Figure 2. Comparing the clinical and re-planned plans for the 13 patients with one or more dosimetric parameters outside the 90% confidence interval. The y-axes represent differences in the dose metrics. If the difference is positive (above the red line), the re-planned plan is better than the clinical plan. The re-planned plans should not deteriorate other dose metrics by more than 1Gy or 1% (should be above the green line).

Conclusion

The proposed plan QA tool can detect outliers with an accuracy of 3-4Gy and 2%-3% (90% CI). Totally 13/46 (28%) of the automatically generated plans were outliers. Indeed, for all of them re-planning resulted in an improved plan. This emphasizes the need for treatment planning QA, also for automated treatment planning. For manual treatment planning, the percentage of outliers is expected to be higher and therefore treatment planning QA is even more important.

OC-0255 Practical use of principal component analysis in radiotherapy planning

D. Christophides[1], A. Gilbert[2], A.L. Appelt[2], J. Fenwick[3], J. Lilley[4], D. Sebag-Montefiore[2]
[1]Leeds CRUK Centre and Leeds Institute of Can cer and Pathology, University of Leeds, Leeds, United Kingdom
[2]Leeds Institute of Cancer and Pathology - University of Leeds and Leeds Cancer Centre, St James's University Hospital, Leeds, United Kingdom
[3]Institute of Translational Medicine, University of Liverpool, Liverpool, United Kingdom
[4]Leeds Cancer Centre, St James's University Hospital, Leeds, United Kingdom

Purpose or Objective

Principal component   analysis (PCA) is a promising technique for handling DVH data in NTCP modelling. However it is challenging to interpret its results clinically and use them to make informed decisions for specific patients. A method is developed that uses PCA-based NTCP modelling to produce treatment optimisation objectives which can be used for treatment plan improvement. The utility of the method is demonstrated in a treatment planning case as well as in a simulation study, for reducing predicted patient reported outcome (PRO) scores of vaginal stenosis.

Material and Methods

Data from 221 female patients treated with pelvic radiotherapy were made available from a larger study (DRF-2012-05-201) on optimising patient outcomes. Vaginal stenosis PRO scores ("Has your vagina felt tight?": "Not at all" (0), "A little" (1), "Quite a bit" (2) and "Very much" (3)) were completed by 74 (29%) patients. The principal components (PCs) extracted from the available external genitalia DVHs, along with clinical factors, were used to construct an ordinal logistic regression model that predicted the probability of patients having vaginal stenosis symptoms.

The model identified age, hormone replacement therapy and the first PC (PC1) as important predictors of vaginal stenosis PRO scores. Based on the model, the probability of grade 2 or greater PRO score could be calculated; as well as a PC1 that could theoretically reduce that probability by 50% (PC1'). PC1' was used to derive a PCA-modified DVH' using the following method: i) the modified principal components were inversely transformed into the DVH domain to obtain a new DVH', ii) DVH' was cropped so the volumes were always greater than 0% and lower than the original DVH, and iii) DVH' was made monotonically decreasing.

An anal cancer patient case was planned using VMAT and the PCA-based model information, as a demonstration of the clinical applicability of PCA-based modelling. The method was then used to modify the DVHs of all available patients (N=221). The probability of having grade 2 ≥ PRO scores using the un-modified patient DVH and the PCA-modified DVH' were compared using a paired t-test.

Results

The treatment planning case demonstrated the clinical relevance of PCA-based modelling by using PCA information to formulate cost functions to reduce the dose to the genitalia (Fig.1), which resulted in a reduction of the predicted probability of vaginal stenosis symptoms (Fig.2). The simulation results showed a statistically significant decrease in the probability of having grade 2 ≥ PRO scores (Reduction in mean = 33%, p<0.001).
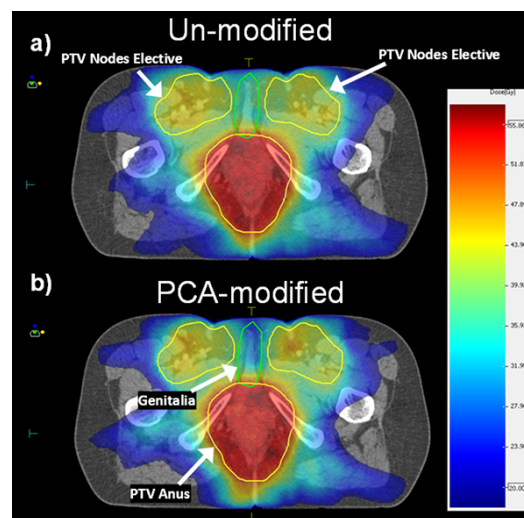

Fig. 1. a) Axial CT slice of the 'Un-modified' plan without any optimisation of the genitalia DVH showing the dose distribution near the genitalia contour, the elective nodes PTV and the anus PTV. b) The dose distribution of the 'PCA-modified' plan demonstrating the dose reduction in the genitalia to reduce the probability of having vaginal stenosis symptoms. The genitalia dose reduction optimisation was based on cost functions constructed using information from the PCA-based modelling (Fig.2).
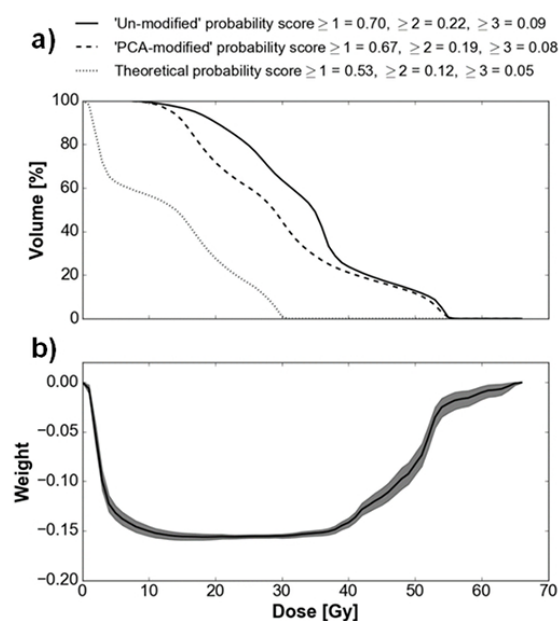
Fig. 2. a) The original genitalia DVH of the 'Un-modified' plan (Fig.1), along with the DVH from the 'PCA-modified' plan (Fig.1) optimised to reduce the dose to the genitalia and a theoretical DVH derived using the proposed method. b) Eigenvector 1 (solid line) was used to set DVH cost functions in the treatment planning system at 20 Gy, 30 Gy and 40 Gy to reduce the dose to the genitalia DVH. The cost functions dose points were chosen to coincide with the higher magnitudes of eigenvector 1. (95% confidence interval is shown, grey shaded area).

Conclusion

The method presented allows for the use of PCA-based NTCP modelling to optimize patient DVHs to improve treatment plans. The clinical applicability of the method was tested on a treatment planning case, with a reduction of the predicted probability of vaginal stenosis symptoms. Furthermore simulation results showed a potential significant reduction of grade ≥ 2 vaginal stenosis PRO scores.

OC-0256 Using a knowledge-based planning solution to select patients for proton therapy

A. Delaney[1], M. Dahele[1], J. Tol[1], I. Kuijper[1], B. Slotman[1], W. Verbakel[1]
[1]VUMC, Radiotherapy, Amsterdam, The Netherlands

Purpose or Objective

The decision to treat a patient with protons or photons is currently based upon the dosimetry of both plans and, for example, whether proton plans reduce dose to organs at risk (OAR) or the estimated toxicity by a pre-determined threshold. However, creation of two treatment plans (TPs) is time intensive, and plans can vary in quality due to patient-specific choices, planning experience and institutional-protocols. RapidPlan[TM], uses a TP library to predict dose-volume histograms (DVHs) and can generate Knowledge Based Plans (KBPs). We investigated 1) whether RapidPlan, currently designed for photons, could also generate proton KBPs and 2) if predicted DVHs alone, could provide an efficient and objective way to select patients for proton therapy.

Material and Methods

Thirty proton and photon TPs for head and neck cancer patients populated proton and photon model-libraries, and were used to create DVH predictions and KBPs for 10 evaluation patients. Accuracy of DVH-predicted OAR mean dose (D_{mean}) was assessed by comparison with achieved D_{mean} of KBPs. KBPs were compared with manually optimized TPs using target homogeneity and D_{mean} of composite salivary ($comp_{sal}$) and swallowing ($comp_{swal}$) organs. To illustrate how patients might be selected for protons, the D_{mean} of the contralateral submandibular, average parotid glands and volume weighted swallowing structures were summated, and protons were selected if the model-predicted proton minus photon D_{mean} (ΔPrediction) was $\geq 6Gy$ (arbitrarily chosen). A correction was applied to account for inaccuracies in predictions (see below). Selection was benchmarked with differences between proton and photon KBPs achieved D_{mean}.

Results

R^2 values between achieved and predicted D_{mean} were 0.95 and 0.98 using proton and photon models, respectively (Figure). On avarage, photon KBPs resulted in 1.3Gy lower D_{mean} and proton KBPs 0.8Gy higher than predicted, however one patient exhibited >10Gy difference with the proton model. On average there was <2Gy difference between KBPs and manual TPs for $comp_{sal}$ and $comp_{swal}$ D_{mean}, and <2% for target homogeneity. Using ΔPrediction $\geq 6Gy$ correctly selected 4/5 patients for protons. Generating DVH-predictions and optimizing proton KBPs typically took <45 seconds and 3 minutes, respectively.
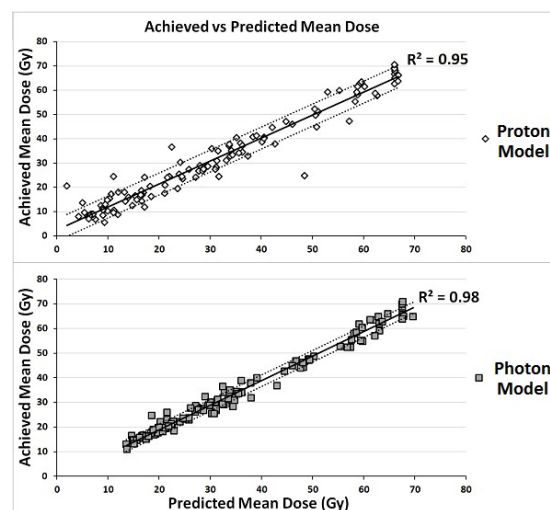
Conclusion

Once model libraries have been created, comparing knowledge-based DVH-predictions allows rapid patient selection for protons without the need to create TPs, minimizing subjectivity and the use of resources. Discrepancies between predicted and achieved D_{mean} for proton KBPs may have been due to the relatively small model libraries and the fact that the current RapidPlan algorithm is designed for photons. A proton-specific platform may address some of the shortcomings. Conversion of predicted DVH to estimated normal tissue complication probability, could further enhance the comparative process.

Proffered Papers: Best of online MRI-guided radiotherapy

OC-0257 Comprehensive MRI Acceptance Testing & Commissioning of a 1.5T MR-Linac: Guidelines and Results

R.H.N. Tijssen[1], S.P.M. Crijns[1], J.J. Bluemink[1], S.S. Hacket[1], J.H.W. DeVries[1], M.J. Kruiskamp[2], M.E.P. Philippens[1], J.J.W. Lagendijk[1], B.W. Raaymakers[1]
[1]UMC Utrecht, Department of Radiation Oncology, Utrecht, The Netherlands
[2]Philips Healthcare, MR Therapy, Best, The Netherlands