Ph.D. Thesis Abstract for Liyong Li

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Directional Interstitial Brachytherapy from Simulation to Application

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Organs at risk (OAR) are sometimes adjacent to or embedded in or overlap with the clinical target volume (CTV) to be treated. The purpose of this PhD study is to develop directionally low energy gamma-emitting interstitial brachytherapy sources. These sources can be applied between OAR to selectively reduce hot spots in the OARs and normal tissues. The reduction of dose over undesired regions can expand patient eligibility or reduce toxicities for the treatment by conventional interstitial brachytherapy.

This study covers the development of a directional source from design optimization to construction of the first prototype source. The Monte Carlo code MCNP was used to simulate the radiation transport for the designs of directional sources. We have made a special construction kit to assemble radioactive and gold-shield components precisely into D-shaped titanium containers of the first directional source.

Directional sources have a similar dose distribution as conventional sources on the treated side but greatly reduced dose on the shielded side, with a sharp dose gradient between them. A three-dimensional dose deposition kernel for the ^{125}I directional source has been calculated. Treatment plans can use both directional and conventional ^{125}I sources at the same source strength for low-dose-rate (LDR) implants to optimize the dose distributions.

For prostate tumors, directional ^{125}I LDR brachytherapy can potentially reduce genitourinary and gastrointestinal toxicities and improve potency preservation for low risk patients. The combination of better dose distribution of directional implants and better NTD ratio between tumor response and late reactions enables a novel temporary LDR treatment, as opposed to permanent or high-dose-rate (HDR) brachytherapy for the intermediate risk T2b and high risk T2c tumors. Supplemental external-beam treatments can be shortened with a better brachytherapy boost for T3 tumors.

In conclusion, we have successfully finished the design optimization and construction of the first prototype directional source. Potential clinical applications and potential benefits of directional sources have been shown for prostate and breast tumors.

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