

Development and Role of Megavoltage Cone Beam Computed Tomography in Radiation Oncology

Olivier Morin

5 *Comprehensive Cancer Center, Department of Radiation Oncology, University of California San Francisco, 1600 Divisadero Street, San Francisco, California, 94143*
Joint UC Berkeley and UCSF Bioengineering Doctorate Program
[E-mail: omorin@radonc.ucsf.edu]

Thesis Advisor: **Professor Jean Pouliot**

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External beam radiation therapy has now the ability to deliver doses that conform tightly to a tumor volume. The steep dose gradients planned in these treatments make it increasingly important to reproduce the patient position and anatomy at each treatment fraction. For this reason, considerable research now focuses on in-room three-dimensional imaging. This thesis describes the first clinical megavoltage cone beam computed tomography (MVCBCT) system, which utilizes a conventional linear accelerator equipped with an amorphous silicon flat panel detector. The document covers the system development and investigation of its clinical applications over the last 4-5 years. The physical performance of the system was evaluated and optimized for soft-tissue contrast resolution leading to recommendations of imaging protocols to use for specific clinical applications and body sites. MVCBCT images can resolve differences of 5% in electron density for a mean dose of 9 cGy. Hence, the image quality of this system is sufficient to differentiate some soft-tissue structures. The absolute positioning accuracy with MVCBCT is better than 1 mm. The accuracy of isodose lines calculated using MVCBCT images of head and neck patients is within 3% and 3 mm. The system shows excellent stability in image quality, CT number calibration, radiation exposure and absolute positioning over a period of 8 months. A procedure for MVCBCT quality assurance was developed. In our clinic, MVCBCT has been used to detect head and neck set-up errors, to position a patient with a paraspinal tumor close to metallic hardware, to position prostate cancer patients using gold markers or soft-tissue landmarks, to monitor head and neck anatomical changes and their dosimetric consequences, and for treatment planning contouring in presence of metallic implants. MVCBCT imaging is changing the clinical practice of our department by increasingly revealing patient-specific localization and/or anatomy variation errors. New

verification protocols are being developed to minimize those errors thus moving the practice of radiation therapy one step closer to personalized medicine.