Design and dosimetry of small animal radiation facilities

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The aim of this work was to develop an irradiation system for radiobiology studies. We designed a novel image-guided micro-irradiator capable of partial-body zebrafish embryo irradiation. The radiation source is a 50 kV photon beam from a miniature x-ray source (Xoft Inc., CA). The source is inserted in a cylindrical brass collimator, 3 cm in diameter and 3 cm in length. The collimator has a 1 mm-diameter pinhole along the longitudinal axis, which provides a well-focused beam with a sharp penumbra. A photodiode is installed at one exit of the pinhole collimator to monitor the photon dose rate. The source with the collimator is attached under a movable table. A video camera, connected to the computer, is placed above the movable table to record position of the specimens in relation to the pinhole collimator. The captured images are analyzed, and the relative distances between the specimens and the pinhole are calculated. The coordinates are sent to the computer-controlled movable table to accurately position the specimens in the beam. Monte Carlo simulations were performed to characterize dosimetric properties of the system, to determine dosimetric sensitivity, and to help in the design. The image-guidance and high precision of the movable table enable very accurate specimen position. The beam monitoring system provides accurate, fast and easy dose determination. Portability and self-shielding make this system suitable for any radiobiology laboratory. This novel micro-irradiator is appropriate for partial irradiation of zebrafish embryos; however its potential use is much wider like irradiation of cell cultures or other small specimens.