Dosimetric Efficiency of a Single-Isocenter vs Traditional Two-Isocenter Technique for Spine Stereotactic Radiosurgery of Two Vertebral Lesions Separated by One Vertebral Body

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Introduction

The purpose of this study was to determine the dosimetric efficiency for the use of a single isocenter versus the traditional two isocenter technique for spine stereotactic radiosurgery (SSRS) of two vertebral lesions separated by one vertebral body.

The plans were compared by evaluating dose to critical structures and target volume coverage. Overall, we were able to achieve comparable plans with one isocenter without compromising target volume coverage and organ at risk dose.

Methods

The dosimetric efficiency was measured by comparing eight previously approved two isocenter plans to a re-optimized one isocenter treatment plan utilizing Phillips Pinnacle 9.10 planning software.

The physician-approved two-isocenter plans served as a baseline for creating optimal single-isocenter plans, and priority was given to GTVs, CTVs, and spinal cord/cauda equina dose. Dose to other normal tissue structures were also considered during the inverse planning optimization process.

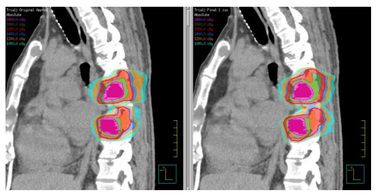


Fig. 1: *Plan 1*-Two Isocenter physician approved plan (Left), Single Isocenter plan (Right)

Plan 1	Max Dose Variance	.01cc Max Dose Variance	Mean Dose Variance	Coverage
T8_CTV	-	-	-	0.8%
T6_CTV	-	-	-	-1.9%
T8_GTV	-	-	-	5.4%
T6_GTV	-	-	-	5.8%
Cord	2.7%	-1.0%	-13.1%	-
Cord+2mm	8.8%	6.4%	-10.6%	-
Esophagus	3.5%	1.3%	6.1%	-
Heart	15.2%	-	0.6%	-
Total Lung	15.0%	-	9.8%	-
Liver	-2.8%	-	20.1%	-

Table 1: *Plan Comparison.* Percent Variance of Single Isocenter Plan and Two Isocenter Plan

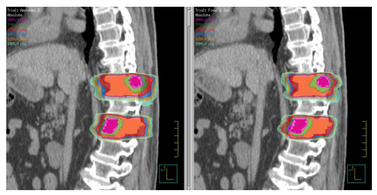


Fig. 2: *Plan 2*-Two Isocenter physician approved plan (Left), Single Isocenter plan (Right)

Plan 2	Max Dose Variance	.01cc Max Dose Variance	Mean Dose Variance	Coverage
T10_CTV	-	-	-	3.3%
T12_CTV	-	-	-	3.1%
T10_GTV	-	-	-	0.6%
T12_GTV	-	-	-	1.2%
Cord	-10.6%	-13.3%	-17.7%	-
Cord+2mm	-4.7%	-4.7%	-13.9%	-
Cauda	-6.6%	-10.9%	-24.6%	-
Esophagus	-8.4%	-13.6%	5.0%	-
Right Kidney	12.0%	-	-9.2%	-
Left Kidney	-10.8%	-	-1.0%	-
Liver	7.4%	-	-3.7%	-
Bowel	0.5%	-	-8.5%	-
Stomach	7.1%	-	9.6%	-

Table 2: *Plan Comparison.* Percent Variance of Single Isocenter Plan and Two Isocenter Plan

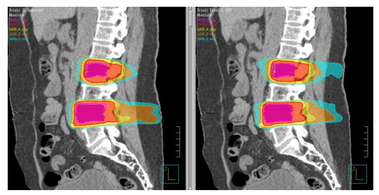


Fig. 3: *Plan 3*-Two Isocenter physician approved plan (Left), Single Isocenter plan (Right)

Plan 3	Max Dose Variance	.01cc Max Dose Variance	Mean Dose Variance	Coverage
L4_CTV	-	-	-	-4.2%
L2_CTV	-	-	-	-3.2%
L4_GTV	-	-	-	2.5%
L2_GTV	-	-	-	2.3%
Cauda	4.8%	5.4%	-3.6%	-
Right Kidney	-14.8%	-	-23.4%	-
Left Kidney	-25.6%	-	-36.3%	-
Bowel	-3.5%	-	-7.7%	-

Table 3: *Plan Comparison.* Percent Variance of Single Isocenter Plan and Two Isocenter Plan

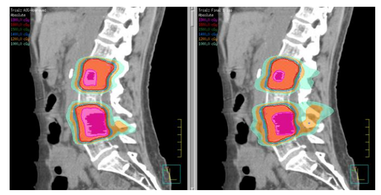


Fig. 4: *Plan 4*-Two Isocenter physician approved plan (Left), Single Isocenter plan (Right)

Plan 4	Max Dose Variance	.01cc Max Dose Variance	Mean Dose Variance	Coverage
L4_CTV	-	-	-	0.0%
L2_CTV	-	-	-	2.1%
L4_GTV	-	-	-	-0.1%
L2_GTV	-	-	-	0.0%
Cauda	0.7%	1.9%	-1.0%	-
Right Kidney	0.7%	-	-15.9%	-
Left Kidney	4.4%	-	-3.3%	-
Bowel	10.0%	-	7.8%	-
Liver	-35.5%	-	-1.9%	

Table 4: *Plan Comparison.* Percent Variance of Single Isocenter Plan and Two Isocenter Plan

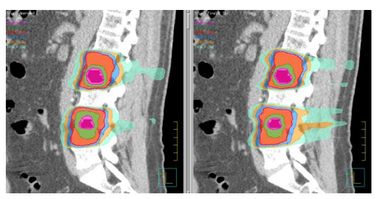


Fig. 5: *Plan 5*-Two Isocenter physician approved plan (Left), Single Isocenter plan (Right)

Plan 5	Max Dose Variance	.01cc Max Dose Variance	Mean Dose Variance	Coverage
L4_CTV	-	-	-	0.0%
L2_CTV	-	-	-	0.6%
L4_GTV	-	-	-	0.0%
L2_GTV	-	-	-	-0.6%
Cauda	-0.6%	-0.7%	-3.0%	-
Cauda+2mm	2.4%	0.6%	-2.1%	-
Right Kidney	-11.3%	-	8.8%	-
Left Kidney	-7.1%	-	-8.3%	-
Bowel	21.6%	-	5.4%	-

Table 5: *Plan Comparison.* Percent Variance of Single Isocenter Plan and Two Isocenter Plan

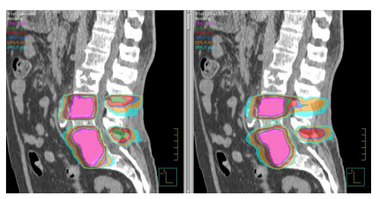


Fig. 6: *Plan 6*-Two Isocenter physician approved plan (Left), Single Isocenter plan (Right)

Plan 6	Max Dose Variance	.01cc Max Dose Variance	Mean Dose Variance	Coverage
L4_CTV	-	-	-	-1.0%
L2_CTV	-	-	-	5.5%
L4_GTV	-	-	-	0.0%
Cauda	76.3%	92.8%	23.9%	-
Cauda+2mm	35.3%	43.2%	25.5%	-
Right Kidney	-24.8%	-	-7.3%	-
Left Kidney	-25.7%	-	-11.4%	-
Bowel	-0.4%	-	0.7%	

Table 6: *Plan Comparison.* Percent Variance of Single Isocenter Plan and Two Isocenter Plan

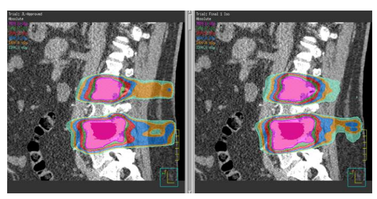


Fig. 7: *Plan 7*-Two Isocenter physician approved plan (Left), Single Isocenter plan (Right)

Plan 7	Max Dose Variance	.01cc Max Dose Variance	Mean Dose Variance	Coverage
L4_CTV	-	-	-	6.5%
L2_CTV	-	-	-	6.1%
L4_GTV	-	-	-	3.6%
L2_GTV	-	-	-	0.0%
Cauda	3.5%	-1.1%	-8.4%	-
Cauda+2mm	5.2%	4.1%	-2.9%	-
Bowel	11.4%	-	10.8%	-
Rt Kidney	3.4%	-	2.0%	-

Table 7: *Plan Comparison.* Percent Variance of Single Isocenter Plan and Two Isocenter Plan

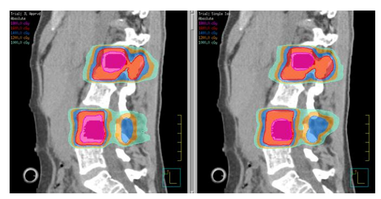
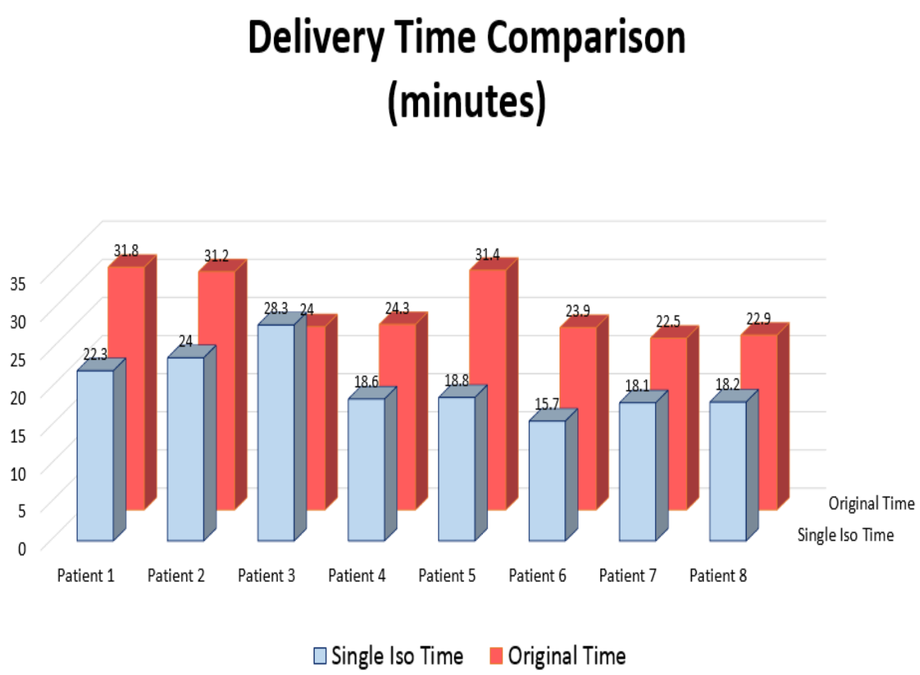


Fig. 8: *Plan 8*-Two Isocenter physician approved plan (Left), Single Isocenter plan (Right)

Plan 8	Max Dose Variance	.01cc Max Dose Variance	Mean Dose Variance	Coverage
L3_CTV	-	-	-	1.6%
L1_CTV	-	-	-	1.6%
L3_GTV	-	-	-	-2.0%
L1_GTV	-	-	-	-0.7%
Cord	-16.5%	-19.8%	-32.8%	-
Cord+2mm	-12.3%	-13.7%	-27.7%	-
Cauda	1.1%	-1.3%	-0.6%	-
Cauda+3mm	-0.3%	-0.6%	-0.1%	-
Lt Kidney	3.6%	-	-7.5%	-
Rt Kidney	-8.1%	-	0.5%	-
Small Bowel	3.1%	-	-0.5%	-
Stomach	1.1%	-	-2.1%	-
Liver	0.0%	-	0.9%	-

Table 8: *Plan Comparison.* Percent Variance of Single Isocenter Plan and Two Isocenter Plan

Average GTV Variance	1.3%
Average CTV Variance	1.2%
Average Spinal Cord/Cauda Equina Variance	-4.5%
Average Time Difference (Minutes)	-6



Results

Overall, we determined that it was plausible to create dosimetrically efficient treatment plans with only one isocenter, since the variance in organ at risk (OAR) doses and tumor volume coverage did not exceed an unacceptable range.

The average variance for GTV and CTV was 1.3% and 1.2% respectively, demonstrating an increase in target volume coverage. The average variance for 0.01cc for spinal cord/cauda equina was -4.5%,resulting in a significant sparing effect of the most critical OARs. The average decrease in treatment time per fraction was 6 minutes.

Conclusions

This study supports the claim that comparable plans are achievable through the use of a single isocenter for two lesion SSRS treatment planning.

The inherent benefits of reducing treatment time, promoting patient comfort, decreasing institutional cost, and developing work flow and patient care by implementing a standard single isocenter treatment technique warrants a change in the current practice of using two isocenters.

Our hope is that the positive outcomes from this research study will encourage future research regarding a reduction of isocenters at various external beam radiation treatment sites.

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