Medical Dosimetry 43 (2018) 106–117

Medical Dosimetry

journal homepage: www.meddos.org

Dosimetry Contribution:

Monaco treatment planning system tools and optimization processes

Mac Clements, MSc, Nicholas Schupp, MS, Megan Tattersall, CMD, Anthony Brown, CMD, and Randy Larson, CMD

Elekta, Atlanta, GA

ARTICLE INFO

Article history:
Received 1 February 2018
Accepted 15 February 2018

Keywords:
Monaco
Monte Carlo
Multicriteria optimization
SRS/SBRT
VMAT
Smart sequencing

ABSTRACT

The Monaco treatment planning system combines Monte Carlo dose calculation accuracy with robust optimization tools to provide high-quality radiotherapy treatment plans for three-dimensional conformal radiotherapy (3D CRT), intensity modulated radiotherapy (IMRT), volumetric modulated arc therapy (VMAT), stereotactic radiosurgery (SRS), and stereotactic body radiotherapy (SBRT). Recent technology advances have allowed for fast calculation speeds, which allow clinicians and patients to benefit from the accuracy of the Monte Carlo algorithm while reducing overall planning time. A collection of biological and physical dose-based planning tools and templates simplify the planning process and allow for consistent results across organizations. At the same time, multicriteria optimization (MCO) ensures critical organs are spared to the greatest possible degree while maintaining target coverage. Monaco encompasses a full suite of treatment modalities, including conventional radiotherapy and particle therapy, and is paving the way for real-time adaptive treatments with developments in magnetic resonance (MR)-guided radiation therapy.

Introduction

Monaco has been designed to meet the key treatment planning challenges of modern radiation oncology clinics. As radiation therapy treatments become faster and more complex, with increasingly higher doses, shorter fractionation schemes and smaller target margins, treatment planning systems are required to be more accurate, increasingly automated, more sensitive to patient biology and integrated with the treatment machine. To meet these challenges, Monaco combines the calculation accuracy of the Monte Carlo algorithm[1,2] with a variety of tools to simulate actual delivered dose to the patient, while ensuring consistent and efficient creation of quality treatment plans that can be delivered seamlessly. Monaco also delivers full functionality for a complete range of radiation therapy modalities, including: 3-dimensional (3D) forward-planning and field-in-field (FiF); dynamic and step-and-shoot intensity modulated radiotherapy (IMRT); arc therapy techniques, including volumetric-modulated arc therapy (VMAT) and dynamic conformal arc therapy (DCAT); cone and multileaf collimator (MLC)-based Stereotaxy; and magnetic resonance (MR)-based treatment planning.

The Planning Process

As the planning process in modern clinics continues to evolve to meet the needs of increased patient throughput,

Reprint requests to Mac Clements, MSc, Elekta, Atlanta, GA.
E-mail: mac.clements@elekta.com, c.mac.clements@gmail.com

https://doi.org/10.1016/j.meddos.2018.02.005

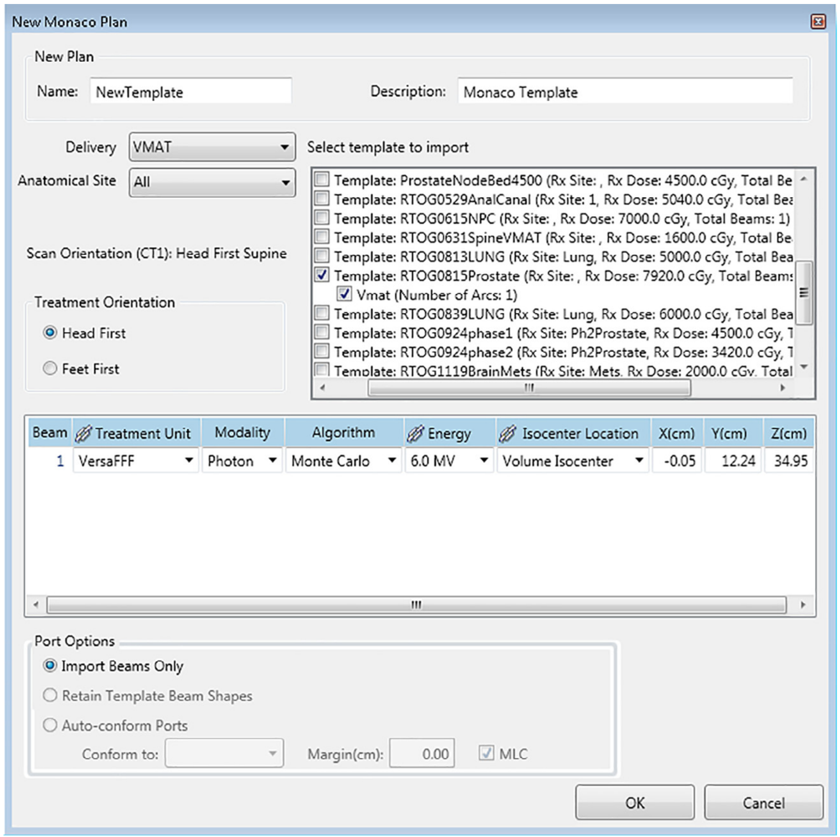

Fig. 1. Creating a single beam VMAT plan from use of a predefined template based on RTOG planning criteria (RTOG0815 Prostate). (Color version of figure is available online.)

Monaco provides clinicians with powerful tools to help automate the planning process. Within Monaco, the user can select presupplied planning templates based on clinical criteria (Radiation Therapy Oncology Group), as well as create, modify, and share their own planning templates (Fig. 1). Templates contain all the information required in the planning process, including beam setup and geometry, plan prescription parameters, dose objectives for both target coverage and organ-at-risk (OAR) sparing (known as IMRT constraints), and isodose display preferences. Monaco is designed to meet IMRT constraint criteria intelligently in the optimization process and includes the option for multicriteria optimization (MCO), which will exceed the constraint criteria as long as target coverage is maintained. Users can also adjust optimization parameters and obtain feedback in real time during optimization. Therefore, by the use of templates, the planning process can be largely automated, producing high-quality plans that meet or exceed goals within as few as 5 mouse clicks. Clinics have the ability to define templates for an entire class of treatment types and to share these templates across multiple clinics, allowing for consistency and standardization in plan protocols and quality across the organization.

Monaco utilizes a unique method for plan optimization that does not rely on the creation of multiple “aid” structures to guide optimizer efforts on where to avoid or escalate dose. Instead, Monaco defines ownership of voxels based on the order of IMRT constraints that are included in the optimization. In addition, visualization tools help the user to determine which constraints are effective in various locations and to what degree they are effecting the overall planning goals (Figs. 2 and 3) In this way, the amount of time spent in creating additional contours is reduced.

For inverse-planning, Monaco has 2 optimization modes: constrained and pareto. In constrained mode, Monaco prioritizes constraints on OARs and ensures that those constraints are met before target coverage is achieved. In pareto mode, Monaco prioritizes target coverage before OAR constraints are met. The benefit of constrained optimization is that it works in harmony with the visualization tools (Fig. 4) to show which constraints are the most difficult to achieve and affect target coverage the most (Fig. 5). These options guide the planner and physician to make informed trade-off decisions based on the patient’s unique anatomy and plan objectives.

Integration

Understanding the capabilities of the treatment machine and utilizing these capabilities to full advantage is para-