Characterizing Dose Distributions of Brachytherapy Sources Using Normoxic Gel

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Abstract

Intertitial brachytherapy using 125I and 103Pd encapsulated sources has become a common treatment for prostate cancer patients resulting in an increased demand for these sources. In response to the growing demand, manufacturers have developed new models of 125I and 103Pd sources. The dose distributions of these low energy emitters are very sensitive to encapsulation geometry, self-absorption, and filtration, all of which vary with each manufacturer. As a result, the dose distribution of each seed must be investigated as detailed in AAPM TG-43. This study investigated the dose distributions of three well-characterized seeds using a normoxic gel. Each seed was encapsulated in a 1 mm diameter canister. A Monte Carlo program was used to calculate the dose rate at every point in the gel. The gels were examined using an optical scanner to obtain a matrix of optical densities. The dose rate dependence of the gel was investigated by comparing the response of the gels irradiated with 125I and 103Pd. The energy dependence of the gel was investigated by comparing the response of the gels irradiated with 125I and 103Pd. The time of irradiation was calculated to deliver the same dose to each gel at 1 cm along the transverse axis of the seed (3% and 9% gels irradiated to different doses).

The dose rate at point \((r, \theta)\) was calculated according to TG-43 two dimensional formalism:

\[
D(r, \theta) = D_{av} + \sum_{i=1}^{n} S_i \left( \frac{G_i}{G_{av}} \right) \left( 1 - e^{-\frac{T}{T_{av}}} \right)
\]

where \(T\) is the time of irradiation and \(T_{av}\) = 1440 s.

After irradiation, the catheter was removed from the gel and the void was filled unirradiated with gel. The gels were imaged using an optical CT scanner (Merran et al, 1986) and images were analyzed using a MATLAB® program written for this study.

A program written in MATLAB® imports the image, finds the location of the seed in the plane, and obtains the average pixel values at specified distances from the source. A dose response curve was determined from measurements of dose around the 6711 seed. The optical density maps of the images and ROI seeds were converted to dose using the 6711 dose response curve. The radial dose function for each was then determined.

Purpose

The purpose of this project is to characterize the dose distributions of 125I and 103Pd seeds using a normoxic gel. This project will contribute to further understanding gel characteristics, as well as providing a framework for future source characterization using normoxic gels. Gel dosimetry provides 3D information so that all of the dosimetric parameters required to calculate absorbed dose can be determined for a source in a single irradiation.

Results

A gel was made containing 3% methacrylic acid and it has been shown to be useful dosimeter. However, gels are very sensitive to oxygen, thus requiring hypoxic condition during their manufacture, storage, and use.

Discussion

The correlation of the measurements were large due to the small relative biological value and the small absolute difference from the source. Future Works

- Replace 1mm ID barex tubing with a larger ID tubing and obtain distribution information at larger distance
- Obtain 3D data from a single irradiation and obtain all TG-43 parameters
- Investigate more sources and compare with published data
- Conduct reproducibility evaluation

References