

Comparative Dose Accuracy of AlignRT and ExacTrac in Non-Coplanar Brain SBRT on a Varian Edge: A Phantom Study

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Introduction

Accurate radiation delivery is essential in cancer treatment to maximize tumor control and minimize damage to healthy tissue. Systems like AlignRT and ExacTrac are used to improve patient positioning accuracy, especially in complex treatments like SBRT. This study compares the dose delivery accuracy of AlignRT and ExacTrac for SBRT brain multi-metastases using non-coplanar beam arrangements on a Varian Edge linac.

Abstract

This study compared the dose delivery accuracy of AlignRT and ExacTrac for single-isocenter, multi-metastatic SBRT. A Cranial phantom with five target volumes was used to measure dose at varying distances from the isocenter using non-coplanar beam arrangements on a Varian Edge linac. Both systems showed similar deviations of the delivered dose compared to the planned dose, with AlignRT deviations ranging from -0.22% to -3.8% and ExacTrac from -0.69% to -4.6%. AlignRT and ExacTrac demonstrated comparable accuracy for multi-metastatic single-isocenter radiotherapy.

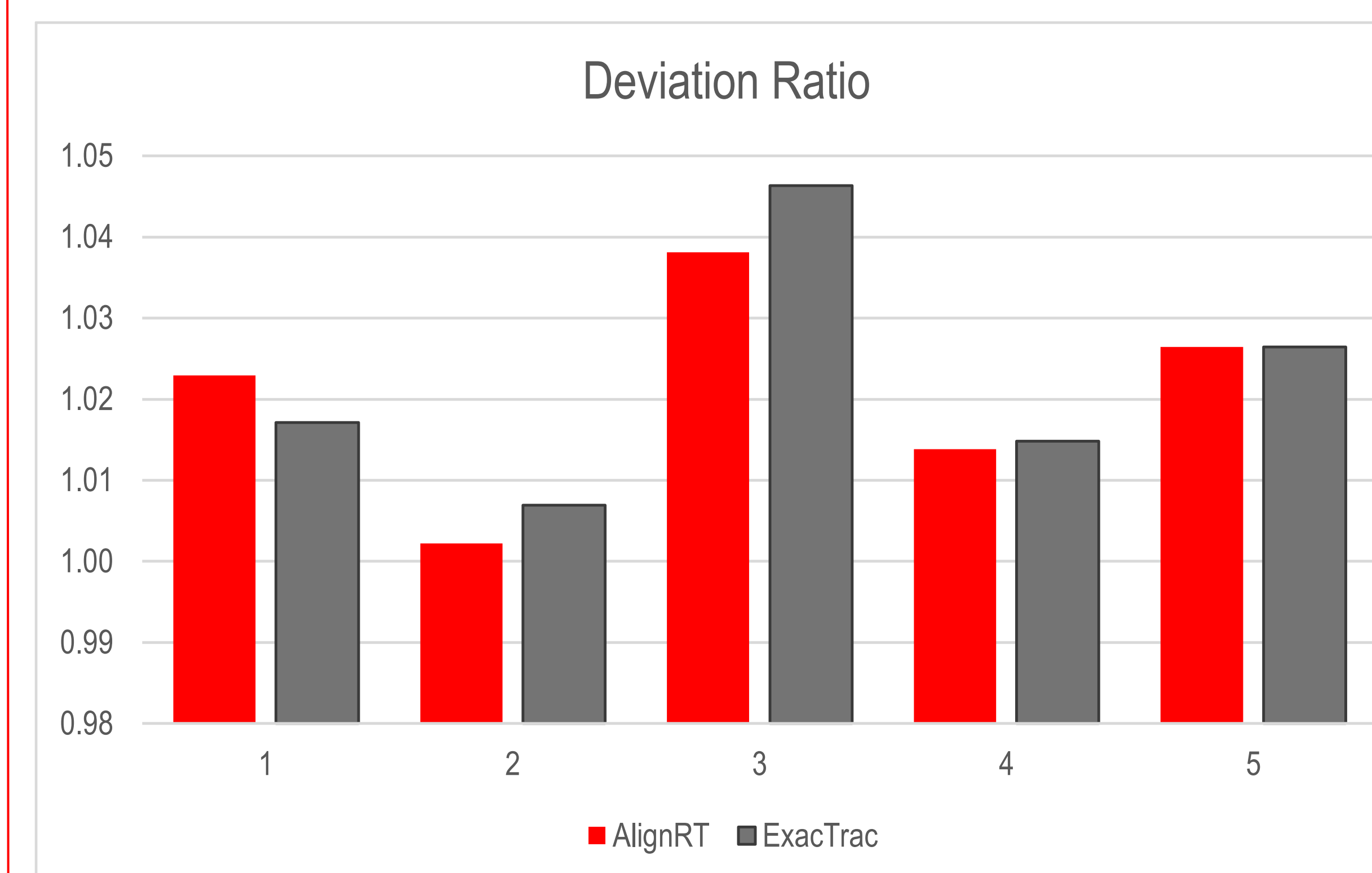
Methods

This study used a cranial phantom to compare the dose delivery accuracy of AlignRT and ExacTrac systems for brain SBRT. Dose measurements were taken at various points within the phantom using non-coplanar beam arrangements.

- A Brainlab cranial phantom with five target volumes.
- Dose measurements were taken at 3.3cm, 3.5cm, 6.5cm, 7.8cm, and 8.1cm from the isocenter.
- 3.3cm – 7.8cm were drilled at a depth of 37mm, and 8.1cm at a depth of 19mm.
- A 1x1mm diode and electrometer were used to measure the delivered dose.
- Civco Type II headrest for immobilization.
- Non-coplanar beam arrangements: 45, 90, 270, and 315 degrees
- Delivered using Varian Edge.
- Eclipse TPS (v16.1)
- 30Gy in 3 fractions
- 4mm GTV with 3mm margin for PTV (7mm)
- Two courses were made, with each containing one identical plan.
- 6x-FFF (Flattening Filter Free)
- Each field acquired a CBCT for AlignRT positioning verification.
- A correction factor was derived to convert the nC readings to absorbed dose to compare the measured dose to the planned dose.
- Orthogonal images were acquired from ExacTrac and registered to DRR from planning CT.
- Weight was placed on the table to simulate the weight of a real patient.

Results

The results indicate a strong agreement in dose delivery accuracy between AlignRT and ExacTrac. While ExacTrac was permitted to use shift corrections and AlignRT was not, both systems exhibited minor deviations from the planned dose. AlignRT showed an average dose deviation of -2.07%, with deviations ranging from -0.22% to -3.8%. ExacTrac's average dose deviation was -2.23%, with deviations ranging from -0.69% to -4.6%. The largest deviation of dose for both systems was observed at 6.5cm distance. Overall, the dose delivery accuracy was comparable.



Discussion

This study demonstrated that both AlignRT and ExacTrac achieved comparable dose delivery accuracy for single-isocenter multi-metastatic brain SBRT. Notably, this similarity was observed despite a procedural difference: ExacTrac was allowed to use shift corrections throughout treatment. This suggests that AlignRT may possess a higher degree of accuracy. The consistent dose delivery deviations by both systems suggest that a slightly larger PTV margin might be considered to ensure adequate target coverage. However, the magnitude of these deviations was small and likely within clinically acceptable tolerances.

Conclusion

This study compared the dose delivery accuracy of AlignRT and ExacTrac patient positioning systems for single-isocenter multi-metastatic brain SBRT using a Varian Edge linac. The results demonstrated that both systems achieved comparable accuracy in delivering the prescribed dose. While slight deviations of the delivered dose were observed for both systems, these deviations were within clinically acceptable tolerances. It can be argued that AlignRT possesses a higher degree of accuracy. Future research could investigate the systems' performance in more complex clinical scenarios, such as those involving patient motion or anatomical variations, to further our understanding of their capabilities.

| ISOCENTER | | | DOSE POINTS | | | DISTANCE FROM ISO (cm) |
|-----------|-------|-------|-------------|-------|-------|------------------------|
| X | Y | Z | X | Y | Z | |
| -0.82 | 11.45 | 23.47 | -2.88 | 12.21 | 25.99 | 3.3 |
| -0.82 | 11.45 | 23.47 | -2.39 | 8.87 | 25.32 | 3.5 |
| -0.82 | 11.45 | 23.47 | 4.34 | 14.21 | 26.31 | 6.5 |
| -0.82 | 11.45 | 23.47 | 3.79 | 6.35 | 27.21 | 7.8 |
| -0.82 | 11.45 | 23.47 | 0.95 | 10.96 | 31.35 | 8.1 |

| Distance | ExacTrac | | | | | | Distance From Planned Point |
|----------|-----------|---|---|--------|-------|-------|-----------------------------|
| | Isocenter | | | Shifts | | | |
| 3.3 | 0 | 0 | 0 | -0.64 | -0.65 | -0.07 | 0.9 |
| | 0 | 0 | 0 | 0.38 | 0.18 | -0.03 | 0.4 |
| 3.5 | 0 | 0 | 0 | -0.56 | -0.59 | -0.05 | 0.8 |
| | 0 | 0 | 0 | 0.5 | 0.32 | -0.11 | 0.6 |
| 6.5 | 0 | 0 | 0 | -0.48 | 0.64 | 0.23 | 0.8 |
| | 0 | 0 | 0 | 0.95 | -0.01 | 0.03 | 1.0 |
| 7.8 | 0 | 0 | 0 | -0.67 | 0.58 | 0.06 | 0.9 |
| | 0 | 0 | 0 | 0.98 | -0.22 | -0.06 | 1.0 |
| 8.1 | 0 | 0 | 0 | -0.64 | -0.58 | -0.02 | 0.9 |
| | 0 | 0 | 0 | 0.67 | -0.52 | 0.18 | 0.9 |

| AlignRT | | | | | |
|------------------------------|----------------------|------------------------|---------------------|----------------------------|-------|
| Distance from Isocenter (cm) | Measured Charge (nC) | Correction Factor (CF) | Measured Dose (cGy) | Calculated Mean Dose (cGy) | Ratio |
| 3.30 | 10.46 | 28.79 | 301.09 | 308.00 | 1.02 |
| 3.50 | 10.68 | 28.79 | 307.42 | 308.10 | 1.00 |
| 6.50 | 10.20 | 28.79 | 293.61 | 304.80 | 1.04 |
| 7.80 | 10.54 | 28.79 | 303.39 | 307.60 | 1.01 |
| 8.10 | 10.35 | 28.79 | 297.93 | 305.80 | 1.03 |
| Average Measured Dose | | | 300.69 | | |

| ExacTrac | | | | | |
|------------------------------|----------------------|------------------------|---------------------|----------------------------|-------|
| Distance from Isocenter (cm) | Measured Charge (nC) | Correction Factor (CF) | Measured Dose (cGy) | Calculated Mean Dose (cGy) | Ratio |
| 3.30 | 10.52 | 28.79 | 302.82 | 308.00 | 1.02 |
| 3.50 | 10.63 | 28.79 | 305.99 | 308.10 | 1.01 |
| 6.50 | 10.12 | 28.79 | 291.30 | 304.80 | 1.05 |
| 7.70 | 10.53 | 28.79 | 303.11 | 307.60 | 1.01 |
| 8.10 | 10.35 | 28.79 | 297.93 | 305.80 | 1.03 |
| Average Measured Dose | | | 300.23 | | |

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