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Small Field Stereotactic Radiosurgery Fluence Measurement for Cone and MLC-Based Plans Using SRS MapCHECK

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INTRODUCTION

Since 1982, physicists have used conventional linear accelerators to deliver stereotactic radiosurgery[1]. Developments since then have included high definition MLCs and frameless systems[2]. Since 2010, clinics have begun to utilize MLCs for single isocenter multi-target SRS, treating small targets off axis with a conventional linac[3,4].

This study investigates whether it is appropriate to use MLC-based planning for stereotactic PTVs ranging in size from 6mm to 10mm through fluence measurements on the SRS MapCHECK. Whereas it is still common to use stereotactic cones of sizes from 4mm up to 15mm, the use of MLCs is becoming more prevalent especially in the context of single-isocenter multiple target SRS. This information is useful to any clinics that currently use cones who are considering switching to MLCs even for small targets and demonstrates the usefulness of the SRS MapCHECK phantom in evaluating these plans. This study sheds light on the question of what is the smallest MLC field size that is clinically deliverable.

AIM

To evaluate fluence of stereotactic cones and MLCs for PTVs of 6mm to 10mm diameter using the SRSMapCHECK in the StereoPHAN phantom.

METHOD

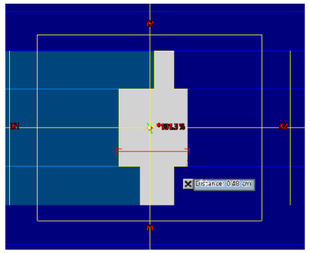
Patients with SRS PTVs of 10mm or smaller were planned using stereotactic cones with diameters of 6mm, 7.5mm, or 10mm using BrainLAB iPlan RT Dose 4.5. Plans used four noncoplanar arcs each with a gantry sweep of approximately 120 degrees (Fig 1a).

The planning process was repeated using the same treatment couch and gantry angles but with MLC dynamic conformal arcs. All plans were calculated with pencil beam algorithm for a Novalis TX with 120HD MLC and a calculation grid of <1mm.

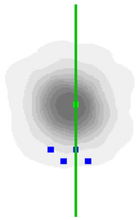
The plans were mapped onto the StereoPHAN with SRS MapCHECK and recalculated dividing the planned MUs by two or three. The phantom was then positioned on the machine and aligned to the room lasers. The plans were delivered on the phantom at the planned couch and gantry angles. The phantom was not repositioned at each table angle with image guidance as is typical of patient treatment delivery. The plans were evaluated in the SRSMapCHECK software using gamma, absolute dose criteria of 1%, 1mm with a threshold of 10. The plans were further analyzed after applying a shift of 0.7mm or with a different dose criterion of 2%, 1mm.

RESULTS

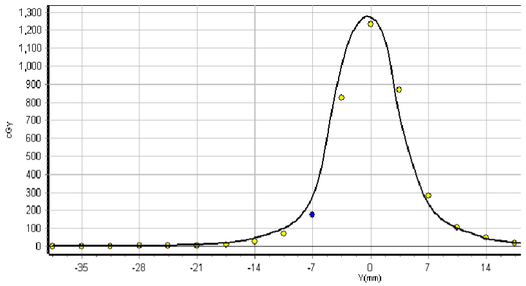
Cone plan passing rates ranged from 97.1% to 100% with 1% 1mm absolute dose criteria (Table 1). MLC plan passing rates ranged from 91.5% to 96.9% without CAX offset and with 1% 1mm analysis (Table 1, Fig1b & Fig1c). A CAX offset of Y = -0.7mm improved all MLC plan passing rates to 100%. Changing the analysis criteria to 2%, 1mm increased the MLC plan passing rates without CAX offsets to 93.6% and above. The 6mm cone plan and the corresponding MLC plan had the lowest passing rates.



(a)



(b)



(c)

Fig. 1 (a) This figure shows one segment of the MLC dynamic conformal arc delivery for a 6mm target where the MLC field size is 0.48cm in width (each leaf is 0.25cm wide at iso). These very small field sizes must be treated with caution. (b) & (c) SRSMapCHECK analysis of the same plan. The plot shows an offset between the measured (dots) and planned (solid line) fluence.)

Table 1. Fluence pass rates for cone and MLC plans. The min MLC FS on CAX is the minimum MLC field width at CAX over all arcs of the plan. This is usually smaller than the corresponding cone size. The CAX Offset applied for MLC plans was Y = -0.7mm. Cone passing rates did not improve with CAX offset.

Patient	Device	min MLC FS on CAX	1% 1mm Pass Rate	Pass Rate w/CAX Offset	2% 1mm Pass Rate
1	10mm cone	NA	98.9%	NA	100%
	MLC	0.75cm	95.2%	100%	98.1%
2	7.5mm cone	NA	100%	NA	100%
	MLC	0.60cm	96.9%	100%	98.5%
3	6mm cone	NA	97.1%	NA	97.1%
	MLC	0.45cm	91.5%	100%	93.6%

CONCLUSIONS

Both cone and MLC based plans had satisfactory passing rates down to 6mm target size under fluence analysis with the SRSMapCHECK. This indicates that MLC-based plans on targets as small as 6mm can be delivered accurately. However, there was a systematic difference between the cone and MLC plans indicated by CAX offsets in the analysis that cannot be ignored.

The magnitude of the CAX shift in our analysis is significant and requires further investigation. Two further avenues of investigation are: one, the systematic difference between cone and MLC isocenter and two, the effect of repositioning via IGRT as during patient treatment delivery.

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