# Diagnostic Scan-Based Planning for Spinal Metastases

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## I. Introduction

It is estimated that in developed countries, close to half of all courses of radiotherapy are employed with palliative intent. Cost, transportation, and treatment duration have been identified as barriers for patients who could benefit from palliative radiotherapy. As CT simulation requires a separate appointment, it contributes to these barriers. In this study, we examined if a patient's previous diagnostics scans could be used in place of CT simulation while treating with clinically effective volumetric-modulated arc therapy (VMAT). This poster frames our view on the benefits of this diagnostic scan-based planning (DSBP) in palliative radiotherapy, the application of DSBP to spinal metastases, and the comparative evaluation of the technique had the patient under-based external therapy.

## II. Methods

Ten patients were planned on any available diagnostic scan that included the spine. On these, clinical targets of T6-T9 vertebrae were contoured for 10 patients, representing spinal metastases cases. Planning target volumes (PTV) were constructed by a uniform expansion of these vertebrae contours by 3 mm. Organs at risk were also delineated. Diagnostic CT scanners, unlike simulation CT scanners, usually do not have assigned to them a CT number to Electron Density calibration curve. When imported into Eclipse, the CT calibration curves for diagnostic scans were assumed to be that of the on-site Philips simulation CT, which likely introduced an error less than 1%[1]. In addition, calculations excluded areas of the body that were not included in the diagnostic scan due to the lower field of view (FOV) for diagnostic scan protocols. Fluence avoidance structures were created to account for both the reduction in FOV and arm presence.

The prescriptions for the DSBP plans were for palliative radiation therapy, 8 Gy in 1 fraction. This treatment scheme was in part motivated by the results of RTOG0631 which compared two treatment arms of 16 Gy in 1 fraction stereotactic body radiation therapy (SBRT) and 8 Gy in 1 fraction EBRT[2]. Ryu et al. stated that there was no additional benefit of the 16 Gy in 1 fraction SBRT arm versus the 8 Gy in 1 fraction EBRT arm[2]. With the 8 Gy in 1 fraction prescription, it was unlikely that the RTOG 0631 dose constraints of 10 Gy to the spinal cord would be jeopardized[2]. Two VMAT arcs were employed for each treatment plan on each diagnostic CT. A DSBP plan was considered acceptable if $D_{95\%} \geq 100\%$ (minimum dose to 95% of the target) and $D_{max} < 107\%$ (maximum dose to the entire body). These DSBP plans were then transferred onto CT simulation data sets and recalculated to determine the accuracy of dose calculation.

## III. DSBP vs. Conventional Planning

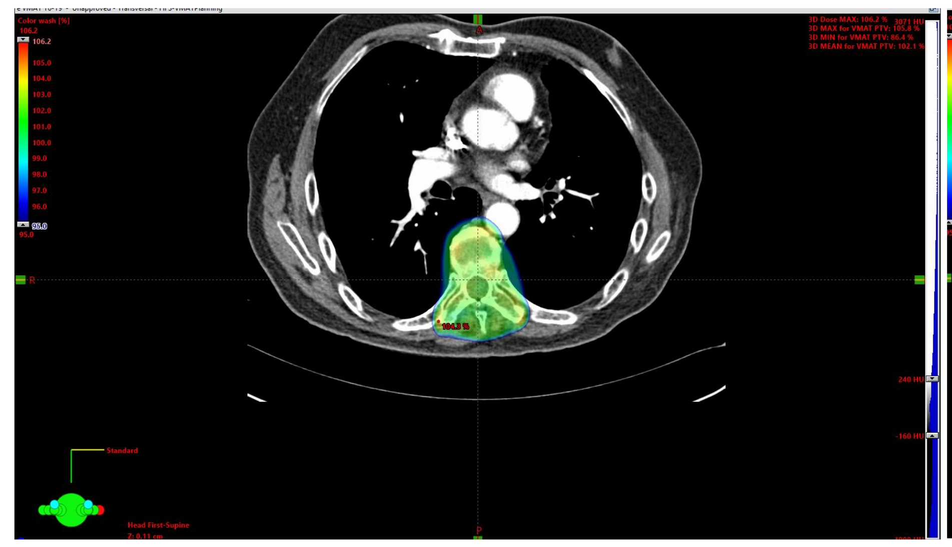

Figure 1. DSBP Dose Distribution

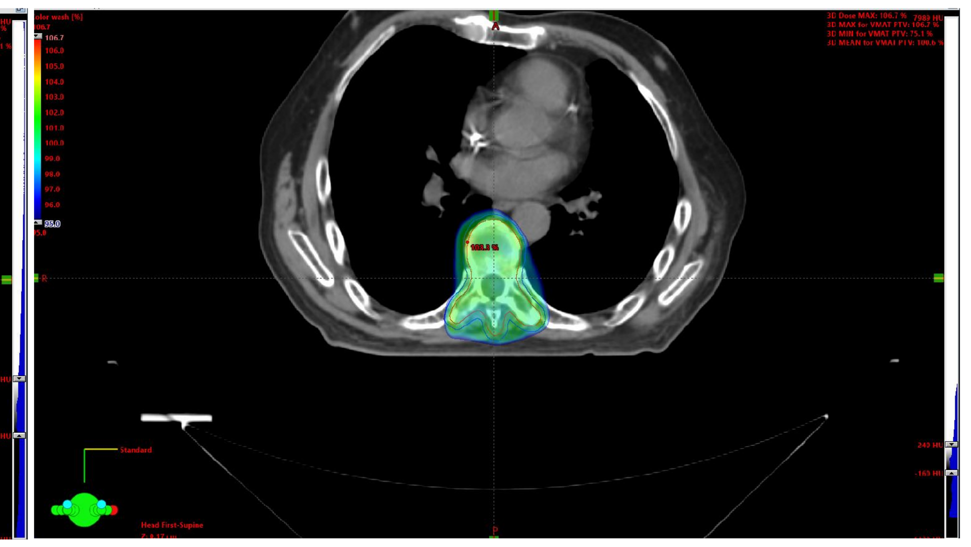

Figure 2. DSBP on Sim CT Dose Distribution

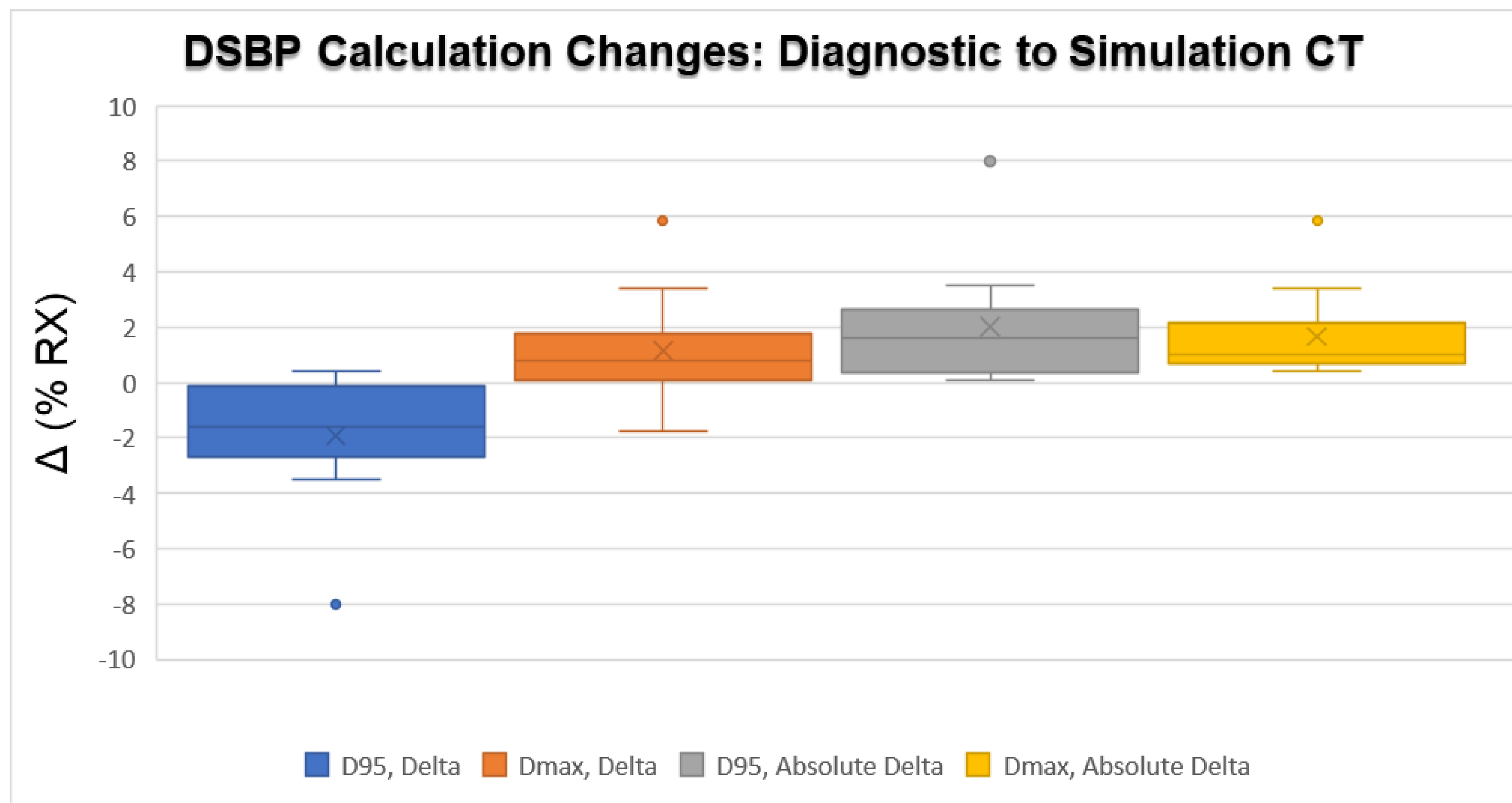


Figure 3. DSBP Calculation Changes: Diagnostic to Simulation CT. This box and whisker plot visualizes descriptive statistics for the delta distributions, including means represented by the crosses, interquartile ranges (IQR) represented by the boxes, and outliers represented by the solid dots. Displayed are total and absolute variations in $D_{95\%}$ and $D_{max}$ for the ten sets of patient plans.

Table 1. Statistical Analysis of DSBP Calculation Changes.

| | $D_{95\%}$, Δ (%) | $D_{max}$, Δ (%) | $D_{95\%}$, Absolute Δ (%) | $D_{max}$, Absolute Δ (%) |
|---|---|---|---|---|
| Minimum | -8.00 | -1.74 | 0.11 | 0.39 |
| $Q_1$ (25%) | -2.28 | 0.42 | 0.42 | 0.75 |
| Median (50%) | -1.60 | 0.79 | 1.60 | 0.99 |
| $Q_3$ (75%) | -0.28 | 1.22 | 2.28 | 1.62 |
| Max | 0.41 | 5.85 | 8.00 | 5.85 |
| IQR | 2.01 | 0.80 | 1.86 | 0.88 |
| Average | -1.92 | 1.14 | 2.02 | 1.67 |

## IV. Comparisons Between Plans

A comparison was made between the resulting plan sets, one being the DSBP treatment plans and the other being these DSBP plans transferred onto the simulation scans (Figures 1 and 2). Clinically pertinent metrics that were assessed were $D_{95\%}$ of the PTV and $D_{max}$ of the body. DSBP plans calculated on the simulation scans were considered passing if $D_{95\%} > 95\%$ and $D_{max} < 115\%$. Changes in these metrics, or deltas(Δ) were assessed for the transfer of the DSBP to simulation CT scans, shown in Figure 3, and Table 1. Here, the Δ are reported in %RX (prescription dose). Based on the data collected from this study, changes to both $D_{95\%}$ of the PTV and Dmax of the body are expected to vary within ~5% of the prescription dose. From these results, it was concluded that employment of the DSBP with proper immobilization would lead to clinically effective results.

## V. Results

DSBP provided excellent target coverage, with a median $D_{95\%}$ of 98% (range, 92%-100%) of the prescription dose with acceptable hot spots, and a median $D_{max}$ of 107% (range, 105%-112%). The ten plans were reviewed by three physicians and determined to be appropriate for treatment. The transferring of plans between diagnostic and simulation scans resulted in changes to $D_{95\%}$ of -1.92% ± 2.33% and $D_{max}$ of 1.14% ± 2.02% respectively, with absolute differences in $D_{95\%}$ of 2.02% ± 2.24% and $D_{max}$ of 1.67% ± 1.61% respectively.

## VI. Conclusion

This preliminary study suggests that diagnostic scan-based planning with VMAT for spinal metastases is a practical approach with an acceptable dosimetrical accuracy. The benefits of earlier radiobiological effects, reduction in required patient commitment, and simplified workflow predominate the relatively small changes to plan accuracy.

## VII. References

1. Thomas SJ. Relative electron density calibration of CT scanners for radiotherapy treatment planning. *The British journal of radiology.* 1999;72(860):781-786.
2. Ryu S, Deshmukh S, Timmerman R, al e. Radiosurgery Compared To External Beam Radiotherapy for Localized Spine Metastasis: Phase III Results of NRG Oncology/RTOG 0631. *Int J Radiat Oncol Biol Phys.* 2019;105:S2-S3.