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Medical Physics Contribution:

Clinical implementation of radiosurgery using the Helical TomoTherapy unit

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A B S T R A C T

The American Society of Radiation Oncology has recently recommended the use of radiosurgery to manage brain metastases. For such a recommendation to be implemented in a widespread manner, radiosurgery must be accessible at community radiation therapy facilities. The work presented here describes our clinical experience in the implementation of radiosurgery using a Helical TomoTherapy unit. Helical TomoTherapy is a unique dose-delivery system designed to perform intensity-modulated radiation therapy (IMRT). The system built on the ring-based gantry has the tight machine tolerances required for radiosurgery. A frameless system consisting of a thermoplastic mask and a noninvasive "stereotactic radiosurgery (SRS)-stereotactic radiotherapy (SRT)" fixation device is used for patient immobilization. Treatment planning is performed using the TomoHD treatment planning system designed for IMRT. The image-guidance system on the Helical TomoTherapy is used for patient localization. Our clinical experience demonstrated that the radiosurgery procedure can be streamlined as we do for IMRT patients. The treatment time of about 10 minutes is comparable with that for IMRT patients. The same patient-specific quality assurance for IMRT is used for radiosurgery. As demonstrated, SRS using Helical TomoTherapy is not a whole-day event, unlike SRS using other dose-delivery systems or SRS performed in the past.

Introduction

Radiation oncology practices are evolving, particularly in the management of metastatic brain tumors. Metastatic brain tumors constitute about 20% to 40% of all patients with cancer.[1,2] This statistic is expected to change because of longer patient survival attributed to better modern imaging techniques and treatment modalities, and increased patient screening. The primary approaches to the treatment of metastatic brain tumors include surgery, stereotactic radiosurgery (SRS), and whole-brain radiation therapy (WBRT).[1-3] Treatment of metastatic brain tumors has become increasingly individualized as surgical and SRS techniques have evolved over the past few decades. Improved systemic therapies have also offered potential for both systemic and intracranial disease control for certain cancer types and genotypes.[4,5] WBRT remains the primary treatment modality for patients with a high intracranial tumor burden. The routine uses of WBRT as adjunctive therapy in patients who are

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candidates for SRS or surgical resection have changed and have been shown not to improve overall survival, but can have a detrimental impact on the patient's quality of life because of neurocognitive decline.[6,7] National radiosurgical and radiation oncological societies have been advocating for the use of SRS alone for 4 lesions or less.[8,9] Recently, the American Society of Radiation Oncology recommended that cancer patients with limited brain metastases who are less than 50 years old undergo SRS without WBRT, showing 13% survival improvement compared with those with WBRT.[9]

Over the past 2 decades, advances in technology, in particular, 3-dimensional treatment planning systems and dose-delivery systems, have transformed the practice of radiation oncology.[10] This had led to the clinical implementation of complex treatment techniques of conformal radiation therapy, intensity-modulated radiation therapy (IMRT), and recently, volumetric modulated arc therapy. All of these treatment techniques require precise patient set-up localization and accurate radiation dose delivery. Newer dose-delivery systems built to perform conformal radiation therapy and IMRT treatment techniques will have tighter machine tolerances. Helical TomoTherapy, a new dose-delivery system built differently, has the tight tolerances that match the requirements for SRS as specified in the American Association of Physicists in Medicine (AAPM) Report No. 54.[11] This work presents our clinical experience on the implementation of radiosurgery using our Helical TomoTherapy unit.

Methods and Materials

We embarked on implementing SRS on our 4-year-old Helical TomoTherapy unit with advanced features using dynamic jaws and an up-to-date treatment planning system. Helical TomoTherapy was uniquely built on a ring-based gantry to maintain stability and rigidity like computed tomography (CT) scanners. Also, Helical TomoTherapy is widely accessible even in community settings. Unlike other dose-delivery systems, acceptance test and commissioning of the installed Helical TomoTherapy unit were performed in close collaboration with the physics group of the company to ensure the integrity of the system was verified. This support offers the assurance that the unit is commissioned appropriately. The clinical procedure of the SRS will be streamlined to produce a workflow that can follow the typical IMRT procedure: (1) immobilization and CT simulation, (2) treatment planning, and then (3) dose delivery. Noninvasive radiosurgical immobilization devices are commercially available.

The Helical TomoTherapy unit is a unique system consisting of a small 6-MV linear accelerator mounted on a ring-based gantry that rotates isocentrically around the patient as the patient moves through the bore yielding a helical path of radiation dose delivery. Although it looks like a helical CT scanner on the outside, the beam intensity is modulated using a binary collimator on the inside. The specially designed binary collimator has 2 banks, and each bank has 64 leaves with a beamlet size of 0.626 cm, giving a total field width of 40 cm. The binary collimator is computer controlled with the leaves sliding in and out of the slit aperture to provide temporal beam modulation. The jaw settings create a beam width of either 1.0, 2.5, or 5.0 cm. The new model of Helical TomoTherapy unit allows the jaws to move rather than be fixed as in the older model, to facilitate treatment planning.[12] The Helical TomoTherapy unit also has megavoltage computed tomography (MVCT) imaging to provide image-guided radiation therapy capability for accurate patient setup.

Before CT simulation, the patient's head is immobilized using a specially designed thermoplastic mask system. During the fabrication, the thermoplastic mask is pulled over such that the opening accommodates the patient's face. After the mask hardens, an "SRS-stereotactic radiotherapy (SRT)" immobilization device, as shown in Fig. 1, is used to limit the head tilt.[13] The device consists of a nosepiece held in position by a hardware attached to a plate indexed to the couch. There is also a custom bite block that is fabricated and utilized for each individual patient. The positional movements have scales for quantitative recordings and set-up verification. Next, a CT image dataset is taken at a 1-mm slice thickness from the top of the head through the cervical spine. After the CT scan is taken, the patient is subjected to a magnetic resonance imaging (MRI) scan in the treatment position. Both the CT and MRI image datasets are downloaded into the Pinnacle treatment planning system (version 9.4) (Philips

Fig. 1. The "SRS-SRT" immobilization device is used to limit head tilt. (Color version of figure is available online.)