Dosimetric impacts of IGRT-determined clinical shifts for spine SBRT patients

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Purpose / Objectives

- Stereotactic spinal treatments deliver a large radiation dose and utilize narrow PTV margins, on the order of 1 mm
- Intrafraction tumor tracking is important to limit excess dose outside of the PTV
- A common method to track patient motion during treatment delivery is to perform cone-beam CT imaging prior to delivery of each treatment arc
- CBCTs are able to provide quantitative deviation values between current patient and planning position
- This work implemented a multiple CBCT workflow and tracked couch shifts during treatment. Dosimetric impacts of these shifts on overall plan quality were investigated in this treatment planning study

Methods and Materials

- A total of 143 spine SBRT treatments were delivered on Varian TrueBeam and TrueBeam Edge linear accelerators (N=32 patients) between November 2024 and January 2026
- Patients were immobilized using a Vac-lok with vacuum sealed shrink wrap
- During treatment delivery, CBCTs were acquired during:
  (1) Initial patient setup (setup CBCT)
  (2) post couch shifts were applied prior to the first arc delivery (verification CBCT)
  (3) between treatment arcs
- CBCTs were registered using the auto-registration tool in the imaging workspace and modified by physicist / physicist if needed
- Image registration shifts were applied for all CBCTs
- To evaluate dosimetric impacts of these shifts, patients (N=10) with clinical shifts larger than 1 mm translationally underwent a treatment planning study
- Treatment plans were split into individual fractions and were recalculated with each arc shifted to mimic the treatment delivery
- PTV coverage and OAR structure dose was evaluated and compared with the original plan

Results

Shift Tracking and Patient Selection

- The average magnitude of patient shifts are shown in Figure 1 and summarized in Table 1.
- For the dosimetric study, 10 patients with the largest shifts between arcs were investigated.
- The average shifts in the vertical, longitudinal, lateral directions were (0.03, 0.04, 0.05) cm and in the rotation, pitch, and roll directions were (0.13, 0.15, 0.26) degrees
- Of the 10 patients, all had translational shifts greater than 1 mm during at least one fraction

TPS Dosimetric Evaluation

- For patients that met inclusion criteria, each plan was copied and broken down into individual fractions
- Dose schemas included (900cGy/fx x 3 fxs and 600 cGy/fx x 5 fxs)
- Shifts were applied to the isocenter, and plans were recalculated for each fraction and a plan sum was generated
- The sum plan with shifts and the original plan were compared (Fig. 2) and DVH statistics were compared (Table 2). Sample tolerances

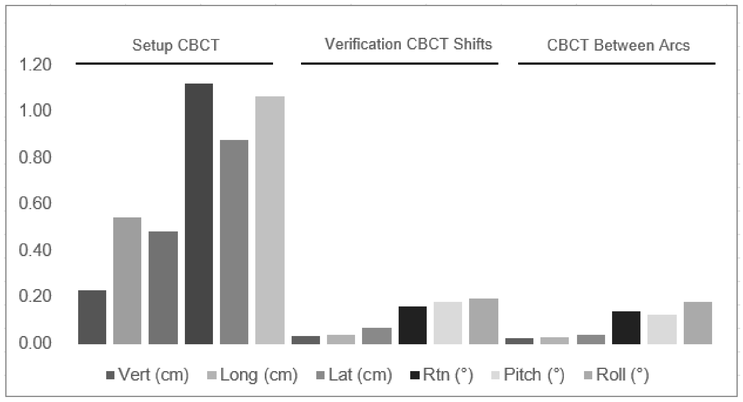

Figure 2: Axial plane comparing dose distribution for the original plan versus the shifted sum plan

Table 1: Summary of average (standard deviation) of clinical shifts across all treatments (N=143)

	Vert [cm]	Long [cm]	Lat [cm]	Rtn [°]	Pitch [°]	Roll [°]
Setup CBCT	0.23 (0.25)	0.55 (0.59)	0.48 (0.47)	1.12 (0.86)	0.88 (0.75)	1.07 (0.87)
Verification CBCT	0.03 (0.08)	0.04 (0.04)	0.07 (0.06)	0.16 (0.18)	0.18 (0.18)	0.19 (0.28)
Between Arc CBCT	0.02 (0.03)	0.03 (0.03)	0.04 (0.04)	0.14 (0.17)	0.13 (0.13)	0.18 (0.28)

Original Plan | Shifted Plan

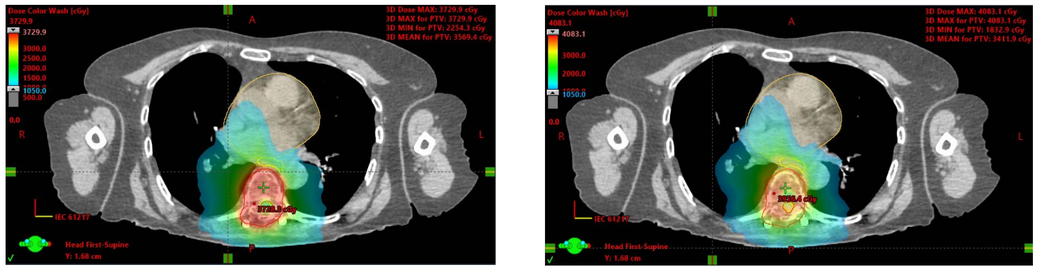

Figure 2: Axial plane comparing dose distribution for the original plan versus the shifted sum plan

Table 2: Average DVH comparison between original plan and shifted plan (N=10)

Structure	Statistic	Sample Tolerance	Difference
PTV	V100	> 95%	-3.8%
Spinal Cord	Dmax	< 2800 cGy	24.5 cGy
Spinal Cord PRV 1 mm	Dmax	< 2190 cGy	10.6 cGy
Brachial Plexus, Left	Dmax	< 2400 cGy	1.1 cGy
Brachial Plexus, Right	Dmax	< 2400 cGy	20.5 cGy
Esophagus	Dmax	< 2250 cGy	8.6 cGy
Bowel	Dmax	< 2400 cGy	22.5 cGy
Thecal sac	Dmax	< 2250 cGy	-71.1 cGy

Discussion

- After initial setup CBCTs, there were generally sub-millimeter and sub-degree patient movement during treatment
- Although shifts were small between arcs, there were 10 patients (out of a total 35 patients) had at least one fraction that had greater than a 1 mm shift in a translational direction
- A dosimetric study showed that if the shifts are not accounted for during treatment (using CBCTs between arcs), PTV coverage decreases, on average, by 4% and OAR dose increases by various amounts
- Spinal cord, on average, increased by 24.5 cGy when shifts were applied. This may have important dosimetric impacts when the plan dose is close to the recommended tolerance
- This work investigated relatively small shifts (sub-mm). In the presented dataset, as shifts increased, PTV coverage decreased and OAR dose increased. Large shifts may have more significant impacts.

Conclusions

- This work showed that small patient shifts show important dosimetric deviations
- Clinically, it is important to track shifts. Prior to this study, the author's institution has implemented performing CBCTs between arcs and triggered imaging during delivery to track intra-fraction motion
- Based on this data, current imaging practices will continue to track patient motion

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