Development of Dosimetric Verification System for Patient-specific Quality Assurance of High-dose-rate Brachytherapy

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Purpose:

Although high-dose-rate brachytherapy (HDR-BT) is an effective treatment for cancer, it has a high risk of error. The aim of this study was to develop a dosimetric verification system (DVS) that includes a simple solid phantom and independent dose-calculation program (IDCP) for the quality assurance (QA) of HDR-BT.

Materials and Methods:

A simple acrylonitrile butadiene styrene (ABS, density = 1.04 g/cm3) slab phantom was designed to apply pretreatment verification for HDR-BT. All measurements were carried out on Gafchromic EBT3 film and the ABS phantom. To verify the dose using a phantom made of ABS rather than water, the conversion factor (CF(r)) between the two materials was determined by Monte Carlo (MC) simulation. By applying the CF(r), we implemented an IDCP that allows dose verification with the ABS phantom. For the feasibility of our DVS that included an ABS phantom and IDCP, the dosimetric accuracy of the comparison between the calculated and delivered dose distribution was analyzed by gamma analysis using global normalization with a 3% dose difference and 3 mm distance-to-agreement for three simulated cases.

Results:

The ABS phantom consisted of a normal and catheter-inserted slab. The CF(r) between the ABS and water phantom was 0.88 at 0.5 cm. This gradually increased with increasing r and converged to 1.08 at 6.0 cm. Point doses 1 cm below the source were 400 cGy in the treatment planning system (TPS), 373.73 cGy in our IDCP, and 370.48 cGy in film dosimetry. Gamma passing rates of dose distributions calculated from TPS and IDCP compared to the dose distribution measured by the film for the three cases were: 99.41% and 100% in single dwell position cases, 96.80% and 100% in elliptical dose distribution cases, 88.91% and 99.70% in elliptical dose distribution with a concave cases, respectively. Thus, the IDCP showed better agreement with film dosimetry than TPS.

Conclusions:

A DVS with a simple ABS phantom and an IDCP was developed to perform pretreatment QA of HDR-BT. The developed DVS can be used as an independent QA tool for HDR-BT.

Keywords:

Patient-specific quality assurance, Dosimetric verification, High-dose rate brachytherapy