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Skin dose comparison between a 1.5 T MR-Linac and a conventional linac using optically stimulated luminescence dosimeters for patients with intracranial tumor

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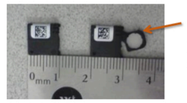
INTRODUCTION

Optically stimulated luminescence dosimeters (OSLDs) are useful devices that can measure surface dose *in vivo*.[1]

We used OSLDs to compare the skin dose for brain patients treated in a conventional linac and a 1.5 T MR-Linac.

To our knowledge this is the first set of *in vivo* skin dose measurements in a 1.5 T MR-Linac using OSLDs. This work builds on our previous work on MR-Linac surface dose.[2,3,4]



1x1x0.2 cm OSLD

AIM

- To use OSLDs to measure skin dose near intracranial tumors
- To compare the skin doses between a 1.5T MR-Linac and a conventional linac
- The hypothesis is that the MR-Linac skin doses will be higher than for the conventional linac as the magnetic field elicits a high exit surface dose, called the electron return effect (ERE).

METHOD

Six patients with intracranial tumors were treated on our MR-Linac.

Patients had prescription doses of 54 Gy or 60 Gy in 30 fractions.

Due to a preventative maintenance day, these patients were treated on conventional linacs for a single fraction with a 6MV beam.

For the single fraction on conventional linacs, and for one fraction on the MR-Linac, an OSLD was placed on each patient's skin located near the PTV.

The conventional linac treatments were planned on a convolution-superposition treatment planning system (TPS) and the MR-Linac treatments were planned using a separate Monte Carlo TPS.

A dose point located at the OSLD and at the water equivalent depth of the OSLD (0.6 mm) was created in each of the TPS's, and then compared with the OSLD measurement.

RESULTS

For 5 out of 6 patients, the MR-Linac OSLD dose was higher than for the conventional linac (11.5%-24.8% higher). The one patient where the MR-Linac dose was lower (-7.5%) had four non-coplanar beams for the conventional linac plan, which might explain the outlier (MR-Linac plans use only coplanar beams).

There was better agreement between the MR-Linac measurements and Monte Carlo TPS (RMSE=7.3%) than between the convolution TPS and the conventional linac OSLD doses (RMSE=17.4%).

Figure 1 shows axial slices of each of the six patients, and the location of the OSLD placements.

Figure 2 and Table 1 show the OSLD and TPS data for both the MR-Linac and conventional linac fractions. The data demonstrates that the agreement between MR-Linac OSLD/TPS doses is closer than for the conventional linac. In interpreting these results, it must be understood that the surface dose TPS estimate is difficult to determine, as the image resolution is insufficient to resolve the OSLD water-equivalent thickness (0.6 mm) and patient surface.

Many of the OSLD skin doses are in the range where skin reactions are expected. Table 2 shows that for 5 out of 6 patients the MR-Linac OSLD dose is higher than for the conventional linac, which suggests that skin reactions may occur earlier in a treatment course for the MR-Linac.

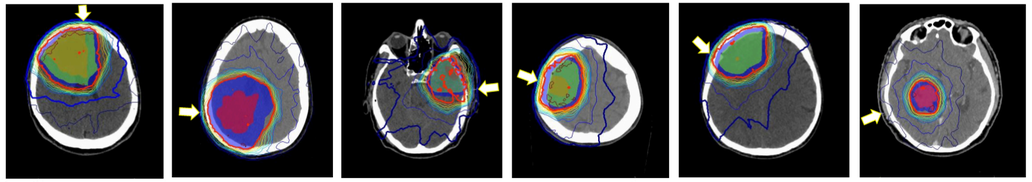


Figure 1: Axial slice of each of the six patients in this study. Colorwash indicates the GTV, CTV, and PTV nested within each other. White arrows indicate the OSLD placements.

Patient #	Conventional linac skin doses			MR-Linac skin doses		
	TPS (cGy)	OSLD (cGy)	% diff	TPS (cGy)	OSLD (cGy)	% diff
1	2742	3630	-24.5%	4017	4530	-11.3%
2	3003	3245	-7.5%	4095	3868	5.9%
3	2067	2679	-22.9%	2757	2478	11.3%
4	3255	3918	-16.9%	4299	4369	-1.6%
5	4443	3940	12.8%	4377	4572	-4.3%
6	860	997	-13.7%	1212	1178	2.9%

Table 1: Numerical OSLD and TPS data for both conventional linac and MR-Linac skin doses. Note that the % differences for the MR-Linac/Monte Carlo TPS numbers are smaller than for the conventional linac/convolution TPS data.

Patient #	OSLD(MR-Linac)/ OSLD(Conv linac)
1	24.8%
2	19.2%
3	-7.5%
4	11.5%
5	16.1%
6	18.2%

Table 2: Ratio between the MR-Linac and the conventional linac OSLD doses, demonstrating that for 5 out of 6 patients the MR-Linac delivers the higher skin dose.

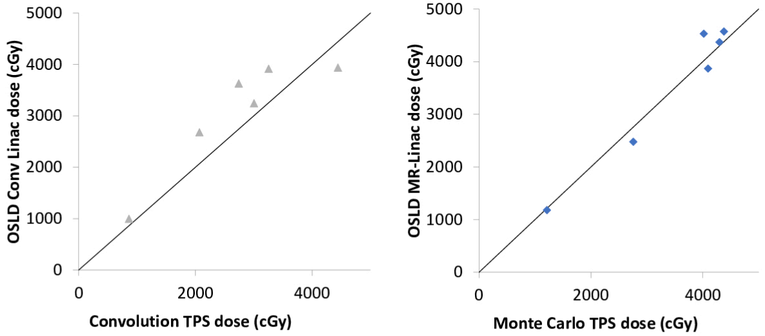


Figure 2: (Left) OSLD conventional linac dose *vs* convolution TPS dose; (Right) OSLD MR-Linac dose versus Monte Carlo TPS dose. The line is the unity line (1:1). Note the agreement is closer for the MR-Linac data than for the conventional linac data.

CONCLUSIONS

MR-Linac patient skin dose measurements are slightly higher (+13.7%) than in an equivalent plan on a conventional linac.

Monte Carlo dose calculation agrees closer to the OSLD measurements than that of the convolution TPS.

Since the MR-Linac measured doses agreed better with the Monte Carlo calculated distribution, there is an opportunity to account for surface dose in the treatment plans to lower unwanted skin dose to the patients.

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