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FOCAL IRRADIATION AND IMAGE FUSION TECHNIQUES (IGRT)—PART IV

Image-guided radiation therapy (IGRT) is currently an emerging technology and is undergoing rapid transformation. There have been different interpretations of this technology. *Medical Dosimetry* journal has devoted 4 special volumes on this topic. With the recent development in positron emission tomography (PET), in particular, the commercial availability of PET-CT hybrid scanner, the advancement of IGRT has been perceived as the integration of images from various medical imaging modalities to support the delineation of targets for three-dimensional (3D) treatment planning. Another interpretation has been toward the application of medical imaging modalities to set up patients prior to dose delivery to reduce patient setup uncertainties. Various technologies have been developed to support this concept including (a) ultrasound imaging, (b) in-room CT (also known as CT-on-rail), (c) mobile kilovoltage x-ray unit, and (d) cone-beam CT technology using kilovoltage and megavoltage radiation beams. The integration of these IGRT technologies to the dose delivery systems has been described in the first IGRT special volume of the *Medical Dosimetry* journal.[1] Of particular interest in the integration of IGRT technologies to the dose delivery system is the implementation of cone-beam CT techniques. This cone-beam CT technique allows patient data to be acquired volumetrically by rotating the gantry of the dose delivery system around the patient. The patient data are then reconstructed to obtain transaxial and/or multiplanar CT images. Along with the advancement of medical imaging modalities for diagnostic radiology and radiation oncology, there have been increasing concerns about the impact of voluntary and involuntary patient movements. Static *in silico* treatment plans may have little resemblance to the dose distributions achieved in living, breathing, fidgeting patients who may gain or lose 10% of their body weight over a 7-week course of fractionated treatments. Involuntary patient movement such as breathing has been addressed using (a) forced breathing technique, (b) shallow breathing technique, and (c) motion-gating techniques. Motion-gating techniques and the technology of cone-beam CT has been reviewed in the second IGRT special volume of *Medical Dosimetry*.[2]

The third and fourth special volumes in the IGRT series are devoted to focal irradiation. In the past, focal irradiation has been limited to the treatment of intracranial lesions. Stereotactic frame systems fixed to the skull have been used to guide the dose delivery. Because the fixation of the frame systems is invasive and difficult to implement for fractionated treatments, frameless techniques using image-guidance technology have been introduced. In addition, stereotactic body frames have been proposed for extracranial irradiation. Medical linear accelerators, which have been modified for stereotactic radiosurgery and stereotactic radiotherapy, by decreasing equipment tolerance and increasing accuracy of patient setup, are being adapted to perform focal irradiation using these frameless techniques. Additional advancement in medical linear accelerator technology for focal irradiation includes the redesigning of flattening filter to increase the dose rate to about 1000 monitor units (MUs) per minute. The implementation of focal irradiation from medical linear accelerators using frameless guidance systems and stereotactic body frames has been reviewed in the third volume of this IGRT series of *Medical Dosimetry*.[3]

This fourth and final special volume of the IGRT series concentrates on extracranial irradiation, specialized focal irradiation dose delivery systems, and image fusion techniques. A clinical assessment on the use of a specialized focal irradiation dose delivery system, the Cyberknife robotic system for the treatment of spinal lesions is reviewed by Gerszten *et al*.[4] Two specialized focal irradiation dose delivery systems, the Cyberknife and the Novalis, are described by Ozhasoglu *et al*.[5] and Jin *et al*.,[6] respectively, in their implementation of IGRT. Holmes *et al*.[7] explored the development of the Tomotherapy system, a newly introduced dose delivery system, to extend the radiotherapy applications to image-guided intensity-modulated stereotactic procedures. The discussion of IGRT is not complete without discussing image registration techniques. Image registration or fusion refers to the process of aligning images acquired at different times or with different imaging modalities. The alignment process can be characterized as hardware-based and software-based image fusion techniques. The principles, advantages, and limitations of image fusion techniques with applications to IGRT are discussed by Saw *et al*.[8] Image fusion technique with the use of fiducial markers registration technique implemented in the Cyberknife robotic system for IGRT is reviewed in the article by Saw *et al*.[9]

The compilation of articles for these 4 IGRT special volumes in *Medical Dosimetry* involves many experts in this IGRT field. Their willingness to participate and to share their experiences signifies their strong support and concerns for our radiation community so that IGRT can be implemented in a proper and effective manner. The significant amount of time and effort invested in writing these articles and the authors' willingness to undergo review are sincerely appreciated by the guest editors. It is the hope of the guest editors that these IGRT special volumes will allow increased familiarization with the conceptual, foundation, and emerging applications of IGRT for the medical physicists, medical dosimetrists, radiation oncologists, and radiation therapists. The guest editors for each of the series of IGRT special volumes take this opportunity to thank all authors and co-authors for their contributions.

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