

## Evaluation of GafChromic EBT Film for IMRT QA Using Two Different Scanners.

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**Introduction:** The interest in film dosimetry for IMRT QA is due to its potential to provide precise two-dimensional absolute dose distributions having spatial resolution in the sub-millimetric range. Unfortunately absolute film dosimetry using radiographic film is very film- and time-consuming because of film processing uncertainties. A set of calibration films has to be irradiated for each IMRT film dosimetry case even if the films belong to the same production lot as the former case. Many institutions irradiate only one patient film with the full dose from all fields, imitating the actual treatment delivery. This one film would have to be processed together with the calibration films, preferably by applying a sensitometric strip to each film prior to processing in order to monitor the stability of the processing. Then sensitometry results have to be evaluated in order to generate appropriate corrections, all films have to be scanned, a calibration curve has to be generated, and finally the patient film can be analyzed. Since it is not feasible in terms of resources to perform this process for each IMRT patient in a busy clinical environment, most physicists either abandon film dosimetry, instead using various dosimetric arrays with low spatial resolution, or resort to relative film dosimetry irradiating only the patient's fields. The analysis creates a two-dimensional dose map using an existing calibration curve and normalizes it to a simultaneous chamber measurement. In addition to everything mentioned, more and more institutions are becoming filmless. Even in cases where a processor is kept for physics purposes, its quality rapidly deteriorates due to lack of service and use.

Radiochromic film which does not require processing was very successfully used for brachytherapy dosimetry, but could not fill the gap in IMRT dosimetry due to its inherent limitations of very low sensitivity, small size, and high price. The GafChromic EBT film recently released by ISP (International Specialty Products, Wayne, New Jersey) was specified with IMRT dosimetry in mind. It is available in 8"x10" and larger sheets, is usable in the external beam therapeutic dose range, and is priced similarly to radiographic film. Its chemical composition is nearly tissue equivalent, and it is almost energy independent. Its post-exposure density nearly stabilizes after 2 hours.

In this work, we studied the applicability of EBT film for absolute clinical IMRT dosimetry by comparing it to Kodak EDR2 radiographic film. The use of two different film scanners was also investigated: the mainstream Vidar VXR-16 DosimetryPro, and the relatively inexpensive Epson Expression 1680 flatbed color scanner.

For radiochromic film, a calibration curve has to be created only once for each energy and production lot of film. Since a calibration curve requires irradiation of about 15 films, it consumes a large part of a box of film (25 films per box). We therefore investigated the possibility of creating the calibration curve from a single sheet of film by cutting it into the appropriate number of small films.

**Method and Materials:** The radiochromic film evaluated in this work was GafChromic EBT Lot # 34267-005, which was compared with Kodak EDR2. All films were irradiated on a Varian 2100C/D linear accelerator. The calibration films were irradiated in a polystyrene phantom consisting of 25 cm x 25 cm slabs, at 100 cm SAD, 10 cm x 10 cm field, 10 cm depth. Patient IMRT films (EBT and EDR2 sandwiched together) were placed at a coronal plane of a specially designed polystyrene phantom and treated by all fields to the full dose in clinical mode. Prior to irradiation the crosshair of the linac was marked on the films at 0 degrees gantry angle by pricking holes in the EDR2 and using a thin marker pen on the EBT film. EDR2 patient films were processed together with the calibration films after a sensitometry strip was flashed on each film using an X-Rite sensitometer. After processing, the sensitometry was evaluated using a Macbeth TD 932 densitometer and the films were scanned using the Vidar scanner and RIT113 software. All EBT films were scanned using both scanners at the same post-exposure density, 24 hours after irradiation. All scans were repeated in two directions: (0 degrees) - long axis of the film coinciding with the direction of the movement of the film (Vidar) or the light source (Epson) and in the perpendicular direction (90 degrees). For all Vidar scans the EBT films were attached to a special yellow filter provided by ISP, which enhances the film response to the broad spectrum light source. All Vidar scanning, as well as subsequent creation of calibration curves, was done using RIT113 software. All Epson scanning was done using Epson-provided software in the 48 bit color mode. The red channel which provides the optimum response for GafChromic film was extracted using Picodose film dosimetry software. The pixel values for the calibration films were measured using Mira by Axiom Research. Finally, all dose distributions from both scanners were analyzed using Memorial Sloan Kettering Cancer Center's Contour film dosimetry software.

**Results:** Fig. 1. shows the calibration curves of EBT film and EDR2 film in terms of pixel value. Fig. 2. shows the corresponding optical densities for the EBT film. The EBT film provided better intensity linearity with dose than EDR2 film and higher pixel values in the clinical dose range. The Vidar produced lower pixel values but higher

optical density than the Epson. The pixel values of the EBT film differed by 3 -9% (Epson) and 11-19% (Vidar) when rotating the film 90 degrees on the scanner. Dose distributions of films scanned in one direction opened with a calibration curve scanned in the perpendicular direction resulted in a 19% (Epson)-30% (Vidar) dose error. Calibration curves based on small films cut from one sheet of film coincided with the curves created from a set of sheets.

Fig. 3. and Fig. 4 show dose distributions of EBT films scanned with both scanners superimposed on the corresponding dose distribution of EDR2 film. For all combinations of scanners and scanning directions, the agreement of the CAX dose was within 3% among EBT films and within 4.5% for EBT and EDR2.

**Conclusions:** GafChromic EBT film provides a good alternative for absolute IMRT dosimetry. Both film scanners provide equivalent dosimetric results. Calibration films and IMRT films have to be scanned in the same direction. The calibration curve can be created using small films cut from one large film.

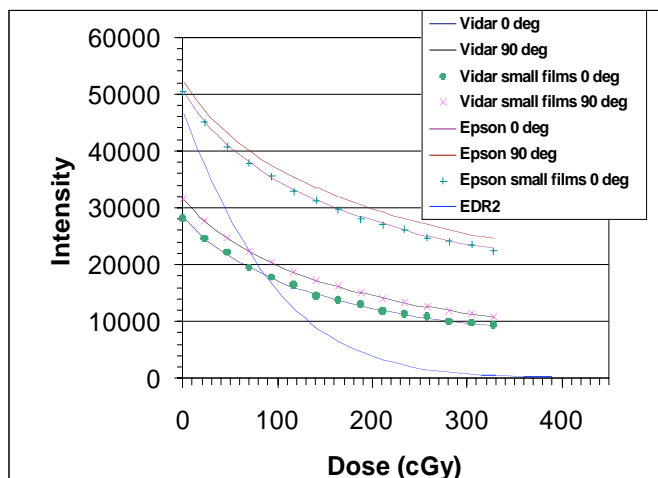


Fig. 1. Intensity (pixel values) vs. dose for large and small EBT films scanned on two scanners in two perpendicular orientations, as well as for EDR2 film.

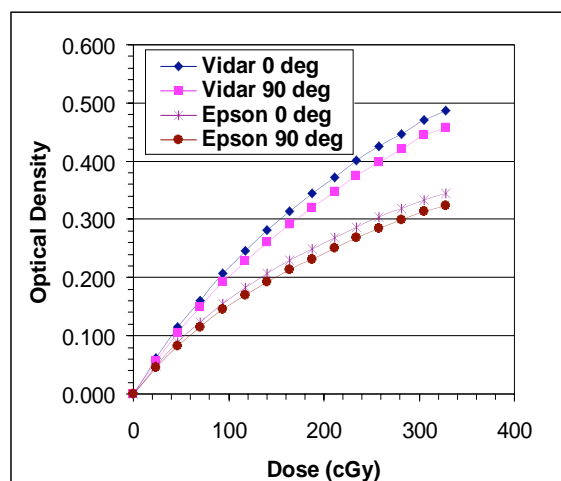


Fig. 2. Optical density vs. dose for large EBT films scanned on two scanners in two perpendicular orientations.

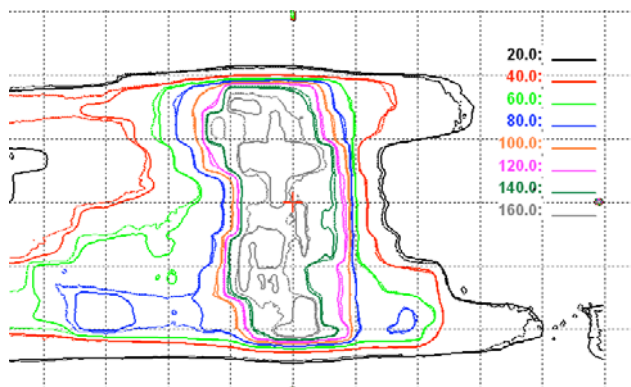


Fig. 3. A patient head and neck coronal plane – EBT film/Vidar scan superimposed on EDR2 film. CAX agreement of 1.9%.

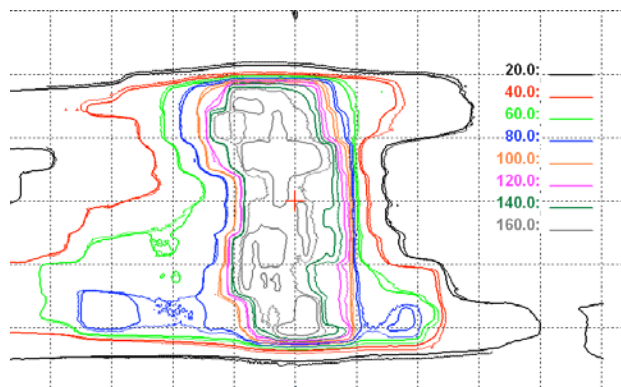


Fig. 4. A patient head and neck coronal plane – EBT film/Epson scan superimposed on EDR2 film. CAX agreement of 3.6%.