Monte Carlo multiscale modelling of photon and proton distribution in heterogenous tissue

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Introduction

Improvements in radiotherapy treatment outcomes can be achieved by reducing uncertainties in dose distribution. Treatment planning cannot effectively calculate dose distribution in complex heterogeneous areas, which increases uncertainty associated with dose distribution. This research aims to study microscopic dose distribution in temporal bone and cochlea.

Method

An open-access DICOM format of the data for the resected temporal bone and cochlea tissue was used with the FLUKA MC code to imitate potential high-dose scenarios associated with volume-modulated arc therapy using the FLOOD option. Twenty-three photon and proton energy levels ranging from 0.055 to 5.5 MeV for photons and 37.59 to 124.83 MeV for protons were simulated separately to calculate dose distribution.

Result

The largest proportion of the dose (48.8%) was deposited in high-density bone, with photon distribution in the low energy range 0.055-0.09 MeV, whereas above 0.125 MeV, the change in dose distribution occurred in low-density tissue where there was a greater deposition, reaching 53%. The dose distribution in the soft bone's intermediate density was 26.4% at 0.07 MeV and dropped to 19.7% at 2.5 MeV. There was a 29% percentage difference in dose distribution on the soft bone between the low and high energy. Dose distribution in low energy (37.59 MeV) did not show any significant changes in protons between the low (54.86%), intermediate (19.75%), and high-density (25.39%) areas. Similarly, the dose distribution in high energy (124.83 MeV) was 54.21% in low-, 19.79% in intermediate-, and 26% in high-density areas.

Conclusion

The simulation concluded that the proton dose distribution was not affected significantly by the region's heterogeneity in micro-CT data. The photoelectric effect in low energy beams did not add a significant dose to the soft bone, depositing the dose in high-density bone, despite having a small weighting factor in low energy compared to high energy.

Feasibility Study of Fricke Xylenol Gel as a Dosimeter for Low Dose Rate Brachytherapy Sources

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Introduction

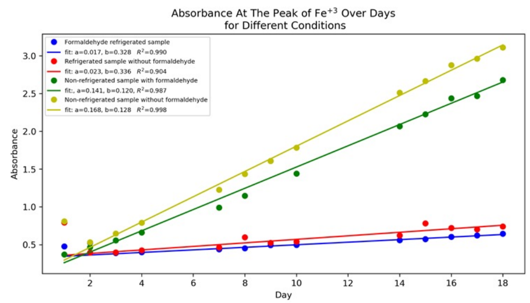
The Fricke Xilenol Gel (FXG) is a widely used chemical dosimeter in medical dosimetry. Its main limitation lies in its tendency for auto-oxidation, which restricts its use to short-duration exposures. The focus of this study is to evaluate a dopant and storage conditions that enable the utilization of FXG in radiation sources with low dose rates and longer durations.

Methods

Dosimeters were produced with and without a dopant. The groups were evenly divided, with half of the samples being refrigerated and the other half kept at room temperature. Spectrophotometric data were collected from the samples over the course of several days, and the average absorbance was calculated for each group. The data were analyzed based on the absorbance at 585 nm, which corresponds to the peak of Fe^{3+} and reflects the dosimeter oxidation.

Results

The addition of formaldehyde as a dopant proved to be highly effective in reducing the natural oxidation of the dosimeter. Temperature also played a crucial role in controlling the dosimeter's natural oxidation. The results obtained were promising towards the intended objective.



Conclusions

The non-doped samples kept at room temperature showed a growth of 2.579 in absorbance at the Fe^{3+} peak, whereas the doped samples refrigerated only exhibited an increase of 0.166. This demonstrates that this method can be effective for dosimetry of low dose rate sources that require longer irradiation times, due to their low natural oxidation.