Advances in Radiation Oncology (2024) 9, 101550

advances in radiation oncology

www.advancesradonc.org

Scientific Article

Using Scorecards to Tune Ethos Directive Templates: An Adaptive Radiation Therapy Individualized Approach-Cervix Dosimetric Planning Study

Kareem Rayn, MD,[a,b,*] Anthony Magliari, CMD,[b] Ryan Clark, CMD,[b] Omar Rana, BS,[c] Kevin Moore, PhD, CMD,[d] and Xenia Ray, PhD[d]

[a]Department of Radiation Oncology, Columbia University Irving Medical Center, New York, New York; [b]Varian Medical Systems, Inc, Palo Alto, California; [c]Boston University School of Medicine, Boston, Massachusetts; and [d]Department of Radiation Medicine and Applied Sciences, University of California San Diego, San Diego, California

Received 1 August 2023; accepted 12 January 2024

Purpose: The Adaptive Radiation Therapy Individualized Approach-Cervix clinical trial uses predefined clinical directive templates (CDTs) combined with RapidPlan dose-volume histogram estimations (DVHe) to guide plan optimization in the Ethos treatment planning system. The dosimetric scorecard is a scoring tool that quantifies improvements in plan quality after physicians have precisely expressed their complete clinical intent. To our knowledge, this is the first study to use the dosimetric scorecard tool to tune an Ethos CDT to improve resulting plan quality.

Methods and Materials: Iterative replanning was used to modify the draft CDT (CDT-1) in Ethos 1.1 to generate a new CDT (CDT-2) that maximized the clinical consensus scorecard's total score compared with CDT-1. CDT-2 was established, and resulting plans were compared with and without a DVHe. Additional fixed field intensity modulated radiation therapy beam geometries were compared between CDT-1 and CDT-2, both with DVHe. After obtaining favorable results when comparing CDT-1 versus CDT-2 for 2 test cases, 10 additional cases were retrospectively identified and tested.

Results: CDT-2 reduced organ at risk doses without compromising planning target volume coverage in the initial test cases. When combined with DVHe, CDT-2 marginally outperformed CDT-1. Plan quality further improved with a 19-field geometry. In the expanded analysis, CDT-2 achieved higher scores than CDT-1 in most cases, with the 19-field approach showing superiority. Optimization and calculation time increased by 1.9 minutes, monitor unit (MU)/field decreased by 44.4, whereas beam-on time increased by 2.8 minutes when increasing fields to 19 from 9. Reoptimization with Ethos 1.1 Maintenance Release 1 resulted in decreased MU and minimal score changes.

Conclusions: The scorecard is an effective tool to adjust an Ethos CDT to improve the average calculated plan quality. It also allowed for easy evaluation of the dosimetric impact of other planning parameters (beam arrangements and use of DVHe) to identify the best approach. Using a finely tuned CDT is expected to improve planning efficiency and decrease intrainstitutional plan quality variability, benefiting cone beam computed tomography–guided adaptive radiation therapy.

Sources of support: This work had no specific funding.

*Corresponding author: Kareem Rayn, MD; Email: Knr9008@nyp.org

https://doi.org/10.1016/j.adro.2024.101550

Introduction

Varian has recently released an online adaptive treatment planning and delivery system called Ethos. The Ethos system is built on the Varian Halcyon platform, and it offers several features for automated planning, adaptive planning, and treatment monitoring. To create plans in the Ethos Treatment Planning System (TPS), the user must set up a clinical directive in the Ethos TPS. This specifies the dose-fractionation regimen and includes a prioritized list of dose-volume goals for the patient. Clinical directives can be saved as a clinical directive template (CDT) for efficiency in planning patients with the same disease type. These CDTs are the input to the dose optimizer and as such have a direct impact on the treatment plans delivered by Ethos. Specifically, the intelligent optimization engine will convert the specified dose goals into optimization objectives that it monitors and adjusts automatically without further user intervention. Previous studies have demonstrated the ability of the Ethos optimizer to generate clinically acceptable plan quality in prostate and head and neck cancers using CDTs.[1,2] However, because of the novelty of the Ethos TPS, there is no clear evidence yet on how CDTs should be designed for optimal performance. Additionally, because they serve as inputs to an artificial intelligence—controlled plan optimization engine, the impact of changes to the goals or reprioritization of the goals is not straightforward to predict. For an individual patient's initial plan, occasional subpar performance of a CDT can be mitigated by iterative adjustments to the CDT and plan reoptimization before plan approval. However, for patients undergoing daily adaptation on the Ethos TPS, the approved CDT will be used each day by the intelligent optimization engine to generate a new plan and, as such, must be robust for variations in anatomy, volume, and target position to minimize impacts on plan quality.

The Adaptive Radiation Therapy Individualized Approach (ARTIA)-Cervix clinical trial is a multicenter, prospective study that aims to demonstrate the benefits of daily online adaptive radiation therapy in reducing acute high-grade gastrointestinal toxicity in patients with locally advanced cervical cancer. Participating sites use the Ethos platform to perform daily adaptation and are provided with a CDT to help ensure a minimum standard plan quality, although they may add to or adjust the list of clinical goals for an individual patient if desired. The ARTIA-Cervix clinical trial also uses RapidPlan dose-volume histogram estimations (DVHe) that Ethos uses as inputs to the dose optimizer. The CDT is designed to prioritize meeting protocol goals and reduce normal tissue doses, and when used in conjunction with RapidPlan DVHe, it will attempt to reduce organ at risk (OAR) doses to predicted levels.

In this study, we sought to evaluate the impact of modifications to the ARTIA-Cervix CDT, the effect of RapidPlan DVHe inclusion, and the dosimetric impact of increasing field number. To easily assess the overall plan quality, we used a dosimetric scorecard that is a scoring mechanism that objectively quantifies improvements in plan quality, allowing physicians to express their clinical intent exhaustively and precisely (Fig. 1). To our knowledge, this is the first study to introduce dosimetric scorecards as a tool to tune an Ethos CDT to maximize dosimetric plan quality.

Methods and Materials

Target and OAR contouring and treatment planning guidelines

Twelve total cases were retrospectively replanned using an Ethos 1.1 emulation system. The first 2 plans were used to tune an existing CDT-1, whereas the remaining 10 plans were used to evaluate plan improvement using the new CDT-2. All data were acquired with institutional review board approval. Cases were planned per the ARTIA-Cervix trial using photon external beam radiation therapy, with intensity modulated radiation therapy techniques. Initial plans used a static 9-field arrangement on the Varian Ethos platform. The prescription dose was 45 Gy in 25 fractions, and OAR constraints were based on ARTIA-Cervix trial thresholds. All plans were normalized so that 100% of the prescription dose covered 95% of the planning target volume (PTV).

Dosimetric scorecards as an objective measure of plan quality

The PlanScoreCard Eclipse Scripting Application Programming Interface tool, available free on the Varian Medical Affairs Applied Solutions GitHub,[3] was used to score candidate plans throughout this study and used batch scoring with comma seperated values output for easy data analysis. Dosimetric scorecards use established scoring methodology of multiple piecewise linear score functions, which measure specific plan quality metrics.[4] The scorecard used in this study was created to precisely quantify a fully aspirational, dosimetric clinical intent because it awarded points for OAR doses lower than those cited in the ARTIA-Cervix trial (222 total points).

In a first order overview of a dosimetric scorecard, how points are assigned between the various competing metrics represents the physician's preference insofar as relative weighting. However, such a limited view omits the

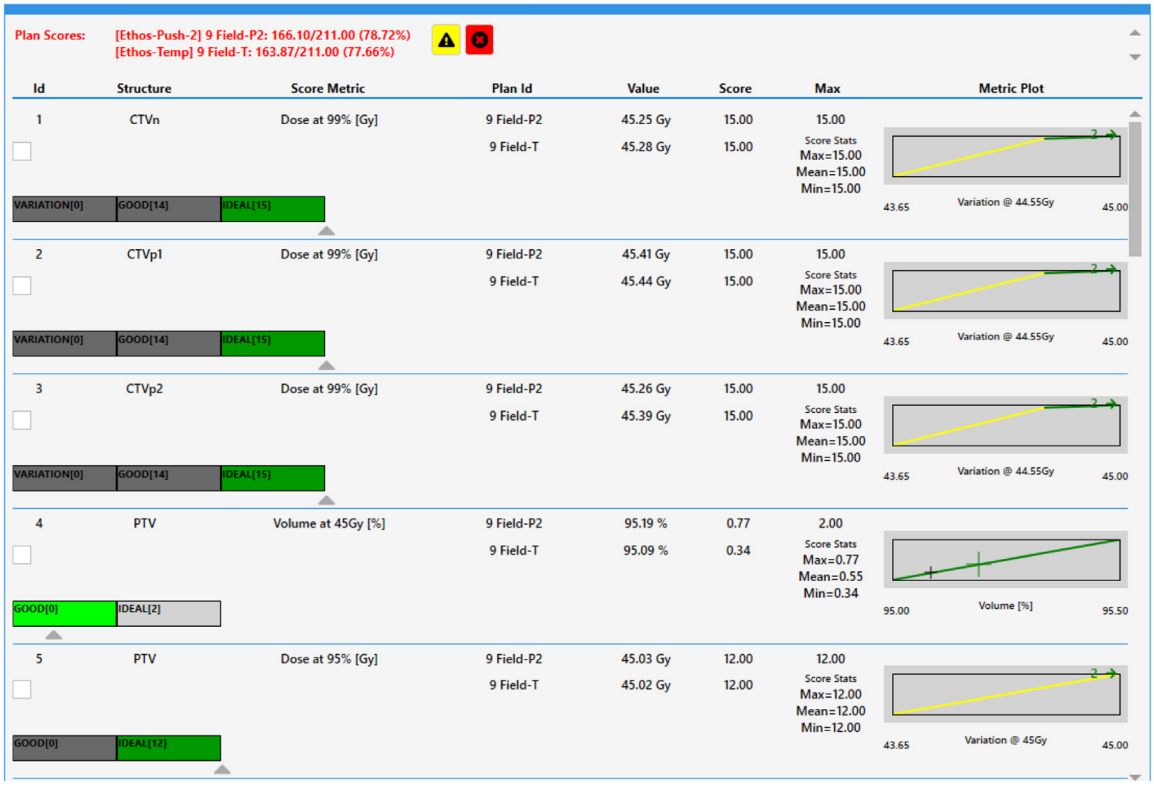


Figure 1 Scorecard of test case for CDT-2 (9 Field-P2; scorecard score, 166.1) versus CDT-1 (9 Field-T; scorecard score, 163.9).
Abbreviations: CDT = clinical directive template; CTV = clinical target volume; PTV = planning target volume.

DVH value range that each metric spans and the second order priority encoded within each metric in the form of a piecewise linear function. Each function spans a range starting from the failing value (0 points) through the maximum, but often purposely unachievable, point value in each metric. Optional intermediate point values can be added in between to create the function shape and provide multiple levels of reasonable expected DVH values. Ideally, most maximum values are not achievable so as to continue to quantify additional improvement in already "very good" treatment plans.

Clinical directive templates

A draft CDT (CDT-1) had previously been developed to meet the specified dosimetric constraints of the ARTIA-Cervix trial. For this study, CDT-1 was modified by a dosimetrist with experience in Ethos based planning. The highest priority goals ("Most Important" and "Very Important") remained unchanged from CDT-1 to maintain both PTV coverage and bowel sparing priorities per protocol. "Less Important" mean dose (Dmean) goals for the bladder, rectum, and femurs were added. "Important" mean dose goals were added for the bowel and bowel bag, whereas 2 ring structures were used to improve conformity around the target and remove unwanted dose toward surface of body (Fig. 2). The first of these rings was an expansion from the PTV surface from 0.2 to 2 cm, whereas the second was generated by cropping the body contour 3 cm from the surface and subtracting the PTV + 2.3 cm. All modifications of the CDT were designed to maximize the resulting plan's score. The scorecard-guided CDT (CDT-2) was then compared with CDT-1 with and without inclusion of RapidPlan DVHe from a publicly available knowledge-based planning model for gynecologic cancers.[5] CDT-1 was intended to be used with a DVHe model, but for the purposes of this study, the performance of both CDT-1 and CDT-2 were assessed with and without DVHe. After obtaining favorable results for 2 test cases, 10 additional cases were retrospectively identified and tested, both with DVHe.

Nineteen-field custom beam geometry

By default, Ethos can create a preset 9-field intensity modulated radiation therapy plan. However, more

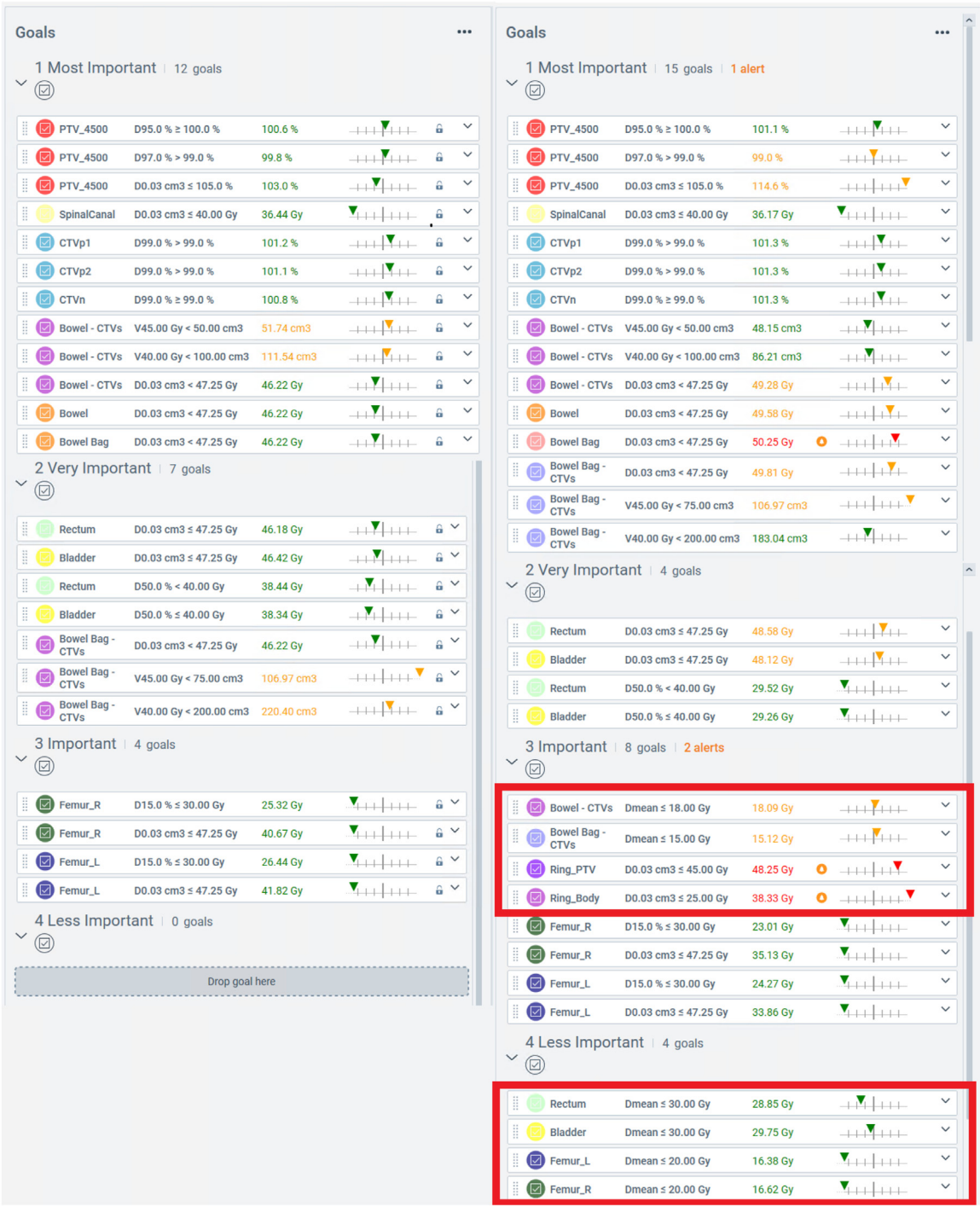


Figure 2 Edits made to CDT-2 are highlighted in red.
Abbreviations: CTV = clinical target volume; PTV = planning target volume.

fields may improve plan quality; thus, a custom 19-field beam geometry was imported and optimized with CDT-1 and CDT-2. For each case, the 19-field score was calculated and compared with the scores from the default 9-field beam arrangement. To evaluate the cost of these added fields, the plan optimization and calculation times were tabulated for the 9- and 19-field arrangements for 10 patients. Additionally, the 9- and 19-field plans were delivered on a clinical Ethos in Plan Quality Assurance mode to determine the extra cost in additional monitor units (MUs) and treatment time for 3 patients.

Results

CDT-2 without RapidPlan DVH estimation on an initial patient

For 1 of the 2 initial test patients, CDT-2 succeeded in decreasing OAR doses compared with CDT-1, without compromising PTV coverage (Fig. 3a). Although both plans on this test case met the protocol target guidelines and OAR constraints, the new plan using CDT-2 had an improved score of 168.73 (80%) versus 160.43 (76%).

CDT-2 with RapidPlan DVH estimation on an initial patient

When the RapidPlan DVHe was included, CDT-2 still outperformed CDT-1 on the same test case, but the difference was smaller (Fig. 3b). Adding DVHe to CDT-2 resulted in more OAR sparing and an even higher score of 177.42 even though the plan hotspot increased to 51.6 Gy, approaching the deviation unacceptable limit of the protocol (51.75 Gy) (Fig. 3c).

Impact of using 19 fields on an initial patient

Plan quality was further improved by increasing the number of fields to 19. Combining CDT-2 with DVHe and 19-field geometry (scorecard score, 184.6) resulted in the greatest benefit compared with the ARTIA-Cervix defined delivery technique with CDT-1, DVHe, and 9-field geometry (scorecard score, 166.1) (Fig. 3d). When comparing the CDT-2 using a 19-field plan with a 9-field plan, there is further improvement in OAR sparing (Figs. 4 and 5).

Expanding the analysis to 10 total cases

Given favorable initial testing results, between CDT-2 and CDT-1, the study was expanded to a separate analysis on 10 new cases (Table 1). These cases had not been used to design either template. Dosimetric parameters were compared and scored for each case using CDT-1 and then CDT-2 (both with DVHe) with a 9- and 19-field approach. For both templates, the use of 19 fields improved the plan score (10/10 patients improved for CDT-1, 9/10 patients improved for CDT-2). CDT-2 outperformed CDT-1 for 9 out of 10 of the 9-field plans and 7 out of 10 of the 19-field plans.

Nineteen-field time penalty

The time penalty for optimization and calculation is summarized in Table E1 where 19 fields added an average of 1.9 minutes (164%) versus 9 fields. The beam delivery time for 3 patients selected at random is summarized in Table E2, which shows that the 9- to 19-field absolute time increased by 2.8 minutes (±0.1) with a relative increase of 78.4%. As a reference, a 3-arc volumetric modulated arc therapy head and neck plan required 1 minute and 13 seconds to deliver and 11 minutes to calculate and optimize (Table 2).

MU penalty with additional fields

The average MU/field was 174.3 (total 1568.3) and 129.9 (total 2468) for 9 and 19 fields, respectively (Fig. 6).

The initial release of Ethos 1.1 was used throughout this work. Ethos 1.1 Maintenance Release (MR) 1 is designed to reduce the MUs needed in delivered plans. Two test plans were reoptimized and calculated with Ethos 1.1 MR 1 using both 9 and 19 fields (Table E3). For case 1, MR 1 resulted in an 8.4% and 6.9% decrease in MU for 9 and 19 fields, respectively. For case 2, MR 1 resulted in a 0.8% and 3.1% decrease in MU for 9 and 19 fields, respectively. In each case, the impact on the plan score was small: case 1 had total score changes of −0.6% and +0.5% for 9 and 19 fields, respectively, whereas case 2 resulted in −3.4% and −0.3% total score changes.

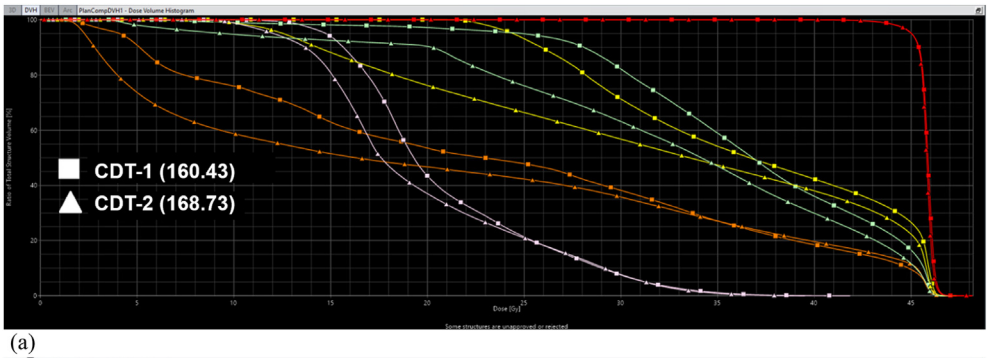
CDT-2 impact on specific metrics

For the 9-field plans generated by CDT-1 and CDT-2, individual metric scores were compared for targets, OARs, and ring structures to determine which components of plan quality led to changes in the overall plan score (Figs. E1 and E2). We observed that for the target metrics, changes were small and had negligible impact on the overall plan score except for 2 cases where the PTV hotspot (D0.03cc) increased, leading to decreases in the plan score. For the OARs, increases in scores were seen for the Bowel Dmean, Bladder D50%, Bladder Dmean, Rectum D50%, and Rectum Dmean. The Bowel, Bladder, and Rectum hotspots (D0.03cc) either remained the same or increased for each individual patient, leading to corresponding decreases in the plan score. Plan score increases were also seen for 3 out of 10 patients from the PTV Ring D0.03cc.

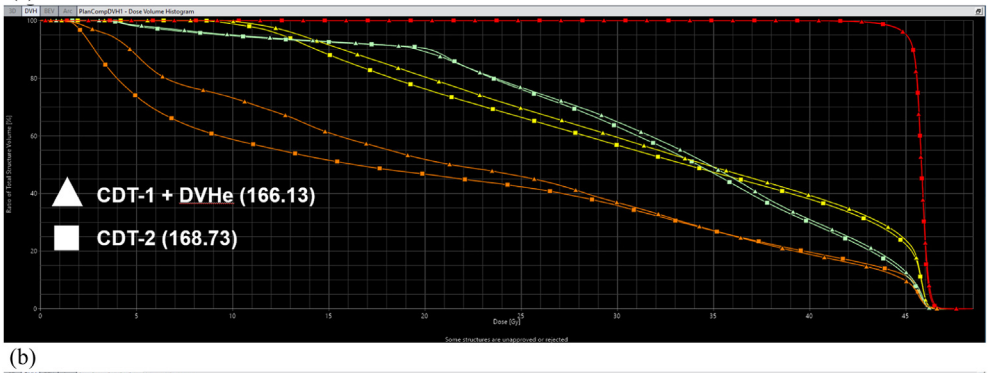
Discussion

Findings and implications

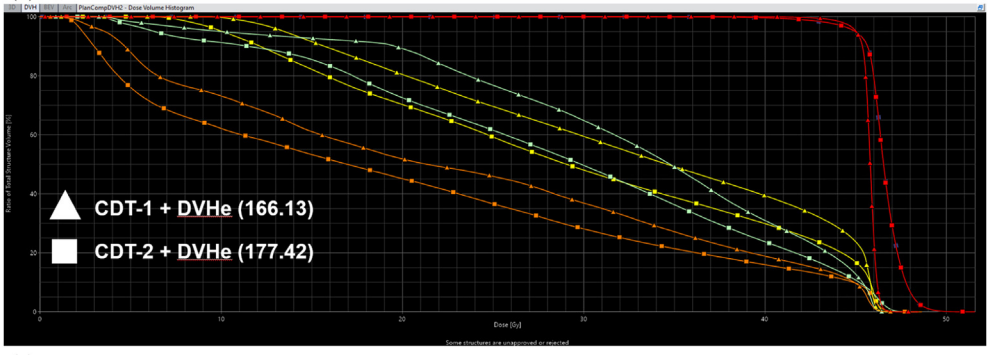
This work demonstrates that dosimetric scorecard is an effective and efficient tool to tune an Ethos planning template for OAR sparing and target coverage. This



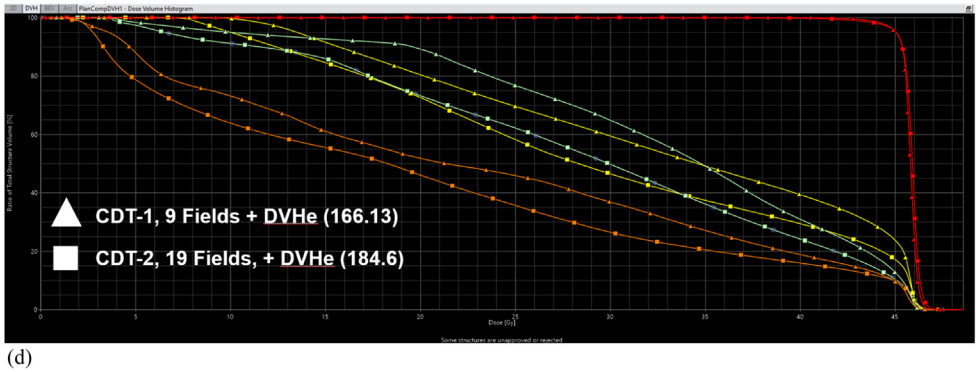
(a)



(b)



(c)



(d)

Figure 3 (a-d) DVHs of an initial case comparing CDT-1 versus CDT-2 created plans. Comparisons show combinations using DVHe and number of fields used during optimization. Results shown are bowel (orange), rectum (green), bladder (yellow), and PTV (red). Respective total plan scores are also shown.
Abbreviations: CDT = clinical directive template; DVHe = dose-volume histogram estimation; PTV = planning target volume.

technique also allowed for straightforward comparison between planning techniques such as the inclusion versus exclusion of DVHe and varying field arrangements. This allows for an overall assessment of an optimal planning and treatment strategy. Clearly defined scorecards, created at the protocol level, have great potential to improve plan quality and standardization throughout radiation oncology. The resulting CDT-2 template from

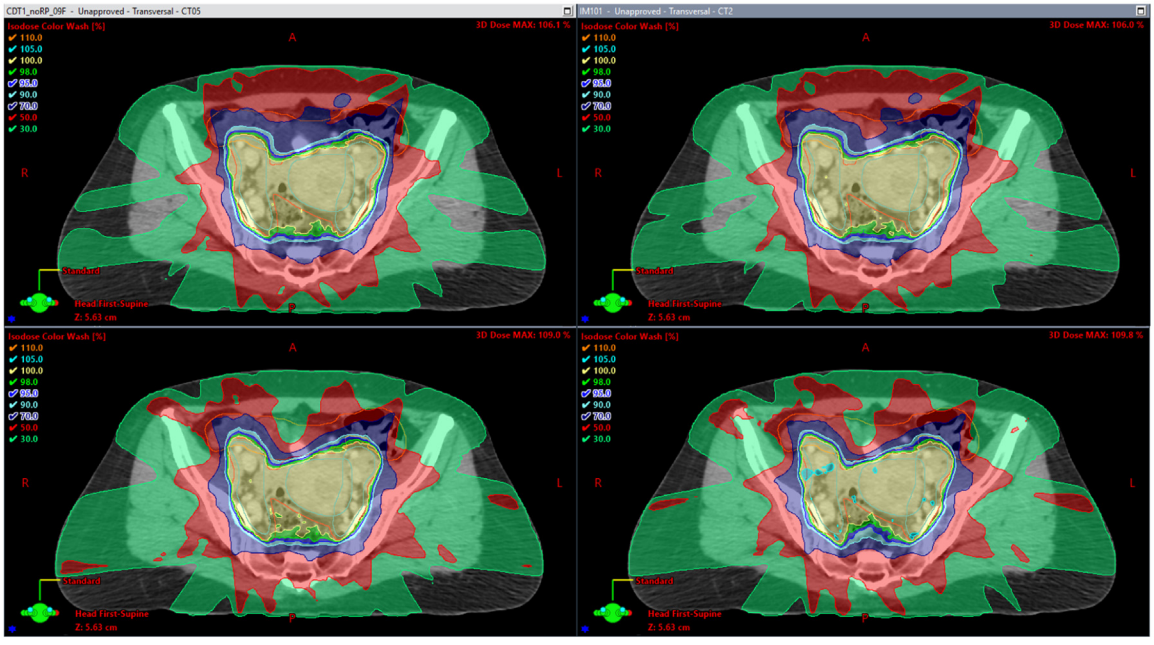


Figure 4 Plan comparison using 9-field beam geometry. Top left, CDT-1 without DVHe; top right, CDT-1 with DVHe; bottom left, CDT-2 without DVHe; and bottom right, CDT-2 with DVHe.
Abbreviations: CDT = clinical directive template; DVHe = dose-volume histogram estimation.

this study may be used by clinics looking to treat patients with cervical cancer on Ethos, although they should still always evaluate the resulting plan for clinical appropriateness before treatment approval. The use of a finely tuned CDT is expected to improve planning efficiency and decrease intrainstitutional plan quality variability, benefiting cone beam computed tomography (CBCT)-guided ART.

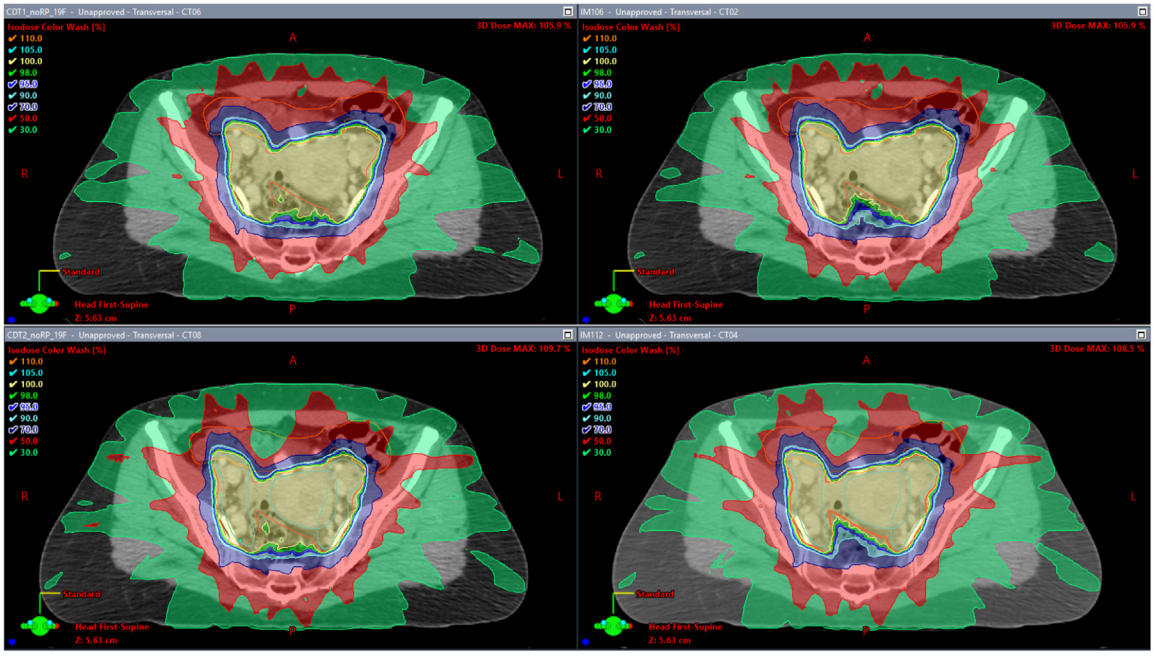


Figure 5 Plan comparison using 19-field beam geometry. Top left, CDT-1 without DVHe; top right, CDT-1 with DVHe; bottom left, CDT-2 without DVHe; and bottom right, CDT-2 with DVHe.
Abbreviations: CDT = clinical directive template; DVHe = dose-volume histogram estimation.

Table 1 Dosimetric comparison of different beam geometries for CDT-1 versus CDT-2 for 10 cases

Dosimetric scorecard comparison				
Case No.	**CDT-1 9f**	**CDT-1 19f**	**CDT-2 9f**	**CDT-2 19f**
1	187.92	**203.66**	198.55	200.45
2	196.60	203.49	209.87	**212.65**
3	180.40	195.09	187.86	**200.32**
4	174.51	**186.55**	171.06	163.04
5	187.41	201.68	195.84	**204.29**
6	191.24	203.75	195.93	**204.00**
7	192.71	215.05	198.43	**217.11**
8	192.44	207.34	200.42	**208.82**
9	190.48	201.54	198.70	**201.56**
10	199.28	**212.28**	209.40	210.24
Average	189.30	**203.04**	196.61	202.25

The "winning plan" with the highest score is highlighted.
Abbreviation: CDT = clinical directive template.

Table 2 Optimization calculation and beam delivery time summary

	Time penalty (min)		
Fields	**9**	**19**	**3 Arc (H/N) reference**
Optimization and calculation	2.9	4.8	11
Beam delivery	3.6	6.4	1.2
Total time	6.5	11.2	12.2

Abbreviation: H/N = head and neck.

Cases where CDT-1 outperformed CDT-2

Interestingly, the original CDT-1 outperformed CDT-2 for a single patient when 9 fields were used and for 3 patients when 19 fields were used. These plans were examined in greater detail, and it was observed that score decreases were likely not due to the increased field geometry directly but rather attributable to a higher magnitude and larger volume of the plan hotspot. We hypothesize that the additional fields somehow caused the optimizer to find a suboptimal solution (hotspot) when encountering drastic overlapping structures (Bowel Bag and PTV)

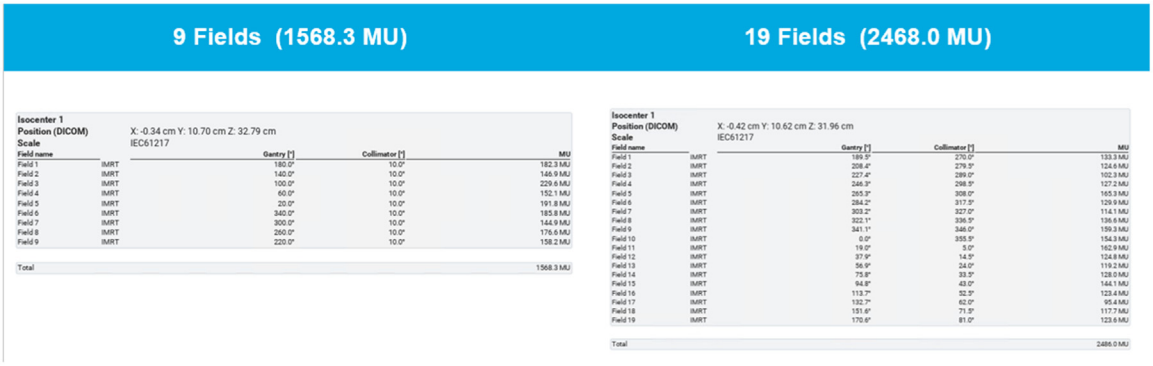


Figure 6 Fifty-seven percent increase in total monitor unit (MU) for 1 of 2 test cases with 19-field versus 9-field beam geometry. MU/field displayed for each beam arrangement.
Abbreviation: IMRT = intensity modulated radiation therapy.

presenting conflicting objectives. These conflicting objectives and the resulting hotspot lowered score contributions from PTV, Bladder, Bowel, Bowel Bag, Ring_PTV, and Ring_Body D0.03cc. CDT-2 has tighter expectations for the bowel dose; this may have led to relative increase in dose heterogeneity and subsequent hotspots after plan normalization. This tradeoff is a clinical decision that would need to be considered on a case-by-case basis by physicians (Fig. E3). Other metrics including Bladder and Rectum Dmean and D50% as well as Bowel Dmean and V40Gy still improved with CDT-2. Furthermore, with only 12 total patients in this study, the range of patient types might be limiting or possibly biasing these results.

Tradeoffs in plan quality and on-couch time

For both CDT-1 and CDT-2, using 19 fields versus 9 systematically improved plan metrics. However, the increase in fields also increased plan optimization and delivery time by approximately 5 minutes. During a CBCT-guided online ART session, it is critical to limit the overall time between when the CBCT is acquired and the end of treatment because of intrafraction motion. Otherwise, the plan generated for that day's anatomy may no longer be appropriate by the time the last field is delivered. For cervical cancers particularly, it has been observed that bladder filling between the first CBCT (taken to adjust daily contours and reoptimize the plan) and the second CBCT (taken to confirm patient position before beam-on) can be substantial enough to push the cervix and uterus out of that day's PTV because adaptive treatments can take longer than 20 minutes.[6-8] For the ARTIA-Cervix trial, clinical target volume (CTV)-to-PTV margins have been reduced from standard 10 to 15 margins to 5 mm on the cervix and uterus (CTVp1), 5 mm on the parametria (CTVp2), and 3 mm on the nodal volume (CTVn).[8] Thus, there is a risk that extending the adaptive calculation and delivery time could lead to target underdosage, although the exact safe time limit for an adaptive session is not known and likely to be patient-specific. One strategy for safe clinical implementation could be to acquire 3 CBCTs per treatment: the first at the start of the process for adjusting contours and calculating the plan, a second immediately before delivering the first beam to confirm that no substantial intrafraction motion has occurred and perform image guided radiation therapy shifts, and a third before the 19th beam to evaluate motion and bladder filling during the treatment delivery. Margins for future treatments could then be reduced on a patient-specific level based on the motion observed during the adaptive session.

Patient comfort and compliance may also be a factor in deciding whether to use a beam arrangement that requires extra on-couch time. It is expected that this triage factor will have a greater impact on whether or not a patient is recommended for the extended adaptive radiation therapy timeslots rather than if they can maintain a static position for the additional 5 minutes from using 19 fields.

Plan scorecard design

The process of creating a dosimetric scorecard, although seemingly straightforward, often requires multiple iterations to fully capture a clinical intent. When scoring a growing cohort of plans, the piecewise linear function score range originally selected could be found to be inadequate. Mainly, the problem is either (1) the range is too wide, not sufficiently capturing increases in plan quality; or (2) too narrow causing metrics to be awarded full points (missing quantification of improved plan quality) or failing with a score of 0 (when a plan with such a dose may be acceptable in certain circumstances). Beyond creating the scoring range for each metric, slopes within the range and the relative points between metrics need to be balanced relative to one another. The resulting scorecard's precise characterization of plan quality may be overly specific to one clinician's or institution's preference. Fortunately, existing scorecards are often published and easily editable. To gain clinical consensus, ideally, scorecards would be designed with the authors of a published protocol prospectively. In this work, the scorecard was created retrospectively with input from the ARTIA-Cervix protocol designers.[9] Additionally, our results support that the scorecard had an appropriate balance in metrics because the observed changes in plan scores were traced back to measurable clinical tradeoffs in individual plan metrics (eg, increasing percentages of 105% in target and OARs vs decreases in OAR Dmean).

Manual template changes for patients with challenging anatomy

This work began as an attempt to quantify and possibly improve the CDT for the ARTIA-Cervix trial before wide distribution. The resulting CDT-2 plus DVHe aggressively drives down OAR doses. With 9 fields, this can in some cases result in more heterogeneous dose distributions within the targets and less conformal intermediate dose levels (Fig. 3c). The use of 19 fields can improve OAR sparing while maintaining homogeneity and conformality. However as discussed, not all Ethos users will use additional static gantry positions because of the increase in on-couch time and risk of target miss due to intrafraction motion. In cases when dose heterogeneity and conformality are unacceptable with CDT-2 and a 9-field arrangement, these quality metrics can be improved by reducing the priority of OARs. Straightforward ways to reduce OAR priority include either detaching the DVHe or removing the mean dose clinical goals for an individual OAR. These steps are most likely to be needed when there is significant overlap between the

contoured bowel and targets. It is advised to always verify that these contours are accurate.

Plan scorecard effectiveness

A previous study designed a scorecard to retrospectively evaluate plan quality for patients included on the ACNS1123 clinical trial.[10] Their results demonstrated the power of this method for evaluating overall plan quality and pinpointing structures likely to be underprioritized during optimization. Additionally, their findings suggested that prospective use of the scorecard could help clinics identify outlier plans that should undergo further optimization before approval even when all required trial dose metrics were within tolerance. In our study, we also found plan scorecard to be a highly efficient tool for plan comparison. Our results include the observed range of plan scores for each CDT and field arrangement and thus could also be used by clinics participating on the ARTIA-Cervix trial to evaluate if their overall plan quality is within expected variation. Standardizing plan quality will decrease the sources of variation in clinical trials and thus may improve the generalizability of the results. Additionally, the plan scorecard we used is publicly available and can thus be used by other clinics looking to evaluate or compare cervical cancer plans at their own institution with minor tweaks to adjust for any local clinical preferences. Similarly, the plan template designed in this study CDT-2 can be used as a starting point for planners wishing to make cervical cancer plans on the Ethos machine.

Study limitations

This study included only 12 subjects in total; more cases would increase anatomic variation and may further challenge the resulting improvements to CDT-2, dosimetric scorecard metric scoring ranges, and the effectiveness of the DVHe model used. Additionally, although this study followed the prescribed dose instructions from the ARTIA-Cervix clinical trial, each institution may further refine their specific clinical intent (eg, OAR dose constraints) to enforce local physician preference. The dosimetric scorecard used in this study may not represent the precise intent and priorities of every institution treating patients with cervical cancer. Finally, an additional iteration of refinement on the dosimetric scorecard, creating a further enhanced CDT, and perhaps even an improved DVHe model could further enhance achievable dosimetric quality of cases in this study.

Conclusions

In this study, we demonstrated that a dosimetric scorecard is an effective tool for tuning an Ethos CDT to improve plan quality for cervical cancer radiation therapy. The scorecard enabled direct comparisons of the dosimetric impact of DVHe and beam arrangements. Our results suggest that using the tuned CDT (CDT-2) with DVHe and a 19-field geometry provides the best plan quality, but a 9-field approach may be preferred when extended delivery time risks intrafraction motion. The CDT and dosimetric scorecard developed here are freely shared online and can serve as valuable resources for clinics implementing cervical cancer radiation therapy on Ethos.[9] Using a well-tuned CDT is expected to enhance planning efficiency and reduce plan quality variability, benefiting daily online adaptive radiation therapy, although individual patient evaluation remains essential.

Disclosures

Kareem Rayn holds an ASTRO-Varian funded fellowship. Anthony Magliari is employed by Varian. Ryan Clark is employed by Varian. Xenia Ray reports receiving personal fees as a consultant from KM Pharmaceutical Consulting LLC; receives payment or honoraria and support for attending meetings and/or travel from Varian, Siemens Healthineers.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.adro.2024.101550.

References

1. Pokharel S, Pacheco A, Tanner S. Assessment of efficacy in automated plan generation for Varian Ethos intelligent optimization engine. *J Appl Clin Med Phys*. 2022;23:e13539.
2. Visak J, Inam E, Meng B, et al. Evaluating machine learning enhanced intelligent-optimization-engine (IOE) performance for ethos head-and-neck (HN) plan generation. *J Appl Clin Med Phys*. 2023;24:e13950.
3. Varian Medical Affairs Applied Solutions GitHub. PlanScoreCard Eclipse Scripting Application Programming Interface (ESAPI). Accessed February 1, 2023. https://github.com/Varian-MedicalAffairsAppliedSolutions/MAAS-PlanScoreCard.
4. Nelms BE, Robinson G, Markham J, et al. Variation in external beam treatment plan quality: An inter-institutional study of planners and planning systems. *Pract Radiat Oncol*. 2012;2:296-305.
5. Covele BM, Carroll CJ, Moore KL. A practical method to quantify knowledge-based DVH prediction accuracy and uncertainty with reference cohorts. *J Appl Clin Med Phys*. 2021;22:279-284.
6. Yock AD, Ahmed M, Ayala-Peacock D, Chakravarthy AB, Price M. Initial analysis of the dosimetric benefit and clinical resource cost of CBCT-based online adaptive radiotherapy for patients with cancers of the cervix or rectum. *J Appl Clin Med Phys*. 2021;22:210-221.
7. Branco D, Mayadev J, Moore K, Ray X. Dosimetric and feasibility evaluation of a CBCT-based daily adaptive radiotherapy protocol

for locally advanced cervical cancer. *J Appl Clin Med Phys*. 2023;24:e13783.

8. Lim K, Small W, Portelance L, et al. Consensus guidelines for delineation of clinical target volume for intensity-modulated pelvic radiotherapy for the definitive treatment of cervix cancer. *Int J Radiat Oncol Biol Phys*. 2011;79:348-355.
9. Varian Medical Systems. Cervix 45Gy (ARTIA). Accessed February 1, 2023. https://medicalaffairs.varian.com/ethos-cervix-45gy-artia-19fld.
10. Olch AJ, Gopalakrishnan M, Murphy ES, MacDonald SM, Hua CH. Toward systematic assessment and improvement of radiation therapy plan quality of cooperative group trial submissions: A report from the Children's Oncology Group. *Pract Radiat Oncol*. 2023;13:e374-e382.