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STAT-SRS: Same Day Frameless LINAC-Based Intracranial Stereotactic Radiosurgery Workflow Development

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Abstract
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Steven Herchko [1], Sridhar Yaddanapudi [1], Jennifer Peterson [2], Daniel M. Trifiletti [3]

1. Radiation Oncology, Mayo Clinic, Jacksonville, USA 2. Department of Radiation Oncology, Mayo, Jacksonville, USA
3. Department of Radiation Oncology, Mayo Clinic, Jacksonville, USA

Corresponding author: Steven Herchko, herchko.steven@mayo.edu

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Abstract

Objectives:

Stereotactic radiosurgery (SRS) is a common treatment strategy at many centers with appropriate expertise. There are two main systems used in the world today: the Gamma Knife and the LINAC-based platform. While generally considered equivalent in terms of patient outcomes, LINAC-based SRS boasts more rapid treatment delivery times, which is appealing for many patients. A major limitation of LINAC-based SRS (compared to Gamma Knife) is that LINAC-based SRS takes routinely 2 weeks to schedule, contour, plan, QA, and deliver, whereas the Gamma Knife SRS platform allows SRS planning and delivery within hours. This delay is not insignificant as brain tumors have been shown to grow over this time, potentially leading to missed tumor. Perhaps most important, the patient experience suffers when they are forced to wait for weeks for a potentially lifesaving therapy. This work aims to develop a “STAT-SRS” workflow, in which patients with brain metastases can undergo treatment planning based on diagnostic magnetic resonance imaging (MRI) alone, and then rapid treatment delivery within hours of presenting to the clinic.

Methods:

Skull and brain structures were segmented on eight previously treated patient computed tomography (CT) datasets using commercially available artificial Intelligence (AI) auto segmentation models. CT-based structures were then transferred to diagnostic MRI images through rigid registration, and an MRI-based atlas segmentation model was created to auto segment skull and brain volumes on MRI images alone. Diagnostic MRI images for an additional patient were auto segmented using the generated MRI atlas-based model, and a bulk-density synthetic CT (BDSCT) dataset was created using average Hounsfield Unit (HU) values for skull and brain volumes from the eight atlas datasets. The BDSCT was sent to the treatment planning system (TPS), and a treatment plan was generated using the previously delineated target volumes. A workflow to use BDSCT for treatment planning to allow patient treatment within hours of presenting to the clinic is proposed.

Results:

The proposed workflow involves creating a treatment plan based on a diagnostic MRI prior to the patient arriving to the clinic. Target delineation and auto segmentation are performed on the diagnostic MRI, and a BDSCT is created with bulk density overrides for accurate dose calculation. Contouring, treatment planning, and plan review all occur prior to the patient’s arrival using the BDSCT. Patient specific quality assurances (PSQA), whether measurement or calculation based, is performed on the BDSCT treatment plan. When the patient presents to the clinic, a CT simulation is performed, and patient specific immobilization devices are created as needed. The CT simulation dataset is then co-registered to the BDSCT and the plan is re-calculated on the CT simulation dataset for final review and approval. The co-registration, recalculation, and final approval can all occur within hours of CT simulation and the patient is treated the same day.

Conclusion(s):

A workflow for STAT-SRS is proposed to deliver same day frameless LINAC-Based stereotactic radiosurgery (SRS). Additional investigation is needed to create a robust auto segmentation atlas for accurate BDSCT creation, and dose calculation accuracy must be thoroughly evaluated to verify dose calculations performed on a BDSCT agree with the CT simulation dataset prior to clinical implementation.