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Clinical, Technical, and Basic Science Progress in Helical Tomotherapy – The Pace Continues to Accelerate

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The last issue of *Technology in Cancer Research and Treatment* (Volume 7, Number 6, December 2008) hosted a set of articles devoted to a unique means of image-guided intensity modulated radiation therapy, helical tomotherapy, a technology that was introduced to the scientific and medical community largely through this journal. The success of helical tomotherapy is further evidenced by the ever-expanding worldwide clinical implementation of this technology along with the concomitant abundance of scientific manuscripts on the subject. Here we include a "part two" in our series of contributions from world authorities in the field.

Leading off the sequence is a fascinating contribution from an international team of experts investigating the concepts of biological effective uniform dose and complication-free tumor control probability index with helical tomotherapy. Using these parameters, Mavroidis *et al*. compared helical tomotherapy against multi-leaf collimator based IMRT for brain and craniospinal tumors. Their results predict a superior clinical outcome with helical tomotherapy, especially in larger sized targets. This interesting radiobiological predictive modeling must be confirmed in the clinic, of course, but hints at an important improvement in the way patients might be planned and treated both with helical tomotherapy and in general.

The next manuscript in our sequence is a study conducted in India by Gupta *et al*. This team looked at the possibility of simultaneously treating both the brain and lung with tomotherapy in lung cancer patients with brain metastases. Given the relatively high frequency of brain metastases in both small cell and non-small cell lung cancer patients, this clinical scenario warrants investigation. Also, given the limited life expectancy of these patients sequential treatment of the brain and lung is currently not considered justified. The life-limiting condition (brain metastases) is therefore treated but the non-life threatening lung lesions typically go untreated. A simultaneous treatment course such as discussed by Gupta *et al*. could be very attractive, as it reduces two separate courses of palliative radiation to a single two week course. They also used a simultaneous in-field boost to address brain metastatic lesions during the whole brain irradiation, which may offer an alternative to the common sequence of whole brain radiotherapy preceded or followed by stereotactic radiosurgery. Thus, this attractive arrangement offers a substantial reduction in overall treatment time for these terminally ill patients. As the authors indicate, such elaborate treatment of multiple body sites demands highly effective immobilization and precise targeting (the authors used fiducial markers on the customized mask) to be practical in the clinic.

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Next, in a case study involving a patient with Ewing sarcoma, Hui *et al*. report on the role of pretreatment multimodality imaging studies for total marrow irradiation using tomotherapy. The multi-modality imaging studies may help identify areas of disease for dose escalation. The team also evaluated the possibility of verifying delivered dose in total marrow irradiation using the megavoltage CT (MVCT) capabilities of the helical tomotherapy unit. Further studies on dose reconstruction in helical tomotherapy for total marrow irradiation and other applications will surely follow this first report.

This is followed by a clinical investigation into total marrow irradiation from Taiwan led by Dr Shueng and colleagues. The team evaluated three patients with multiple myeloma who were actually treated with a preconditioning regimen using a total marrow irradiation technique plus melphalan. As expected, the dosimetric results reveal a significant improvement over conventional total body irradiation. Their three patients appeared to tolerate the treatment well, raising the possibility of dose escalation in the future. One reality of tomotherapy-based total marrow irradiation is the prolonged daily treatment time and the concomitant challenges of patient discomfort during the long sessions. However, Shueng *et al*. seem to have managed this well for their initial few patients.

The final paper in our set is an evaluation of an image-guided intracranial stereotactic positioning system used with helical tomotherapy by Soisson *et al*. The system they evaluated has several advantages, including the elimination of the need for an external coordinate system encoded into the treatment planning system and the ability to address multiple targets in a single session, since helical tomotherapy permits non-isocentric treatments. The team used a novel method employing megavoltage CT imaging (as well as an optical tracking system) along with a minimally invasive head frame and head frame couch interface to answer two questions. First, what is the capability of MVCT to detect shifts and second, what is the precision of fixation with their system? The researchers herein present data revealing favorable answers to both questions. This study demonstrates the power of MVCT for stereotactic localization and therefore represents a first step in confirming the feasibility of helical tomotherapy as a precise and accurate means of delivering stereotactic radiosurgery. Their preliminary work may very well pave the way for routine clinical application of stereotactic radiosurgery using helical tomotherapy.

Often in multidisciplinary clinical science, one particular subspecialty moves along at a far faster pace than the others. For example, in many novel technological medical advances, the physics tends to outstrip the biology. With helical tomotherapy however, the radiobiology has kept up quite nicely with the technology and physics. Given the rapid and persistent progress of all areas of investigation related to helical tomotherapy – basic physics, technology, radiation dosimetry, and radiobiology – we can expect a deluge of additional papers as ongoing clinical studies mature in upcoming years.