# Commissioning of Venezia Lunar Ovoid Applicator Using Electron Autoradiograph

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## Introduction

The Venezia applicator (Elekta, Sweden) is a new applicator designed for high-dose-rate brachytherapy (HDR-BT) treatment of gynecological (GYN) malignancies. It gains clinical application potential because (1) it is easier to be assembled than a Fletcher or a Utrecht GYN applicator; (2) it provides more flexibility in dose distribution by combining intracavitary and interstitial HDR-BT treatment together. One unique design is its lunar-shaped ovoid, which is challenging to applicator reconstruction.

The purpose of this work is to present our commissioning experience with the Venezia ovoid reconstruction. Specifically, to develop a new method to measure Venezia lunar ovoid offset (the distance from center of the most distal source dwell position to lumen tip end).

## Methods

Electron autoradiographs were acquired for offset measurement. An EBT3 film was taped to a Venezia lunar ovoid applicator (30 mm diameter) which was attached to a Flexitron brachytherapy remote afterloader through a transfer tube. The ovoid was oriented similar to clinical setup of an HDR treatment for gynecologic cancers (Figure 1). An Ir-192 HDR source was sent to dwell at the most distal position for 25 s, leaving a visible mark on the film that defines the 1st dwell position. With the ovoid still taped to the film, it was exposed to 600 MU from a 12 MeV electron beam from a TrueBeam linac. The tip end of the lumen was visible on the exposed film, which was marked and digitized using a flatbed scanner. Distance from source dwell center to the marked lumen end was measured using ImageJ software. This process was repeated for 22 and 26 mm diameter lunar ovoids.

Figure 1 shows setup for electron autoradiograph measurement (Left) using a TrueBeam linear accelerator and (Right) using a Flexitron HDR afterloade. The lunar ovoids were taped to EBT3 films. The source paths from afterloader to ovoids were kept as straight as possible, in order to achieve similar clinical setup for HDR-BT treatment using the Venezia ovoids.

Figure 2 shows a comparison between an electron and a photon autoradiograph for the same Venezia lunar ovoid applicator. Multiple photon beams were used to optimize lunar ovoid layout on films. Venezia ovoid is thicker and has a more intricate design, therefore even the most optimized photon autoradiograph did not provide enough information to quantify offset (Figure 2 (Right)).

Figure 1: (Left) External beam component of the autoradiograph. (Right) Setup using an HDR afterloader. Ovoid/film orientation was designed to mimick clinical HDR treatment for cervical cancer.

## Results

Electron autoradiograph showed intricate details of the ovoid's lunar shape, the lumen tip end, and the source dwell position on the EBT3 film (Figure 2, Left). Measured offset for right/left ovoid was summarized in Table 1. Offsets from photon autoradiographs could not be determined due to inferior image quality.

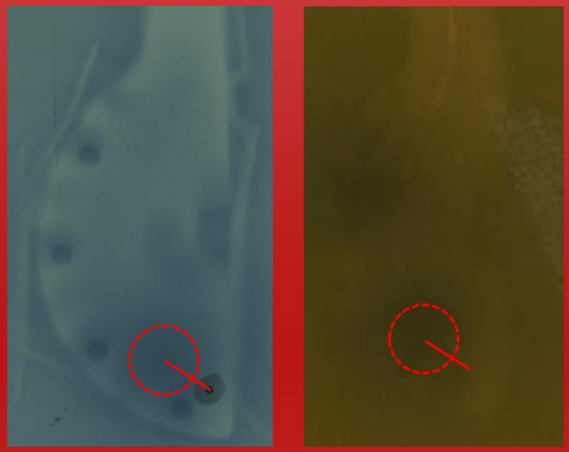

Table 1 – Venezia ovoid applicator offsets

| Ovoid (mm) | Electron autoradiograph (mm) | |
|---|---|---|
| 22 | $5.21^a$ | $5.92^b$ |
| 26 | $5.18^a$ | $5.56^b$ |
| 30 | $5.14^a$ | $6.53^b$ |

a = right ovoid, b = left ovoid

Figure 2: Autoradiographs for a 26 mm right Venezia ovoid applicator. (Left) Exposed with an electron beam (12 MeV, 600 MU). (Right) Exposed with a photon beam (80 kVp, 600 mAs, 10 exposures) with a marker cable inserted within. Dashed circles indicate source dwell. Red lines refer to measured offset (distance from lumen end to center of first dwell position)

## Innovation/Impact

Compared to photon autoradiographs using kV x-rays with a marker cable, the electron autoradiograph has three advantages. (1) It improves offset measurement accuracy by displaying a detailed layout of source dwell position and inner lumen within a Venezia lunar ovoid applicator. This is challenging for standard kV x-ray autoradiograph, because the Venezia ovoid has a thicker lunar-shaped design. (2) It removes offset measurement uncertainties introduced by using an x-ray marker cable for photon-based autoradiograph. (3) It is accessible for clinics who do not have a portable x-ray unit. To the best of our knowledge, this is the first study of acquiring electron autoradiographs for Venezia lunar ovoid applicators.

## Conclusion

We presented a robust new method for acquiring the Venezia lunar ovoid offset values, which are crucial to safe applicator commissioning. An electron beam was used for what is typically the external beam component of an autoradiograph. Compared to the more common photon beam approach, the electron beam provided more details of lunar ovoid inner design, which can potentially improve offset measurement accuracy. As there are no vendor-reported values, our measured offsets can be used as comparison data by other clinics when commissioning the Venezia lunar ovoid applicators.