

Auditory Apparatus sparing in Pediatric Medulloblastoma Patients

A Comparison of Clinical Target Volume Coverage between Intensity-Modulated Arc Therapy (IMAT) and Static-Field Intensity-Modulated Radiation Therapy (IMRT) planning techniques for Posterior Fossa Boost Plans

S.K. Chennupati, C. Marquez, W. Laub, J.A. Tanyi, M. Fuss

Department of Radiation Medicine, Knight Cancer Institute,
Oregon Health & Science University, Portland, Oregon, USA



Background

IMRT is the current standard for delivering the posterior fossa boost in patients with medulloblastomas. Previous reports have described the advantages of IMRT for sparing the auditory apparatus (AA) (Huang et al 2002, St. Clair et al 2004). It has been proposed that a mean total dose of less than 42 Gy to the AA helps reduce ototoxicity. Given an assumed dose of 36 Gy to the craniospinal axis, a steep dose gradient to spare the AA to a 6 Gy dose level is necessary. The compromise in tumor volume coverage with these sparing techniques has yet to be described between Intensity-modulated Arc Therapy (IMAT) and static-field IMRT plans. The specific aim of the current analysis was to compare tumor coverage and delivery times using three different IMRT-based planning techniques.

Methods

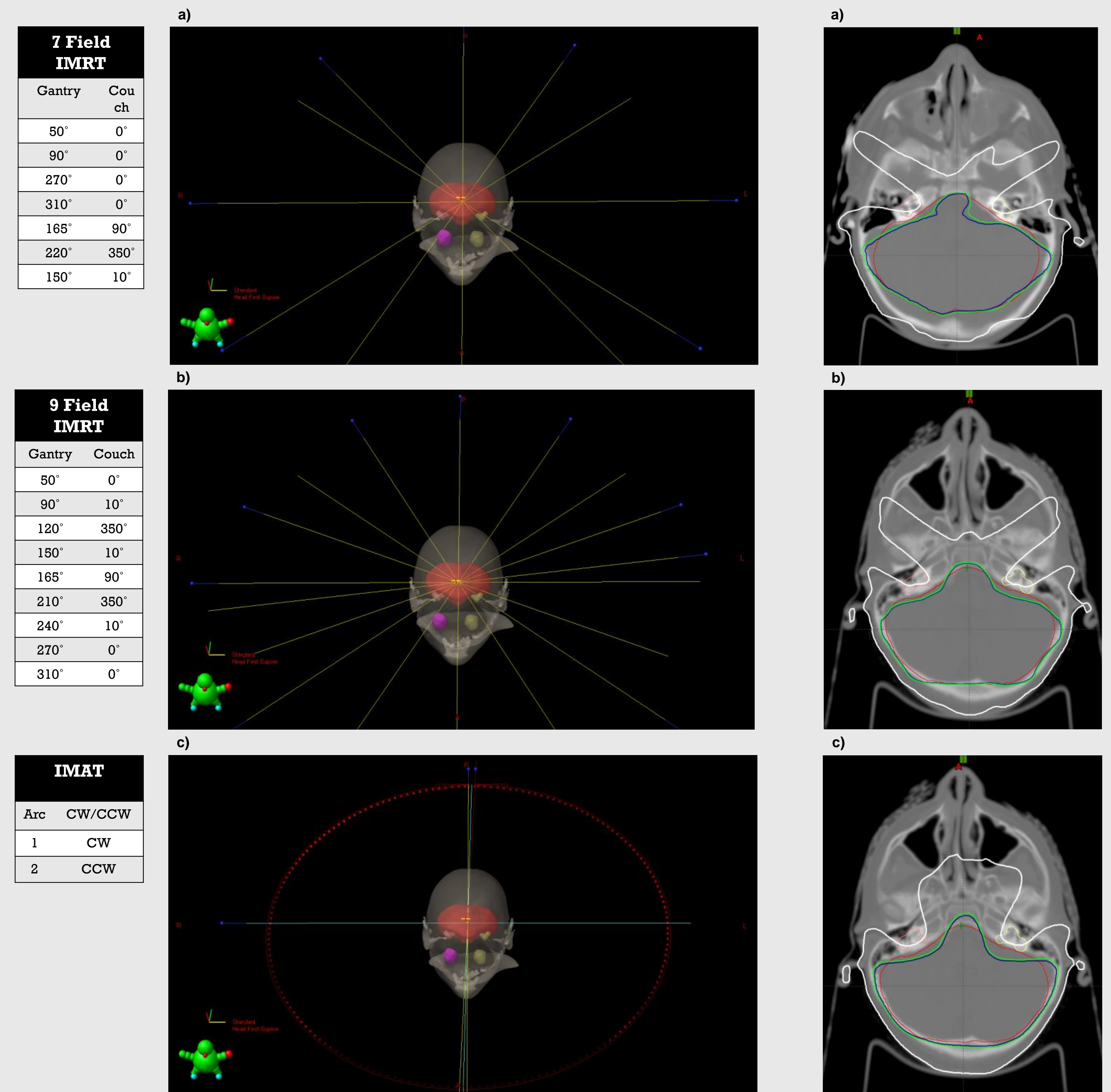
Posterior fossa boost plans were created for 10 children using 7 and 9 field static-field IMRT plans, and compared to an IMAT plan (RapidArc, Varian) (please refer to figure 1 for field/arc parameters). All boost plans were planned for delivery on a Brainlab Varian Novalis TX with HD-MLC (leaf width 2.5 mm) using 6 MV (Figure 1). Aside from the posterior fossa as the clinical target volume (CTV), the AA was delineated to include the cochlea, inner auditory canal and semi-circular canals. In addition, the optic nerves, chiasm, and pituitary gland were delineated. All boost plans were prescribed to 19.8 Gy over 11 fractions. Optimization aimed to limit the mean AA dose to 6 Gy, for a cumulative total dose to the AA of <42 Gy. All plans were normalized that neither L nor R mean AA dose exceeded 6 Gy. We then assessed what percentage of the posterior fossa CTV was covered by the prescribed dose. CTV coverage >90% was judged as acceptable and coverage >95% as excellent. A paired t-test was used to evaluate the results. We also assessed maximum doses to CTV (CTVmax), pituitary, optic nerves and chiasm.

Radiation delivery times of the different technologies were compared. Initial setup was estimated at 60 seconds, delivery of each arc was estimated at 60 seconds, each change in table angle was estimated at 60 seconds, mode up time between IMRT fields was estimated at 15 seconds, and treatment time for IMRT plans was based on a 600 MU/minute delivery rate. Image guidance was not included in this delivery time estimate.

Results:

Given the plan dose normalization based on AA mean dose of 6 Gy, IMAT plans had mean target volume coverage of 96.5%, compared to 90.3%, and 92.3% for 7 and 9 field IMRT plans ($p < 0.00001$ and $p = 0.002$), respectively. Ninety percent of IMAT plans had excellent coverage and 10% had acceptable coverage compared to 10% and 40% of 7 field IMRT plans, and 20% and 70% of 9 field IMRT plans. Mean radiation delivery time was increased by 82% and 160% using 7 and 9 field IMRT plans compared with IMAT plans, respectively. CTVmax and maximum dose to organs at risk were within acceptable limits, and did not differ significantly between plans.

	7 Field IMRT	9 Field IMRT	IMAT
Mean CTV coverage	90.3%	92.3%	96.5%
	$p < 0.00001$	$p = 0.002$	
Excellent coverage	10%	20%	90%
Acceptable coverage	40%	70%	10%
Percent increase in delivery time compared to IMAT	82%	160%	



Conclusions:

IMAT planning afforded superior CTV coverage over static-field IMRT plans while respecting the specified auditory apparatus dose limitations. In addition, the estimated reduction in treatment delivery times makes IMAT advantageous for a pediatric population given the frequent need for sedation with each treatment. Thus, IMAT, using RapidArc planning and delivery techniques, is considered a superior alternative to IMRT when delivering a posterior fossa boost in children with medulloblastoma.

References:

- Huang, E., B. S. Teh, et al. (2002). "Intensity-modulated radiation therapy for pediatric medulloblastoma: early report on the reduction of ototoxicity." *International Journal of Radiation Oncology Biology Physics* 52(3): 599-605.
- St Clair, W. H., J. A. Adams, et al. (2004). "Advantage of protons compared to conventional X-ray or IMRT in the treatment of a pediatric patient with medulloblastoma." *International Journal of Radiation Oncology Biology Physics* 58(3): 727-734.
- Breen, S. L., P. Kehagioglou, et al. (2004). "A comparison of conventional, conformal and intensity-modulated coplanar radiotherapy plans for posterior fossa treatment." *The British Journal of Radiology* 77(921): 768-774.