Benefits of 3D Optimization on Palliative Spine Cases

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ABSTRACT

Palliative care is essential in preserving the quality of life for individuals with limiting health conditions. This research is focused on comparing RayStation's auto field-in-field (AFIF) script with the 3D optimization tool and 3D conformal arc (3DCA) techniques to conventional planning strategies. The purpose of this study is to achieve target coverage, dose to the organs at risk (OARs), and increase dose conformality in hopes of identifying a better strategy for delivering radiation in palliative care treatment. The researchers retrospectively evaluated ten anonymized patients with targets that ranged from the cervical to lumbar spine treated with three-dimensional conformal radiation therapy (3D-CRT). The plans were reconstructed using AFIF and 3DCA on RayStation 12A SP1 (v.13.1). The results indicate that utilizing either AFIF or 3DCA can create a significant increase in coverage ranging from 95% to 99% with an enhanced improvement in dose conformality and homogeneity. Furthermore, the findings indicate that various limitations may arise with each treatment technique..

Key Words: AFIF, 3DCA, palliative spine, homogeneity, conformality

INTRODUCTION

Palliative spine cases are challenging to plan because patients are in pain and have difficulty with mobility. Perfecting a palliative spine case by reducing the dose to Organs at Risk (OARs) while maintaining adequate target coverage is the goal of a dosimetrist. There are a variety of approaches that different institutions around the world take to treat palliative spine cases including: anterior/posterior beam setup (AP/PA), a 3DCA, 3 field technique, and a 3D optimized plan created by the treatment planning system (TPS).

To gain an understanding of the advantages and disadvantages that each planning approach, ten patients will be planned with each technique mentioned. Consistent plan parameters and values will then be evaluated to determine if 3D optimization can improve the dosimetry of palliative spine cases. The goal of this research is to investigate the possibility of using a recent feature of RayStation: AFIF and step-and-shoot, to create a homogeneous dose distribution while minimizing dose to the organs at risk (OARS). Furthermore, the outlook of this research is to shed light on 3D optimization as a viable planning technique that dosimetrists can use for palliative spine patients by comparing the plan parameters to the conventional methods.

METHODS

Ten anonymized patients with tumor volumes primarily in the T-spine, two extending into the L-spine, were studied. Each case underwent two optimization trials: AFIF and 3DCA, using 3D optimization. Beam energy and modifiers such as wedges and multi-leaf collimators (MLCs) were used as needed per plan. The approved plan was compared to each technique with a focus on parameters including coverage of the PTV, total monitor units (MU's), dose to the spinal cord, esophagus, small bowel, and kidneys. The prescription used in the patients' approved plans remained consistent. If the original plan was treated with an AP/PA standard beam arrangement, another 3DCRT plan was created with a 3 or 4 beam setup for the optimization for the AFIF trial. To calculate the homogeneity and conformality index, the formulas were obtained from a case study published in the Journal of Medical Radiation Sciences performed by Michael G. Jameson.

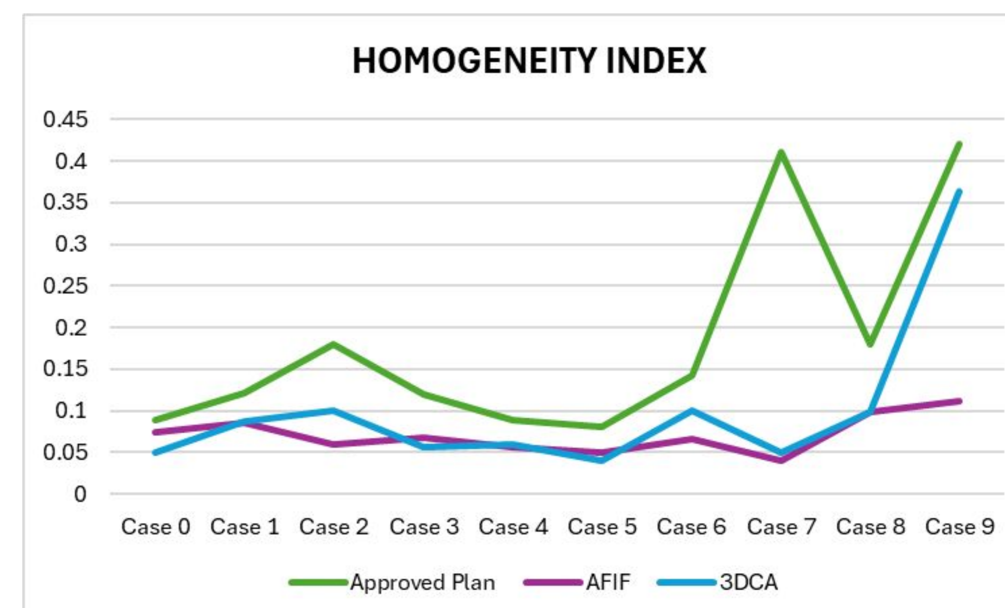

Figure 1: The homogeneity index for each case with an optimal value of 0. The further the index deviates from the value 0, the less homogenous the target is.

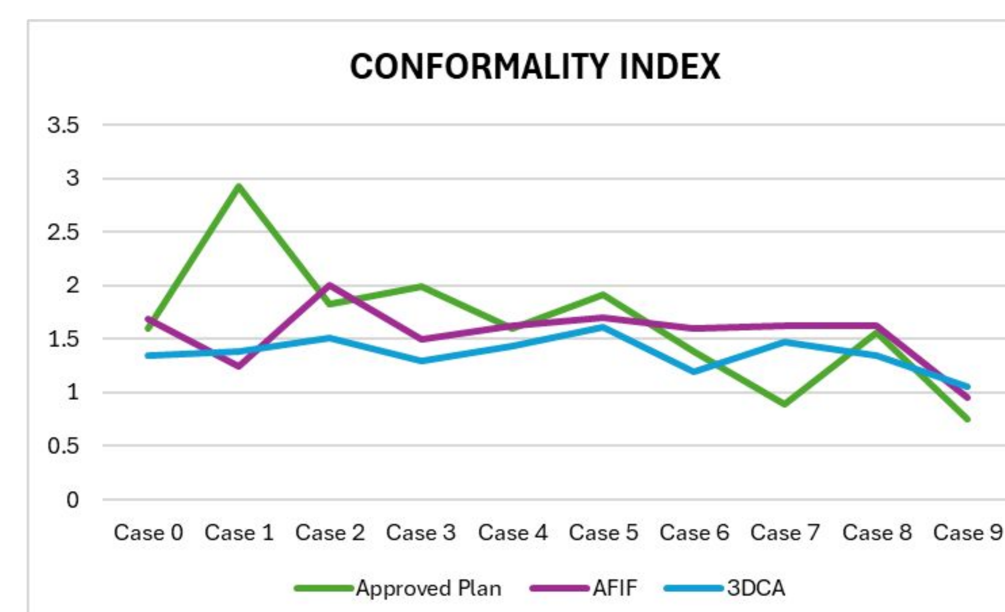

Figure 2: The conformality index for each case with an optimal value of 1. The further the value deviates from 1, the less conformal the prescription isodose line is to the target.

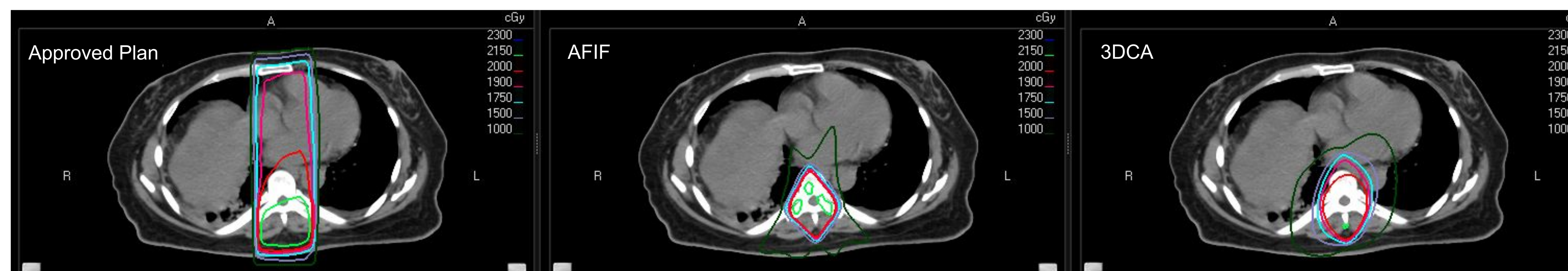

Figure 3: An example of an axial view comparison of the original approved plan, AFIF, and 3DCA. The prescription was 20Gy in 5 fractions treating T5-T11.

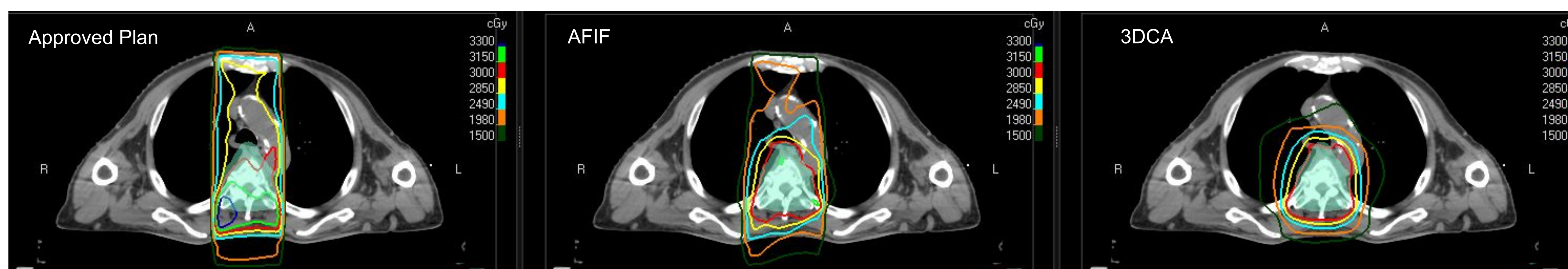

Figure 4: An example of an axial view comparison of the original approved plan, AFIF, and 3DCA. The prescription was 30Gy in 12 fractions treating T1-T5.

Plan PTV Coverage

Technique	Case 0	Case1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
Approved Plan	95.83%	99.74%	95.55%	82.71%	86.52%	95.96%	91.16%	58.52%	98.47%	60.11%
AFIF	96%	99.62%	98.17%	95%	95%	95.97%	95%	95%	96.05%	95.03%
3DCA	95%	96.51%	97.79%	95%	95%	99.99%	95.04%	95%	96.29%	95.02%

Figure 5: Comparison of PTV coverage of the original approved plan, AFIF, and 3DCA.

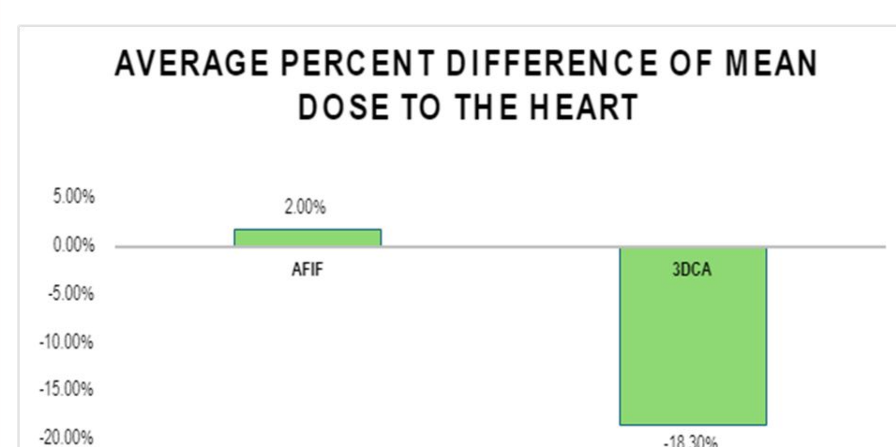

Figure 6: Average percent difference of the mean dose to the heart between AFIF and 3DCA to the approved plan.

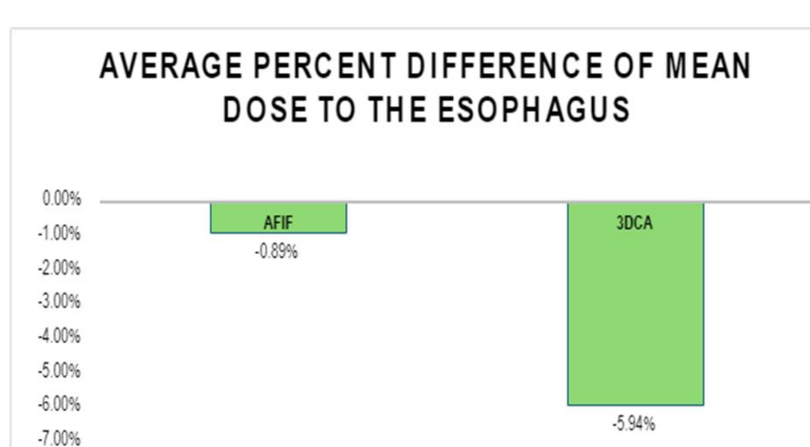

Figure 7: Average percent difference of mean dose to the esophagus between AFIF and 3DCA to the approved plan.

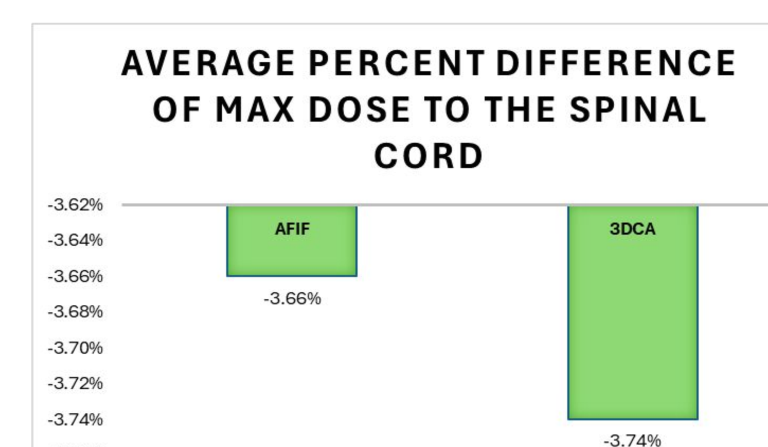

Figure 8: Average percent difference of the max dose to the spinal cord between AFIF and 3DCA to the approved plan.

RESULTS

All plans were assessed using consistent parameters for research. Parameters included PTV coverage, average and maximum doses to the spinal cord, esophagus, and heart, along with conformality and homogeneity indices.

Figures 3 and 4 illustrate a trend of improved conformality in cases planned with 3DCA. However, this led to higher average esophageal doses due to increased exposure and limited modulation to spare the organ. Furthermore, 3DCA demonstrated superior target coverage compared to the approved plan, with a maximum deviation of 0.61. This indicates its advantage in ensuring target volume coverage and conformality through the plan.

Improved dose modulation was a result of plans utilizing the AFIF technique. Running the AFIF script in addition to constructing objectives in RayStation's 3D optimizer helped maintain target coverage while achieving lower average doses to the esophagus and spinal cord (Figure 7 and 8).

A limitation involved altering beam arrangements to align with the AFIF script, particularly for cases treated with AP/PA beam setup. It was observed that the 3-field setup may be more suitable for clinical approval, offering improved script execution and increased segment options for the TPS. Additionally, the 3DCA technique is preferable for patients with arms out of the field or targets located more inferiorly, such as the lumbar spine.

CONCLUSION

The aim of study was to assess the benefits of utilizing AFIF or 3DCA methods to improve PTV coverage while reducing radiation exposure to OARs compared to the approved plans. Results showed both techniques consistently maintained PTV coverage at ≥95% while limiting OAR radiation doses. Approved plans, although minimizing OAR exposure, often resulted in inadequate PTV coverage. These discoveries underscore the need for further investigation into the implementation of AFIF and 3DCA techniques for the development of optimal treatment strategies.

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