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Original Article

Oncology Section

Comparison of Static Conformal Beam and Intensity Modulated Radiation Therapy for Intracranial Stereotactic Radiosurgery

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ABSTRACT

Introduction: Stereotactic Radiosurgery (SRS) by high end Linear Accelerator is very common. There are different treatment planning and delivery options for doing Linear accelerator based SRS namely by Conformal beam or dynamic conformal arc or Intensity Modulated Radiotherapy (IMRT).

Aim: To perform a dosimetric comparison between the static conformal beam and fixed field IMRT for intracranial SRS planning.

Materials and Methods: A retrospective study was conducted in which four patients treated for single lesion brain metastasis by frame-based SRS (18 Gy) on a 6 MV linear accelerator equipped with microMLC (3 mm) were included. All these patients were planned using BrianLAB iPlan system (PBC algorithm with heterogeneity correction) using 9-14 non-coplanar static conformal fields. For each case, fixed-field IMRT plans were also generated using the same field arrangement. Target coverage V95% (target volume receiving 95% dose) and D95 (dose to 95% target volume), normal tissue sparing 80% dose volume (V80%), 50% dose volume (V50%) and 25% dose volume (V25%) and treatment efficiency (total Monitor Units (MU)) were compared between conformal fields and IMRT.

Results: The median target volume for all the lesions was 10.67cc, range 2.90-28.85 cc. Target coverage of conformal beam and IMRT was almost similar (p=0.78). V95% and D95 of conformal beam plan were 96.9±1.7 % and 17.4±0.3 Gy; whereas the readings for IMRT were 98.9±1.6 and 17.7±0.3 Gy, respectively (p=0.18). V80%, V50% and V25% of conformal beam plan were 21.9±18.5cc, 41.1±33.4cc, and 121.5±89.3cc, respectively; on contrary the same for IMRT were 23.9±18.5cc, 45.8±33.8cc, and 122.5±94.5cc. (p= 0.11) When comparing the treatment efficiency, the conformal beam plan resulted in a significantly smaller total MU. The total MU of conformal beam plan was 3080.5±306.8 MU (median: 3172.5 MU); whereas the same for IMRT was 4905.3±360.1 MU (median: 5034 MU) (p=0.04).

Conclusion: Conformal beam SRS planning is no different from fixed field IMRT plan in terms of target coverage and normal tissue sparing; however conformal beam plan resulted in a significantly smaller total MU which may have a clinical impact.

Keywords: Dosimetric comparison, Fixed-field intensity modulated radiotherapy planning, Monitor units, Target coverage

INTRODUCTION

The SRS refers to precise, conformal and focused delivery of high dose of radiation in a single session to an intra or extra-cranial target while minimising the dose to surrounding normal tissues [1,2]. There are 3 main types of machines that can do SRS treatment; CyberKnife, GammaKnife and high-end Linear Accelerator. SRS by high-end Linear Accelerator is very common in practice throughout the world. Further, there are different treatment planning and delivery options for doing Linear accelerator-based SRS namely by Conformal beam or dynamic conformal arc or IMRT (fixed field/Arc). Linear accelerators having a Multileaf Collimator (MLC) allow the use of noncircular apertures, resulting in more conformal dose distributions to target tissue sparing organs at risk. Conformal beam and IMRT (fixed field/Arc) are the most common types of SRS planning [3-8]. Minimal literature is available to compare the use of fixed-field IMRT with static conformal beam SRS planning, hence the present study was carried out with an aim to perform a dosimetric comparison between static conformal beam and fixed field IMRT for intracranial SRS planning in terms of Target coverage, normal tissue sparing and treatment efficiency (total MU).

MATERIALS AND METHODS

A retrospective study was conducted in which four consecutive patients treated within the department between June 2008-June 2010 were taken. Consent for intracranial SRS treatment was taken from each patient according to department and institute protocol. Metastatic infiltrating ductal carcinoma or adenocarcinoma of breast or lung primary with single lesion brain metastasis treated by frame-based SRS (18 Gy) on a 6 MV linear accelerator equipped with microMLC (3 mm) were included in the study. Patients with multiple brain metastasis or brain primary were excluded.

All patients were planned using BrianLAB iPlan system (PBC algorithm with heterogeneity correction) using 9-14 non-coplanar static conformal fields. For each case, fixed-field IMRT plans were also generated using the same field arrangement. For Target coverage V95% (target volume receiving 95% dose) & D95 (dose to 95% target volume), Dmax (Gy) and Dmin (Gy) were compared. To see normal tissue sparing 90% dose volume (V90%), 80% dose volume (V80%), 50% dose volume (V50%) and 25% dose volume (V25%) and treatment efficiency (total MU) were compared between static conformal fields and fixed field IMRT plans.

STATISTICAL ANALYSIS

Statistical analysis was done using the Statistical Package for the Social Sciences; (SPSS) IBM Corporation, New York, USA) version 22. A two tailed paired t-test was used to analyse the differences between the static conformal beam and fixed field IMRT plans. p-value <0.05 was considered as significant.

RESULTS

In present study, the median target volume for all the lesions was 10.67cc, range 2.90-28.85 cc. Target coverage of conformal beam and IMRT was almost similar (p=0.78) V95% and D95 of conformal beam plan were 96.9±1.7 % and 17.4±0.3 Gy; whereas

the same for IMRT was 98.9±1.6 and 17.7±0.3 Gy, respectively (p=0.18,0.36). V80%, V50% and V25% of conformal beam plan were 21.9±18.5cc, 41.1±33.4cc, and 121.5±89.3cc, respectively; on contrary the same for IMRT were 23.9±18.5cc, 45.8±3.8cc, and 122.5±94.5cc. (p=0.11, 0.09, 0.08, respectively.) When comparing the treatment efficiency, the conformal beam plan resulted in a significantly smaller total MU. The total MU of conformal beam plan was 3080.5±306.8 MU (median: 3172.5 MU); whereas the same for IMRT was 4905.3±360.1 MU (median: 5034 MU) (p=0.04) [Table/Fig-1].

DISCUSSION

In present study, the target volume was same for both plans making it more objective for the comparison of both plans. Target coverage of the conformal beam and IMRT plans were similar with no statistically significant difference [Table/Fig-2]. In a conformal beam plan, conformally shaped photon beams are placed on a single isocenter with avoidance of the overlapping volumes between the entrance and exit beam [9-11]. Marks LB et al., and Bourland JD and McCollough KP, have shown that using manual beam placement with several equally-spaced coplanar beams good conformity can be achieved [10,12]. However, manually placing non-coplanar beams often becomes difficult. Static field IMRT plan is delivered using, automatic, iterative beam placement and optimisation to modulate the radiation beam [9-13]. In present study, no statistical significant difference between static conformal beam and fixed-field IMRT plan was found for target volume V95 (%), D95 (Gy), Dmax (Gy), Dmin (Gy) and for normal tissue V90, V80, V50, V25 [Table/Fig-3,4].

Little DJ et al., in their study have found that IMRT plans improved conformity for the majority of patients but did not significantly improve conformity for the entire patient group. The mean 50% CI was 11.1 for Conformal beam plans vs. 9.1 for IMRT plans (p 0.001) [14]. In present study comparison of the treatment efficiency showed that the conformal beam plan resulted in significantly smaller total MU as compared to fixed-field IMRT SRS plan which may have a clinical impact later on. This is in agreement with previous studies using static conformal or dynamic conformal arc fields [14-18]. Present study finding is supported by study by previous study Woo SY et al. They have shown that a conventional radiosurgery planning is no different from intensity modulated planning for a single small target [15].

Limitation(s)

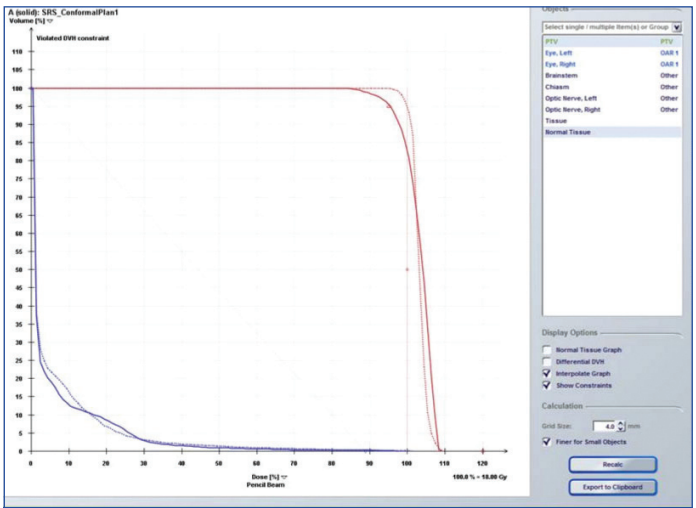
It was a retrospective study with only 4 patients with 4 intracranial lesions. A larger prospective study should be done to validate the findings of this study.

CONCLUSION(S)

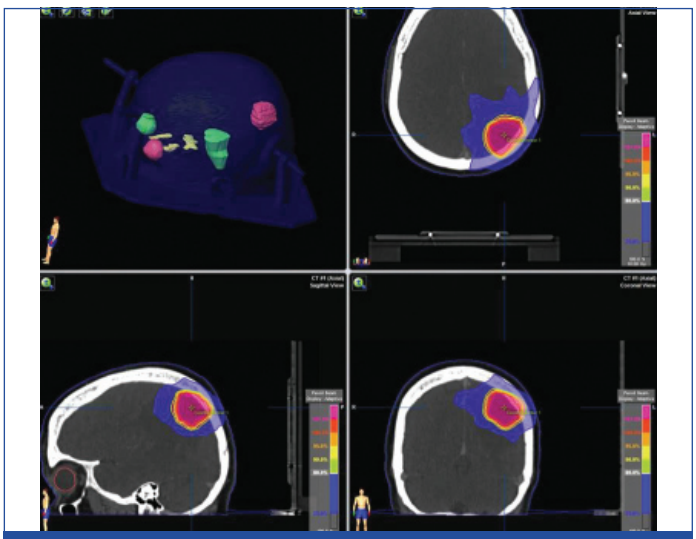
The results of the present study indicate that fixed field IMRT plan was similar to conformal beam SRS planning in terms of target coverage and normal tissue sparing; however later is associated with higher MU delivery which may have a clinical impact. The present study findings may be useful for the centres who want to start intracranial SRS treatment plans using the BrianLAB iPlan system (PBC algorithm with heterogeneity correction) using 9-14 non-coplanar static conformal fields.

		Patient-1		Patient-2		Patient-3		Patient-4		All Patients (n=4)		p-value
		Conformal beam	IMRT	Conformal beam	IMRT	Conformal beam	IMRT	Conformal beam	IMRT	Conformal beam	IMRT	
Target	Target vol (cc)	13.081	13.081	28.85	28.85	8.252	8.252	2.904	2.904	10.67cc (median)	10.67cc (median)	0.78
	V95 (%)	94.9	99.9	98.5	99.6	96	96.5	98.1	99.4	96.9±1.7	98.9±1.6	0.18
	D95 (Gy)	17.2	17.34	17.78	17.86	17.14	17.23	17.4	17.7	17.4±0.3	17.7±0.3	0.36
	Dmax (Gy)	19.5	19.75	19.55	18.9	19.39	18.38	19.63	19.26	19.52±0.5	19.07±0.7	0.38
	Dmin (Gy)	13.92	16.85	14.23	15.53	14.6	15.28	15.07	15.51	14.46±0.4	15.79±0.5	0.14
Normal tissue (in cc)	V90	16.7	20.415	39.294	39.325	10.407	11.122	4.05	4.372	17.61±.6.6	18.81±6.9	0.12
	V80	20.968	26.49	47.873	48.64	13.25	14.618	5.391	5.819	21.9±18.5	23.9±18.5	0.11
	V50	40.04	51.117	87.848	91.997	25.561	28.206	10.795	11.828	41.1±33.4	45.8±33.8	0.09
	V25	167.083	134.3	222.679	249.18	68.616	75.636	27.49	30.695	121.5±89.3	122.5±94.5	0.08
Plan parameters	No Fields	9	9	14	14	12	12	11	11	11±1	11±1	0.80
	Total MU	3295	5124	2658	5168	3050	4385	3319	4944	3080.5±306.8	4905.3±360.1	0.04

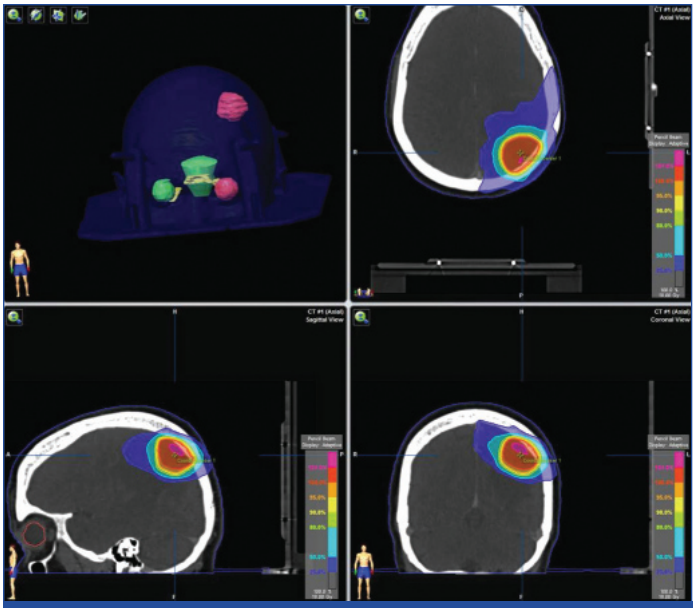
[Table/Fig-1]: Target coverage, normal tissue sparing and treatment efficiency (total MU) values obtained from the analysed metrics.
A two tailed paired t-test was used



[Table/Fig-2]: Dose Volume Histogram comparison of static conformal beam and Fixed field Intensity Modulated Radiation Therapy SRS planning.



[Table/Fig-3]: Dose colour wash of static conformal beam SRS Planning.



[Table/Fig-4]: Dose colour wash of Fixed field Intensity Modulated Radiation Therapy SRS planning.

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