Derivation of anisotropy functions and dose-rate constants for ^{192}Ir brachytherapy sources using primary and scatter dose separation

The scatter dose around high energy brachytherapy sources is dependent on the characteristics and geometry of the scattering volume, while the primary dose depends only on the material along the source to calculation point path. Hence, algorithms based on primary and scatter dose separation will facilitate scatter dose integration and heterogeneity corrections. Source characterization by means of Monte Carlo simulation of dose deposition per source emitted radiant energy allows dose separation into primary and scatter contributions. Simulations were made in water, air and vacuum for ^{192}Ir sources used in the MicroSelectron HDR/PDR and GammaMed 12i HDR afterloading units. Sources were positioned freely in unbounded phantoms and in combination with nylon and stainless steel source channels. Radial dose profiles for primary and total scatter dose contributions at different angles to the source axis were scored and parameterized using functions based on 1D transport theory. Anisotropy functions were derived and are shown to agree within ±3% with published Monte Carlo calculated functions and ±5% with measured values at angles between $10 \leq \theta \leq 170°$ to the axis. Calculated dose-rate constants, Λ_0, agree to within ±1% the value recommended in AAPM Task Group 43 report. Λ_0 is relatively insensitive to the material of the source channel, however, anisotropy functions were reduced by 15% for steel channels compared with nylon channels at angles close to the source axis.