Uniformity of Dose Distribution in Radiation Fields Surrounding the Spine using Film Dosimetry and Comparison with 3D Treatment Planning Software

Sadegh Masoudi , Vahid Fayaz ,Hassan Zandi, Asieh Tavakol

***Abstract*—**The overall penumbra is usually defined as the distance, p20–80, separating the 20% and 80% of the dose on the beam axis at the depth of interest. This overall penumbra accounts also for the fact that some photons emitted by the distal parts of the source are only partially attenuated by the collimator. Medulloblastoma is the most common type of childhood brain tumor and often spreads to the spine. Current guidelines call for surgery to remove as much of the tumor as possible, followed by radiation of the brain and spinal cord, and finally treatment with chemotherapy. The purpose of this paper was to present results on an Uniformity of dose distribution in radiation fields surrounding the spine using film dosimetry and comparison with 3D treatment planning software.

***Keywords*—**Absorbed Dose , Spine , Radiotherapy, 3D treatment planning software

I. INTRODUCTION

MEDULLOBLASTOMA is classically identified as a primitive neuroectodermal tumor arising in the cerebellum, which comprises 20–30% of brain tumors and about 40% of all posterior fossa tumors in children [1]. The peak age at presentation is 5–10 years [2],[3]. Surgical resection followed by craniospinal irradiation (CSI) has been the mainstay of medulloblastoma therapy for many years [4]. The standard radiation regimen has comprised a dose of 36 Gy to the entire craniospinal axis followed by a boost to the whole posterior fossa, for a total dose of 55 Gy [2-6].

In all axial co-planar irradiation techniques, there is an overlap of the penumbrae of all treatment Fields around thesuperior and inferior ends of a planning target volume (PTV), yielding a relatively large distance between the overall 95 and 50% isodose surfaces in these regions [7],[8].

Around field corners, the dose fall-off is even shallower due to lateral electronic disequilibrium in both longitudinal and lateral directions. As a result, in superior and inferior direction large field margins should be added to a beam's eye view projection of the PTV to comply with ICRU-50 recommendations for dose homogeneity [9].Medulloblastoma is a densely cellular tumor with small, darkly staining ovoid cells with hyperchromatic nuclei and frequent mitoses. The same radiation technique was used for all Medulloblastoma patients. Patients were placed in a prone position, with the head and neck immobilized by use of a plastic mask. Bilateral opposite fields and 6–8 MV X-rays were used to irradiate the brain and posterior fossa. Spinal irradiation utilized electrons, 6–8 MV X photons, or mixed rays. Two to three fields were established according to spine length, with the fourth sacral aperture used as the inferior limit of the spinal fields. If X-rays were used, a 0.5–1.5 cm gap was left between the brain field and spinal field or between the upper and lower spinal fields, corresponding to the depth of the spine. The whole-brain and spinal irradiation fields were usually partitioned immediately inferior to the fourth cervical vertebra. Each week, the gaps between fields were moved in the superior or inferior direction, a distance equivalent to the width of the gap[6].

Sadegh masoudi is with the islamic azad university, dehdasht branch (corresponding author to provide phone: +989127070053; e-mail: hasanznd@yahoo.com).

Vahid fayaz is with department of physics , hamedan branch , islamic azad university (corresponding author to provide phone: +989127070053; e-mail : fayaz_vahid@yahoo.com).

Hassan zandi is with the islamic azad university, dehdasht branch (corresponding author to provide phone: +989127070052; e-mail:hasanznd@ yahoo.com).

Asieh tavakol is with the islamic azad university, dehdasht branch (phone: +989171066495; e-mail: aseieh_tavakol @yahoo.com).

II. MATERIALS AND METHODS

All measurements were performed using a Primus linac (Siemens, Germany) established in the Mahdieh Radiotherapy and Oncology, Hamadan, Iran. The primus linac provides two low and high energy photon beams (6 and 15 MV) and a range of electron beams (5-12 MeV). The original fluence maps were manipulated for several transitional and rotational displacements. The results, as evaluated maps, were then compared with the original fluence maps, as reference maps. All of the current work procedures were performed using in-house codes written by MATLAB.

A. Phantom

A solid water phantom Plate was used for this study (12cm diameter), representative of a neck or breast. The surface 1cm of this phantom was bolus material. Measurement positions were identified on the surface of the phantom using marks and radiopaque fiducials. The phantom was CT scanned, giving CT pixels 1.3mm x 1.3mm x 2.5mm. This is representative of the imaging parameters used in our clinic.

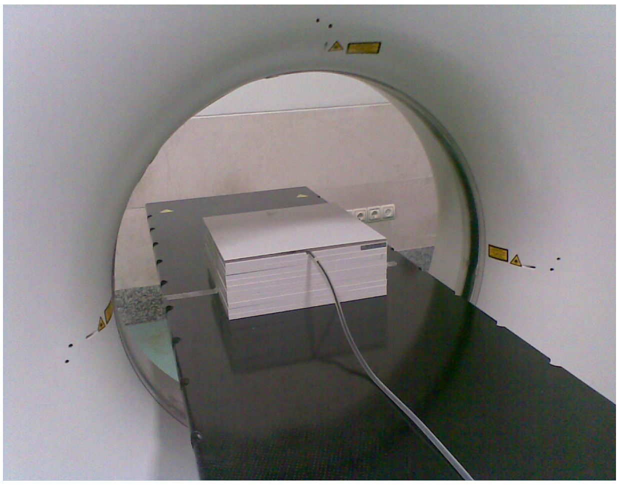

Fig. 1 phantom placed in CT scan device

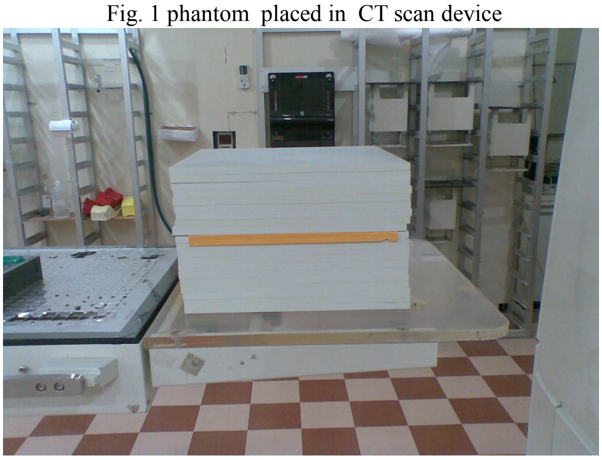

Fig. 2 set up for solid water phantom Plate

B. Treatment planning system calculations

Separate plans were created in COREPLAN for each experimental setup. Skin doses were calculated by first creating a 2mm thick 10mm x 10mm surface structure centered on the measurement mark (as seen using fiducials in the CT images). For the propose of this study, skin dose was calculated as the mean dose to this structure. The dose calculation grid was set to 2.5mm, as this is the size used for most clinical cases . The measured and calculated doses were compared, and the differences were expressed as a percentage of the measured dose.

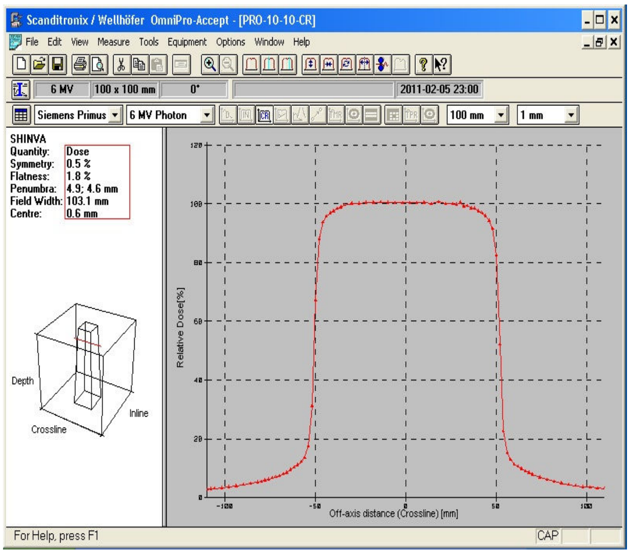

Fig. 3 Standard Field (10*10) Measurement With semiconductor

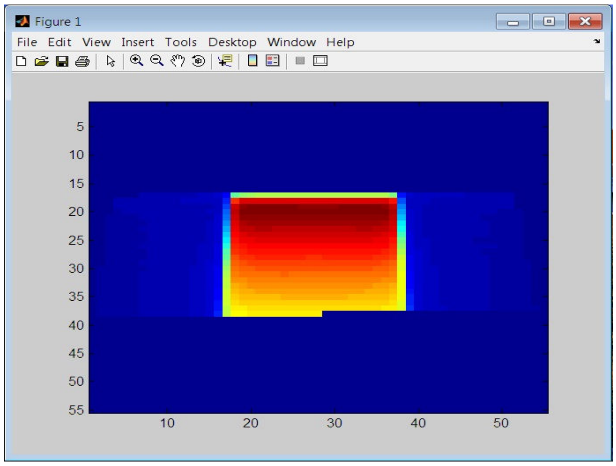

Fig. 4 Dose distribution in phantom Taken with Radiochromic

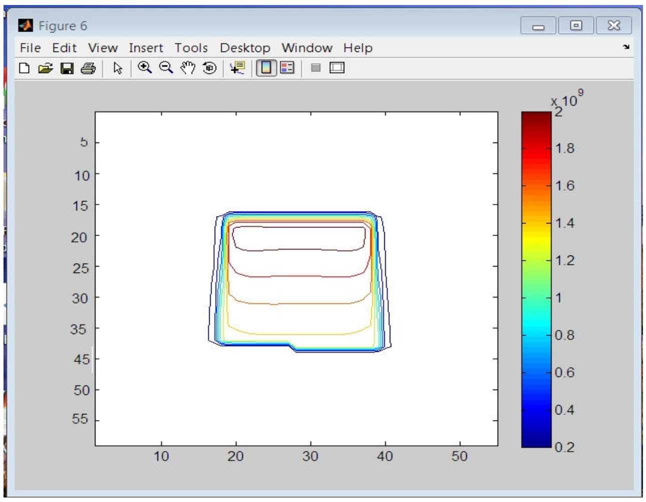

Fig. 5 relative dose difference maps

C. GafChromic EBT films

Radiochromic phenomena involve the direct coloration of a material by the absorption of radiation without the use of external chemical, optical or thermal agents. Radiochromic films are nearly transparent before irradiation and consist of a micro-crystalline active thin layer based on polydiacetylene, coated on a flexible polyester film base. After irradiation, their color changes to blue due to polymerization effects[10].

The internal structure of GafChromic EBT consists of two active layers of 17 µm thickness separated by a 6 µm layer coated on a 97 µm polyester base on each side. This design decreases the effects of environmental and ultraviolet light[11]. The atomic composition of the film material is C (42.3%), H (39.7%), O (16.2%), N (1.1%), Li (0.3%) and Cl (0.3%) with an effective atomic number of 6.98. Its sensitivity is 10 times larger than its predecessors, such as GafChromic MD- 55-2 and HS. The useful dose range is from 1 to 800 cGy, and presents two absorption peaks at 636 and 585 nm,[12] its response is energy independent,[13] and according to the manufacturer specifications, it has a real time response.

III. Conclusion

All patients with nondisseminated medulloblastoma should undergo complete resection if feasible. In some cases, extension into the brainstem precludes complete resection without significant morbidity.

Two to three fields were established according to spine length, with the fourth sacral aperture used as the inferior limit of the spinal fields. If X-rays were used, a 0.5–1.5 cm gap was left between the brain field and spinal field or between the upper and lower spinal fields, corresponding to the depth of the spine.Accurate measurements of the penumbra region are important for the proper modeling of the radiation beam for medulloblastoma patients. The usual data collection technique with a standard semiconductor artificially broadens the measured beam penumbrae due to volume effects. The average decrease in the measured width of the 80%-20% penumbrae of standard field of size 10-10 cm, at 5 cm depth in water-equivalent plastic was about 5mm.

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