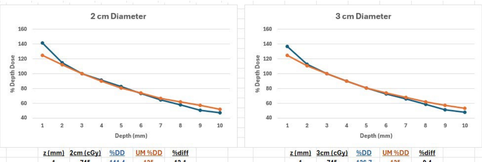






RESULTS/DISCUSSION

These results were all within expected uncertainty at the depths of clinical interest. However, given that there was some variability in aligning the film precisely to the very edge of the solid water slab, measurements were taken using a second setup.

Setup 2:

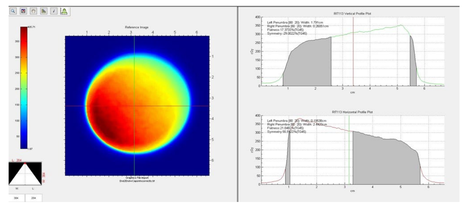


z (mm)	2cm (cGy)	%DD	UM %DD	%diff
1	745	141.4	125	13.1
2	605	114.8	112	2.5
3	527	100.0	100	0.0
4	480	91.1	90	1.2
5	435	82.5	81	1.9
6	385	73.1	74	-1.2
7	340	64.5	67	-3.7
8	305	57.9	62	-6.6
9	265	50.3	57	-11.8
10	250	47.4	52	-8.8

z (mm)	3cm (cGy)	%DD	UM %DD	%diff
1	745	136.7	125	9.4
2	615	112.8	111	1.6
3	545	100.0	100	0.0
4	490	89.9	90	-0.1
5	440	80.7	81	-0.4
6	395	72.5	74	-2.0
7	360	66.1	68	-2.8
8	320	58.7	62	-5.3
9	280	51.4	57	-9.8
10	260	47.7	53	-10.0

At clinically relevant treatment depths (2-4 mm), film proved to be an appropriate dosimeter for depth dose measurements, with Setup 1 demonstrating better agreement across all measured depths. In addition to its improved dosimetric agreement, Setup 1 required only a single irradiation for each applicator, eliminating the need for multiple 1 mm solid water slabs.

Following the initial applicator commissioning, an end-to-end test was performed, and surprisingly, this was the resultant dose distribution:



Upon visual inspection of setup, it was noted that one edge of the plastic cap was not flush with the applicator face, illustrating how easily improper cap seating can be overlooked.

Consequently, the pre-treatment checklist was updated to include a second verification of cap placement prior to Parafilm® wrapping and treatment delivery.

CONCLUSIONS

A fully film-based commissioning approach was successfully implemented for the Valencia applicator using in-house resources. The process enabled efficient verification of source positioning, flatness/symmetry, absolute output, and depth dose, while revealing a clinically relevant applicator assembly sensitivity. This workflow offers a practical pathway for routine clinical commissioning.

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