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SRS/SRT SUPPLEMENT

COMPARATIVE DOSIMETRIC STUDY OF THREE-DIMENSIONAL CONFORMAL, DYNAMIC CONFORMAL ARC, AND INTENSITY-MODULATED RADIOTHERAPY FOR BRAIN TUMOR TREATMENT USING NOVALIS SYSTEM

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Purpose: To investigate the dosimetric differences among three-dimensional conformal radiotherapy (3D-CRT), dynamic conformal arc therapy (DCAT), and intensity-modulated radiotherapy (IMRT) for brain tumor treatment.
Methods and Materials: Fifteen patients treated with Novalis were selected. We performed 3D-CRT, DCAT, and IMRT plans for all patients. The margin for the planning target volume (PTV) was 1 mm, and the specific prescription dose was 90% for all plans. The target coverage at the prescription dose, conformity index (CI), and heterogeneity index were analyzed for all plans.
Results: For small tumors (PTV ≤2 cm^3), the three dosimetric parameters had approximate values for both 3D-CRT and DCAT plans. The CI for the IMRT plans was high. For medium tumors (PTV >2 to ≤100 cm^3), the three plans were competitive with each other. The IMRT plans had a greater CI, better target coverage at the prescription dose, and a better heterogeneity index. For large tumors (PTV >100 cm^3), the IMRT plan had good target coverage at the prescription dose and heterogeneity index and approximate CI values as those in the 3D-CRT and DCAT plans.
Conclusion: The results of our study have shown that DCAT is suitable for most cases in the treatment of brain tumors. For a small target, 3D-CRT is useful, and IMRT is not recommended. For larger tumors, IMRT is superior to 3D-CRT and very competitive in sparing critical structures, especially for big tumors. © 2006 Elsevier Inc.

Dosimetric comparison, Three-dimensional conformal radiotherapy, Dynamic arc radiotherapy, Intensity-modulated radiotherapy.

INTRODUCTION

Three techniques have primarily been applied in linear accelerator-based, single-fraction stereotactic radiosurgery and fractionated stereotactic radiotherapy for brain tumors: conventional arc therapy, three-dimensional conformal radiotherapy (3D-CRT), and dynamic conformal arc therapy (DCAT). Recently, intensity-modulated radiosurgery or intensity-modulated RT (IMRT) has also been introduced with the advent of the commercial micro-multileaf collimator and treatment planning systems.

Several reports have compared the dosimetric difference between conventional arc therapy and 3D-CRT (1–6). These studies have typically concluded that 3D-CRT with a micro-multileaf collimator demonstrated an enhanced ability to conform the dose distribution to an irregularly shaped target. Single isocenter 3D-CRT has been argued to be preferable to single and multiple isocenter circular collimator treatment, because it can provide a more uniform dose distribution to an irregularly shaped target, thereby reducing the dose to surrounding brain tissue. The technique of DCAT, which includes intensity-modulated arc therapy, has been applied to intracranial tumor treatment within the previous decade (7–13).

Dynamic conformal arc therapy can offer highly conformal dose distributions for different sites, and the planning is sometimes faster than for 3D-CRT. However, most commercial planning systems for DCAT use forward planning methods, obliging the planner to compare different plans visually and then adjust the parameters. The use of IMRT, with an inverse planning strategy, starting with a description of a desired dose distribution and then deriving the beam intensity profile, has been widely implemented for treatment of various extracranial tumors (14). IMRT can allow steep dose gradients between a target and a nearby dose-limiting structure.

Cardinale *et al.* (15) compared IMRT plans with conventional arc therapy and 3D-CRT plans for three nonspherical

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Table 1. Fifteen patients selected for study

Group	Pt. no.	PTV (cm^3)	Tumor site
1	1*	1.44	Right cranial nerve
	2	1.46	Left acoustic nerve
	3	2.02	Right acoustic nerve
2	4	7.91	Pituitary gland
	5	8.19	Right frontal lesion
	6	12.06	Cerebral meninges
	7	12.14	Left eye
	8	12.38	Pineal gland
	9	14.50	Optic region
	10	18.07	Brainstem
	11	21.45	Cerebral meninges
	12	38.10	Orbit
3	13	62.36	Nasopharynx
	14	150.42	Cerebellum
	15	179.70	Right brain

Abbreviations: Pt. no. = patient number; PTV = planning target volume.

* Treated with three-dimensional conformal radiotherapy, others by dynamic conformal arc therapy.

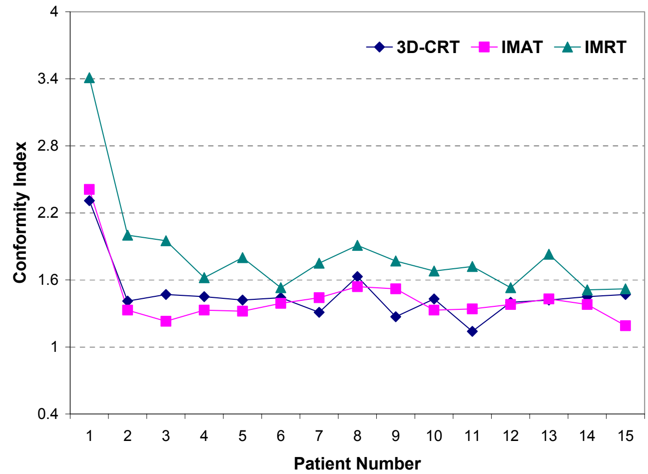

Fig. 2. Conformity index for three different plans. Diamonds indicate three-dimensional conformal radiotherapy (3D-CRT), squares indicate dynamic conformal arc therapy (DCAT), and triangles indicate intensity-modulated radiotherapy (IMRT). Target volume increased with patient number.

intracranial target shapes. These investigators concluded that IMRT resulted in improved dose conformity and decreased the dose to nontarget brain tissue. Baumert *et al.* (16) compared IMRT plans generated on the BrainLAB treatment planning system (BrainLAB AG, Heimstetten, Germany) with those for 3D-CRT for the treatment of tumors in the skull base. They concluded that IMRT was typically advantageous in terms of planning target volume (PTV) coverage, especially for irregular and concave targets, but the volume of normal tissue receiving a low dose can be larger with IMRT.

In this study, we investigated the dosimetric differences among 3D-CRT, DCAT, and IMRT plans for a broad range of brain tumor volumes in an effort to determine whether a preferred method can be identified on the basis of pretreatment characteristics.

METHODS AND MATERIALS

We randomly selected 15 cases from the database of patients with brain tumors who had been treated with the Novalis m3 (BrainLAB AG, Heimstetten, Germany) at our institution. The patients were numbered in the order of the planning tumor volume (Table 1). Fourteen of them were treated with DCAT and one with 3D-CRT. Using BrainSCAN, version 5.21, we created 3D-CRT, DCAT, and IMRT plans for all cases. In this study, the beam numbers in the 3D-CRT or IMRT plans were the same as the arc numbers in the DCAT plans, and the gantry angle of each beam in the 3D-CRT or IMRT plans was at the middle angle of each arc in

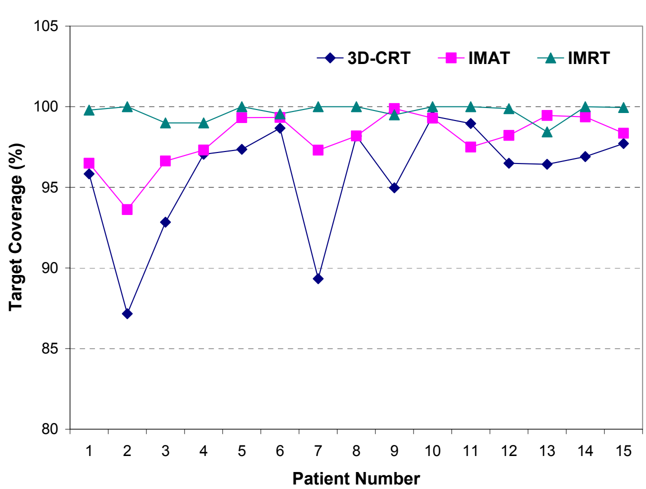

Fig. 1. Target coverage for prescription dose for three different plans. Diamonds indicate three-dimensional conformal radiotherapy (3D-CRT), squares indicate dynamic conformal arc therapy (DCAT), and triangles indicate intensity-modulated radiotherapy (IMRT). Target volume increased with patient number.

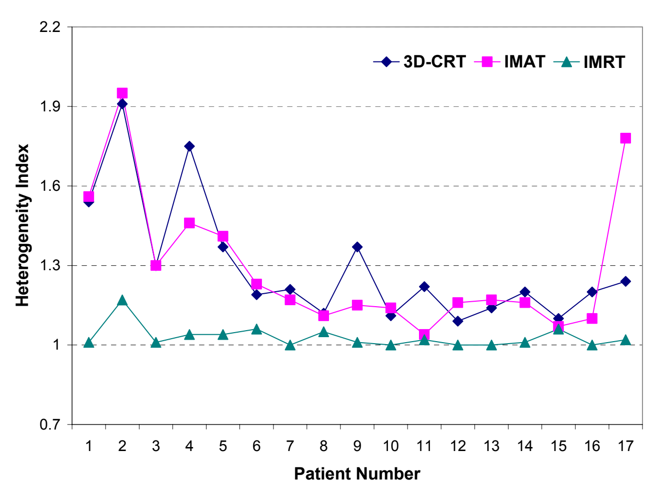

Fig. 3. Heterogeneity index for three different plans. Diamonds indicate three-dimensional conformal radiotherapy (3D-CRT), squares indicate dynamic conformal arc therapy (DCAT), and triangles indicate intensity-modulated radiotherapy (IMRT). Target volume increased with patient number.