Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.elsevier.com/locate/rpor

Original research article

Software-based evaluation of a class solution for prostate IMRT planning

Sarah Clarke[a], *Josie Goodworth*[b], *Justin Westhuyzen*[b], *Brendan Chick*[a], *Matthew Hoffmann*[a], *Jacqueline Pacey*[b], *Stuart Greenham*[b,*]

[a] *Department of Radiation Oncology, Mid-North Coast Cancer Institute, Port Macquarie, New South Wales 2444, Australia*

[b] *Department of Radiation Oncology, Mid-North Coast Cancer Institute, Coffs Harbour Health Campus, Coffs Harbour, New South Wales 2450, Australia*

ARTICLE INFO

Article history:
Received 22 March 2017
Received in revised form
21 July 2017
Accepted 2 August 2017

Keywords:
Prostate
Radiotherapy planning
Software
Solutions

ABSTRACT

Aim: To use plan analysis software to evaluate a class solution for prostate intensity modulated radiotherapy (IMRT) planning.

Background: Class solutions for radiotherapy planning are increasingly being considered for streamlining planning. Plan analysis software provides an objective approach to evaluating radiotherapy plans.

Materials and methods: Three iterations of a class solution for prostate IMRT planning (T1, T2 and T*final*) were compared to the clinical plan of 74 prostate patients using radiotherapy plan analysis software (Plan IQ™, Sun Nuclear Corporation). A set of institution-specific plan quality metrics (scores) were established, based on best practice guidelines.

Results: For CTV coverage, T*final* was not significantly different to the clinical plan. With the exception of 95% PTV coverage, T*final* metrics were significantly better than the clinical plan for PTV coverage. In the scoring analysis, mean dose, 95% and 107% isodose coverage scores were similar for all the templates and clinical plan. 100% coverage of the CTV clinical plan was similar to T*final* but scored higher than T1 and T2. There were no significant differences between T*final* and the clinical plan for the metrics and scores associated with organs at risk. The total plan score was similar for T*final* and the clinical plan, although the scores for volume receiving total dose outside the PTV were higher for T*final* than for the clinical plan ($P < 0.0001$).

Conclusions: The radiotherapy plan analysis software was useful for evaluating a class solution for prostate IMRT planning and provided evidence that the class solution produced clinically acceptable plans for these patients.

* *Corresponding author at*: Department of Radiation Oncology, Mid-North Coast Cancer Institute, Coffs Harbour Health Campus, Coffs Harbour, New South Wales 2450, Australia.
E-mail address: stuart.greenham@ncahs.health.nsw.gov.au (S. Greenham).

http://dx.doi.org/10.1016/j.rpor.2017.08.001

1. Background

Intensity modulated radiotherapy (IMRT) is a widely used and well established technique for external beam radiotherapy. The potential for automation was identified early on[1]; the possibility of a class solution for prostate radiotherapy treatment planning was also considered at an early stage.[2,3] The concept of a class solution has received increasing attention as it has moved from concept to clinical reality.[4–10] Some authors consider class solutions as a starting point[8] for the treatment planning process and more recently it has been suggested that radiotherapy planning will become fully automated within the next decade.[11]

A class solution for radiotherapy planning can be defined as a set of dosimetric objectives and geometric beam arrangements that are sufficiently robust to produce a clinically acceptable dose distribution regardless of the patient anatomy, target volume or organs at risk (OAR).[7] The resulting plan should also be less dependent on treatment planner experience[12] and resulting in an efficient clinical workflow.

Treatment plan dose distributions are often deemed clinically acceptable with respect to department protocols (including clinician experience) and international recommendations. With the introduction of IMRT, assessment using objective dose volume histogram (DVH) criteria has increased; however, it can still often be subjective in determining whether the treatment plan is considered clinically acceptable. Current literature[12,13] suggests that clinical experience, individual knowledge and planner skill introduce a bias when determining quality of treatment plans and a more structured analysis or quantitative evaluation of treatment plans is required. Ruan et al.[12] developed a set of evolving institution specific criteria as a standard by which to assess plan quality with a view to reducing or eliminating bias. Ventura et al.[14] incorporated planning and clinical criteria into a plan evaluation tool (SPIDERplan) which was based on a scoring approach and included graphical representation in the form of radar plots. The quality of the dose distribution in the PTV and OARs of possible treatment plans could be easily compared.

Plan quality can be evaluated using dedicated task specific software. Software developed to analyse radiotherapy plans have tools to measure, compare and validate treatment plan quality. For example, Plan IQ^{TM} is a treatment planning system independent, DVH analysis tool that enables the user to create plan quality algorithms.[15] A plan quality algorithm may contain many plan quality metrics (PQM) with specific weightings or scores assigned to each, enabling plans to be given an overall quality score for ease of comparison and validation.[13] This type of software provides effective tools for analysing and validating class solutions.

The development of a class solution for prostate IMRT has recently been described.[16] In the current study, we use analytical software tools to evaluate a class solution for intact prostate radiotherapy planning.

2. Methods and materials

2.1. Patient selection

Retrospective planning data was collected for 74 prostate patients treated in late 2014 through to early 2015. All patients were treated with 81 Gy in 45 fractions in a single phase treatment approach. All patients were simulated with the same computed tomography (CT) scanning protocol. Patients were contoured in accordance with the institutional protocol which is developed from evidence-based guidelines.[16] The work met the criteria for a Quality Improvement project according to the NSW Health Ethics Guideline document GL2007_020 and did not require formal ethical review (HREC reference number QA160).

2.2. Class solution for prostate IMRT

As a quality improvement initiative, an optimal template (class solution) for IMRT prostate patients has been developed within our institution.[16] Using a stepwise quality improvement model and evidence-based guidelines, a template based on 10 patients underwent three stages of development, refinement and evaluation. The first evaluation involved 20 patients at two centres using sensitivity analysis; the second involved a major review of treated plans across a larger number of cases ($n = 50$); the review informed the development of a final template, T*final*. In the current study, the criteria of the developmental templates (termed T1 and T2) and T*final* were applied and calculated on each patient data set. These class solutions were compared to each other and the clinically treated plan (CP). Along with the final clinical treatment plan, this information was then exported to radiotherapy plan analysis software (Plan IQ^{TM}, Sun Nuclear Corporation, Melbourne, FL, USA) where the plan quality metrics (PQM) was applied. Monaco V5.0 (Elekta-CMS Software, MO, USA) was used to generate all treatment plans using plan templates.

2.3. Building the metrics

A prerequisite to the analysis was to establish a robust set of institution-specific metrics that would identify a high-quality treatment plan. The PQM for this study were drawn from the IMRT prostate protocol used at our institution which outlined the target planning aims and organ at risk (OAR) dose constraints. The metrics used and the dose constraints from the local clinical protocol are summarised in Table 1. To further assess plan quality, other metrics including conformity, regions of high dose outside the planning target volume (PTV) and plan global maximum location were assessed. Each metric was assigned a weighting, achieved through a maximum score, with respect to clinical importance (see Table 1). In total there were eight metrics associated with target coverage, ten metrics associated with OARs and three metrics that had a lesser weighting and were indicators of overall plan quality.