MO-0297 Fast catheter trajectory planning for patient-tailored cervical cancer brachytherapy applicators

Straathof, R.; Perez, S.M.; Kolkman-Deurloo, I.K.K.; Prof.dr. Nout, R.A.; Heijmen, B.J.M.; Wauben, L.S.G.L.; Dankelman, J.; van de Berg, N.J.

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The mean difference between total delivered and prescribed dose has improved for rectum compared to results before our adaptive workflow, while for sigmoid it has increased as its position is difficult to control. For individual patients large differences for OAR doses were found, but this was within the treatment planning doses constraints in the majority of cases.

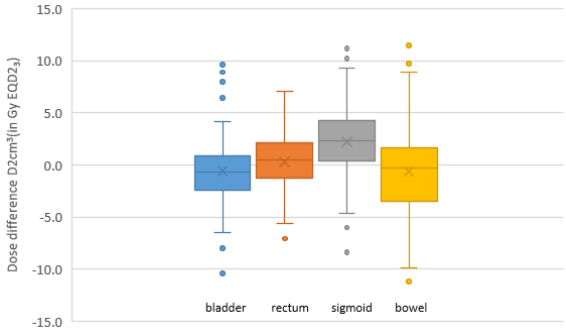

Figure 2. Boxplots showing the dose differences as total delivered minus total prescribed dose of bladder, rectum, sigmoid and bowel, for 70 patients.

Conclusion

With an MRI scanner integrated into the brachy suite repeated MRI scanning is possible. This allows for multiple interventions before planning or irradiation and let to a customized, patient centered treatment and better estimation of the real delivered dose.

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R. Straathof[1,2], S. van Vliet-Pérez[2,1], I. Kolkman-Deurloo[2], R. Nout[2], B. Heijmen[2], L. Wauben[1], J. Dankelman[1], N. van de Berg[1]

[1]Delft University of Technology, BioMechanical Engineering, Delft, The Netherlands; [2]Erasmus MC Cancer Institute, University Medical Center Rotterdam, Radiotherapy, Rotterdam, The Netherlands

Purpose or Objective

Patient-tailored hybrid intracavitary/interstitial (IC/IS) cervical cancer brachytherapy (BT) applicators may aid in improving dose conformity in large tumours or unfavourable anatomies. Several manual or partially automated methods to customise implant configurations have been proposed, but optimality and convergence thereof rely on expertise of the clinician or quality of a small set of a priori specified (straight) dwell segments. Fully automated curved source or catheter channel planning is not yet available. The aim of this work is to introduce and validate a fast approach for generating a large set of feasible catheter trajectories, and selecting sets of optimal configurations that can be integrated in 3D-printed patient-tailored applicators.

Materials and Methods

The proposed workflow (Figure 1) was applied retrospectively to generate virtual implant configurations for the first fraction in five patients previously treated with the IC/IS Venezia applicator (Elekta, Stockholm, Sweden). The patient-tailored applicator shape was derived from the distended vaginal geometry and contained existing tandem and lunar ovoids. Additional candidate catheter channels were iteratively planned between straight IS and entry segments. As channels' centrelines were represented by Bézier curves, i.e. smooth spatial curves defined by a set of control points, minimisation of a channel's curvature could be formulated as a quadratic program (QP). Non-convex applicator boundary constraints were iteratively refined into QP bounds on the control points to ensure feasibility. Geometric target coverage planning by integer programming was used to compute minimal sets of catheter configurations. Dose plans for Venezia and custom implant configurations were generated using the linear formulation of IPSA.

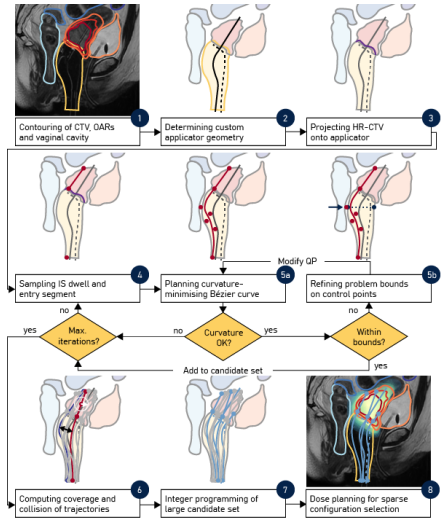

Figure 1: Overview of the proposed method. (1) Relevant anatomy is contoured, (2) the custom applicator shape is derived (yellow) including IC structures (black), and (3) an exit region for catheters is computed (purple). To build the candidate set, iteratively (4) an IS and entry segment (red) are sampled, and (5a-b) a curvature-minimising Bézier curve is computed (red). Feasibility is ensured by adding bounds on control points (dark blue). Clinicians may select an implant configuration (blue) based on solutions from (7) integer programming, using (6) coverage and collision criteria, and (8) treatment planning optimisation.

Results

Optimal channel configurations based on hundreds of candidate trajectories were determined within 5 minutes. For all patients a sparse implant configuration could be found that contained the same number of or fewer catheters (median: 4, range: 3-4) than clinically implanted (median: 5, range: 3-6), whilst satisfying all planning constraints (Figure 2). Dosimetric indices were similar for Venezia / patient-tailored applicators; the median (range) D90% of the HR-CTV was 93.1 (90.0-94.8) / 91.9 (90.7-93.8) Gy EQD2, and the D2cm3 of OARs were 77.6 (75.5-78.9) / 77.6 (75.7-79.1), 60.1 (48.8-62.6) / 62.2 (50.9-64.6), and 68.7 (59.4-69.3) / 66.7 (58.3-68.6) Gy EQD2 for bladder, rectum and sigmoid respectively.

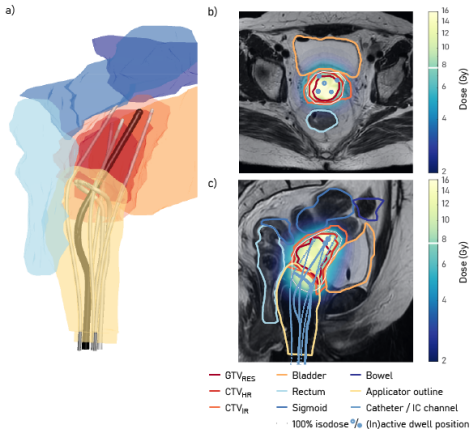

Figure 2: Example of the proposed method for a T2bN1M0 cervical cancer patient. (a) Three-dimensional view of the patient-tailored applicator design, (b) Axial view of the optimised dose distribution, (c) Sagittal view of the optimised dose distribution.

Conclusion

The proposed method was shown to be capable of generating BT implant configurations using less catheters than clinically implanted whilst achieving similar dose planning objectives. As the optimisation procedure returns an array of sparse catheter configurations, the user may select a specific configuration and plan that best meets clinical objectives, and potentially reduces the amount of catheters required.

MO-0298 Prospective assessment of interstitial needles with TRUS in cervical cancer brachytherapy

J. Knoth[1], A. Sturdza[2], A. Zaharie[2], A. Winkler[2], H. Sperrer[2], J. Widder[2], N. Nesvacil[2], C. Kirisits[2], M.P. Schmid[2]
[1]Medical University of Vienna, Department of Radiation Oncology, Comprehensive Cancer Center, Vienna, Austria; [2]Medical University of Vienna, Department of Radiation Oncology, Comprehensive Cancer Center , Vienna, Austria

Purpose or Objective

To prospectively evaluate the visibility (quantitatively and qualitatively) of interstitial needles in cervical cancer patients with combined intracavitary/interstitial (IC/IS) applications using transrectal ultrasound images (TRUS).

Materials and Methods

This is a prospective single arm cohort study. Inclusion criteria were (1) treatment with MR-IGABT for cervical cancer and (2) utilization of IC/IS. TRUS (bk5000, BK Medical) was performed during and after applicator insertion and each inserted needle was documented by an axial screenshot on the level of the largest diameter of the high-risk clinical target volume (HR-CTV) for analysis. For qualitative assessment, the visibility of each needle was rated on TRUS with the following scoring system: 0=no visibility, 1=poor discrimination, margin blurred 2=fair discrimination, margin indistinct, 3=excellent discrimination, margin distinct. For quantitative assessment, the distance between the tandem and each needle was