Dosimetric analysis of a Cone-Based and a MLC-Based Treatment Planning Technique for Multiple Brain Metastases Stereotactic Radiosurgery

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JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

INTRODUCTION

Several treatment planning techniques are currently available for multiple brain metastases stereotactic radiosurgery, including HyperArc, Gamma Knife, CyberKnife, and Elements *etc.* These systems create distinct plans which differ with regards to target coverage and normal tissue sparing. Different systems also vary in efficacy when concerning targets of vary sizes, shapes, and placements.

AIM

This study dosimetrically compared a MLC-based automatic planning and a cone based manual planning with respect to target coverage and normal tissue sparing. The intent was to investigate the advantages of each system and provide guidance for institutions when starting a multiple metastases radiosurgery program.

METHOD

Cone plans were previously generated in the CyberKnife MultiPlan module (v5.2, Sunnyvale, CA) for 10 patients with 2-5 metastases. PTV size ranged from 0.03 to 9.19cc in volume and 0.36 to 2.84cm in diameter. Prescription dose ranged from 18 to 20Gy in 1 fraction. MLC plans were created in Brainlab Elements Multiple Brain Mets module (v2.0, Munich, Germany) with a single isocentre for a Varian TrueBeam STx with HDMLC and 6XFFF. MLC plans retained the same prescription dose, CT/MR images, and structures as the corresponding cone plans. Dosimetric parameters including PTV coverage, maximum dose (Dmax), Conformity Index (CI), Homogeneity Index (HI), Volume normal brain receiving 12Gy (V_{12Gy}) and 3Gy (V_{3Gy}), Dmax to OARs, and beam-on time were obtained

RESULTS

MLC-based Elements automatic plans resulted in better PTV coverages, as well as superior dose sparing to normal brain tissues and OARs as shown in **Table I**.

	Elements	CyberKnife	Diff (E-CK)
Conformity Index	1.42	4.88	-3.46
Homogeneity Index	1.21	1.21	0.00
Max Dose (%)	118.6	120.4	1.8
Minimum PTV Coverage (%)	99.5	99.1	0.4
V_{12Gy} (cc)	6.43	9.50	-3.07
V_{3Gy}(cc)	89.92	224.20	-134.28
Brainstem (Gy)	2.51	4.29	-1.78
Chiasm (Gy)	0.67	1.88	-1.21
Cochlea (Gy)	1.30	1.63	-0.337
Lens (Gy)	0.83	0.18	0.65
Optical Nerves (Gy)	0.93	1.44	-0.51
MU/Fraction	7480.7	15724.0	-8234.3
Beam on Time (min)	6.23	19.65	-13.42

Table I Dosimetric parameters averaged over ten patients for both Cone and MLC plans

The V_{12Gy} was 6.43cc for MLC plans compared to the 9.50cc of cone plans on average. V_{3Gy} of automatic plans was also lower by a factor of 2.5. **Figure 1** shows typical dose distributions for both Cone and MLC plans, from patient #10 which has three targets. With the same PTV coverages, MLC plans provided more conformal dose as shown by the 20Gy (100%), 10Gy (50%), and 3Gy isodose lines.

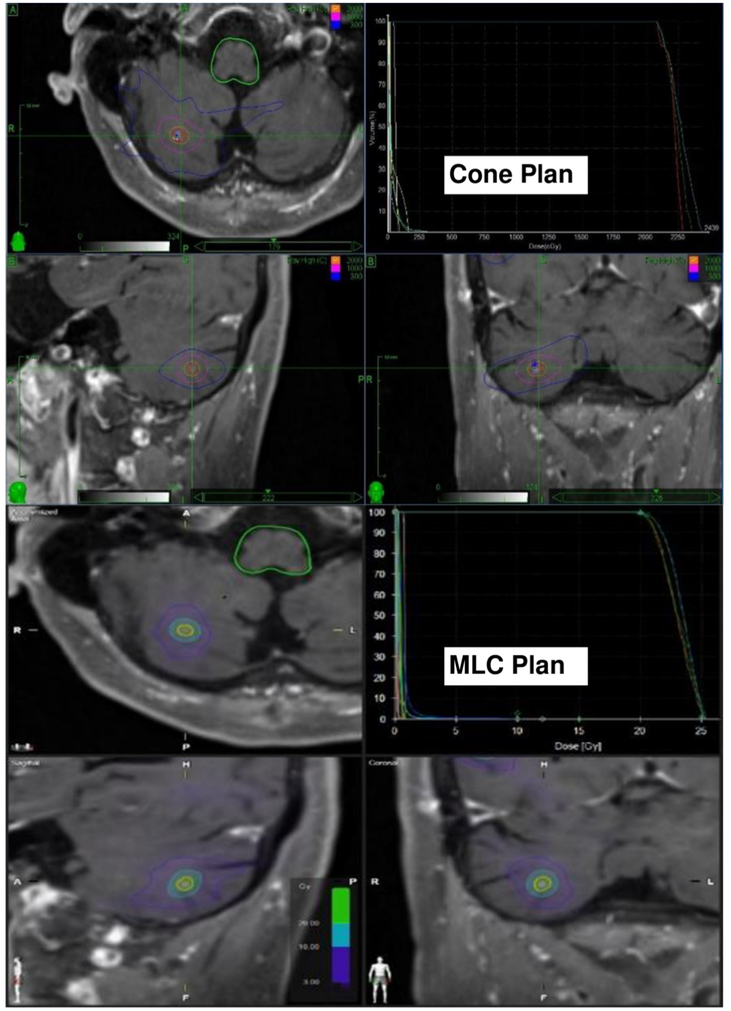

Figure 1 Dosimetric comparison of Cone and MLC plans for patient #10, with 20Gy, 10Gy, and 3Gy isodose lines

Figure 2 shows the relative difference for the dosimetric parameters investigated in this study. As shown, there was no significant difference for PTV Dmax and HI between MLC and cone plans. MLC plans provided significantly lower CI, V12Gy, and V3Gy, which indicated superior normal tissue sparing. Total MUs were reduced by 50% on average. Beam-on time was also reduced due to both reduced MUs and increased dose rate.

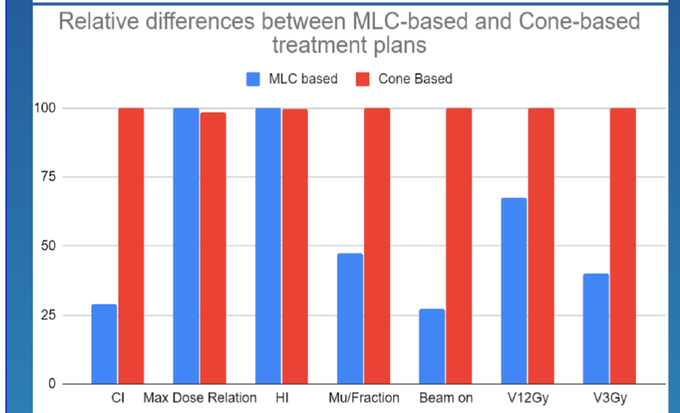

Figure 2 Relative difference for CI, D_{max} to PTV, HI, Total MUs, Beam-on time, V_{12Gy}, and V_{3Gy}, between cone-based and MLC-based plans, averaged over ten patients. Smaller relative values indicate better plan quality

CONCLUSIONS

Both cone-based and MLC-based planning produced clinically acceptable plans. MLC plans provided significantly superior normal tissue sparing with equivalent PTV coverage, while requiring less beam-on and planning time. This study demonstrated that automatic MLC planning is an effective alternative to cone-based planning for multiple metastases treatment planning.

CONTACT INFORMATION

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