

PROTON RADIATION THERAPY

FIRST PATIENT TREATED USING IUCF PROTON BEAM

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Malignant astrocytoma of the brain remains a challenging problem, as it is rarely proven to be curative even with the most aggressive, comprehensive treatments. This makes it a good candidate for more innovative radiation therapy designed to deliver a higher dose to the tumor bed while minimizing the normal brain tissue radiation exposure. Proton irradiation can offer such an advantage because the Bragg peak allows delivery of a higher tumor dose with good spatial resolution. This past year, the Indiana University School of Medicine became the 3rd active proton radiation therapy center in the United States, when 200-MeV protons from the Indiana University Cyclotron Facility (IUCF) were delivered to a patient.

The patient is a 22-year-old Caucasian male with recently diagnosed anaplastic astrocytoma located at the left occipital parietal area. The patient had a large left temporal anterior lobe resection 17 years ago for intractable seizure disorder. Further resection would be incapacitating for the patient, therefore we recommended a combination of photon and proton beam irradiation. The total tumor dose was 69 cobalt Gray equivalent (CGE). The external-beam photon treatment consisted of 54 Gy in 30 fractions to the tumor with 3 cm of margin using 6 MV photons. The photons were delivered through left lateral and vertex wedge-pair fields. The proton beam treatment consisted of 15 CGE in five fractions to the tumor with 1 cm of margin, with each fraction equally divided among three fields.

Prior to treatment, three titanium screws were inserted into the patient's skull to serve as fiducial markers for precise patient positioning in the proton fields. After the screws were inserted, a spiral CT scan was performed with the patient immobilized in a specially designed thermoplastic mask encompassing the patient's head. The CT scans were used to determine the position of the tumor with respect to the titanium screws, which are clearly visible in the port verification films.

Since the protons are delivered in a fixed horizontal beam line, the patient was immobilized in a seated position. A 1-cm tumor margin was given to the proton treatment field, which was carefully designed according to the 3-D treatment planning, with known tumor volume and relevant land marks. Figure 1 shows the central slice from the treatment plan, with iso-dose contours at the 10, 30, 50, 70, 80, 90, and 95% levels. Also seen are the thermoplastic mask and a cross-section of the frame to which it was fastened. A wax bolus is represented on the left posterior of the patient. A three-field technique was used, with bilateral and posterior fields using a 6-cm diameter circular field. A 4-cm spread-out

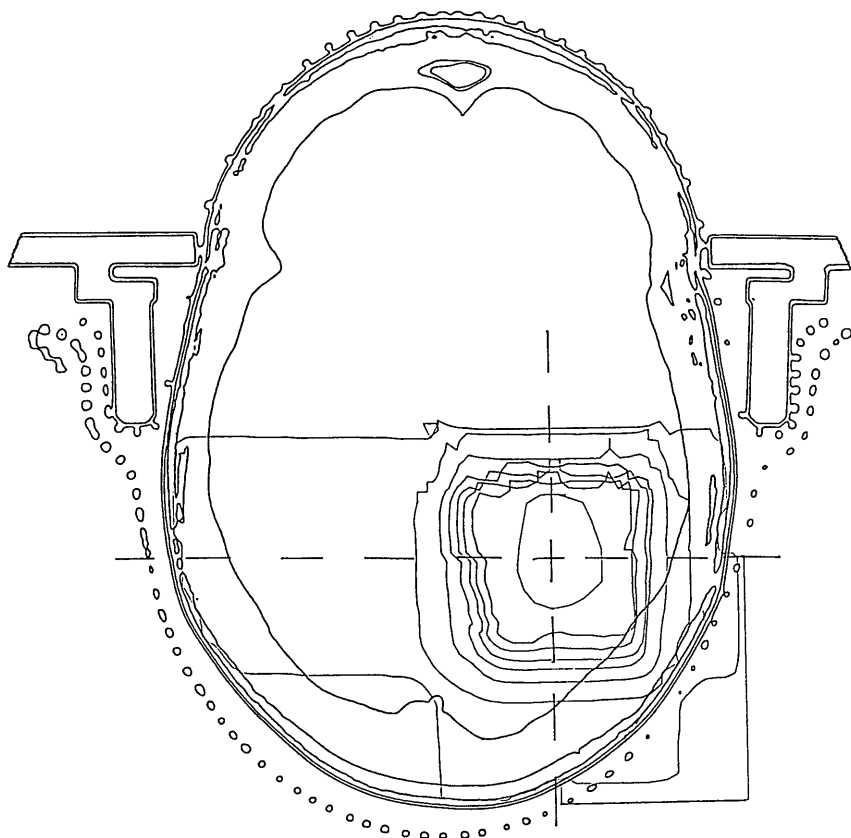


Figure 1. The central slice from the CT-based proton treatment plan. The inner-most outline is the tumor volume. Surrounding outlines represent levels of constant dose at the 95, 90, 80, 70, 50, 30, and 10% (of the maximum) level. Also visible are the thermoplastic mask and mounting frame, and the wax bolus used at the left posterior.

Bragg peak (SOBP) was achieved with a range modulator, and a different range shifter was installed for each field treated. Figure 2 shows a single field dose distribution measured in a water phantom as a function of depth and lateral position. Prior to each treatment, the position of the tumor relative to the beam center was verified by an x-ray port film. Adjustment of the patient was performed until the desired position of the target region was achieved. Field placement accuracy was within 2 mm.

Four months post-treatment, a PET scan of the patient's brain was performed and compared to a pre-treatment PET scan. The comparison revealed the disappearance of FDG (Flouro 18-Deoxy-Glucose) uptake, which indicates tumor response to treatment. There were no acute complications observed, and no signs of radionecrosis. The patient is being carefully followed for delayed toxicity.

With the combined photon and proton therapy, we are hoping to gain superior tumor control for this patient, and hopefully obtain longer survival duration. With successful delivery of precision proton beam irradiation, we hope to develop proton treatment for other primary brain malignancies, prostate cancer, cholangiocarcinoma, locally advanced head and neck carcinoma, and rectal tumors.

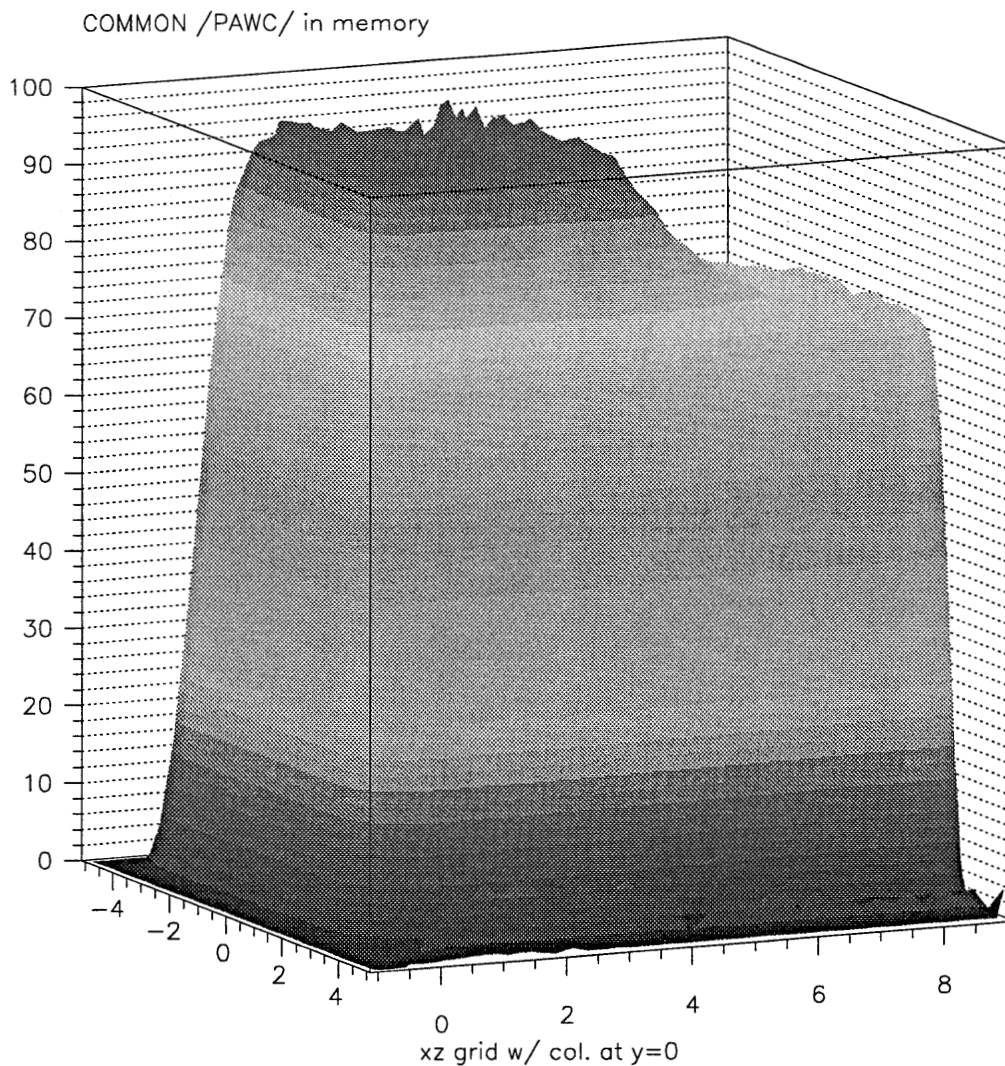


Figure 2. A single field dose distribution as measured in a water phantom. The origin on the depth axis represents the maximum depth of the Bragg peak, while the origin on the lateral axis represents the beam's central axis.

Most recently, the United States Food and Drug Administration granted the IU proton therapy facility an investigational device exemption, allowing further treatments of this type. Preparations are presently in progress for the next patients.

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