Purpose: We propose to optimize the geometry of the Scanning-Beam Digital Tomography system (SBDX) for application to lung tumor biopsies, thereby providing real-time 3D tomographic reconstructions for target verification. The unique geometry of the system requires trade-offs between patient dose, imaging field of view and tomosynthesis angle.

Methods: We used PCXMC, a Monte Carlo simulation software package, to determine the dose to organs of interest as well as the Average body dose and Effective Dose (both ICRP 60 and 103) for source to detector distances (SDDs) between 90cm and 150cm. To facilitate modeling our system, a modified version of PCXMC was created. We also used matlab to evaluate the possible tomosynthetic angles that result across the field of view for the same SDDs.

Results: To maximize the tomosynthesis angle while leaving space for the patient, an SDD of between 90cm and 110cm is appropriate. At SDD 100cm, patient centered at 40 cm from the detector, operated in fluoro mode, the SBDX system delivers ~0.38x the dose of a normal mobile fluoroscopy system operating at 30 fps. Because of the inverse geometry of the system, the dose to the patient goes up as the patient gets closer to the detector. Tomosynthetic angles up to 15 degrees over a 5-cm field-of-view can be achieved for this geometry. The patient must be placed within 45cm of the detector in order to achieve the benefits from reduced SDD and increased tomosynthetic angle.

Conclusions: The dose-rate for our optimized geometry is acceptable, although higher dose rates for improved nodule visualization may be required. Additional dose optimization steps include modifying the scanning beam pattern to optimize for tomosynthetic image acquisition. Overall dose during the biopsy procedure will likely decrease since nodule targeting will be improved and the overall number of biopsies required will be reduced.

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