

Quality assurance of advanced radiotherapy techniques with Delta4

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INTRODUCTION

Advanced techniques such as gated radiotherapy and Single Arc IMAT present additional challenges for quality assurance. Delta4 (Scandidos AB) is particularly suited to dealing with these challenges. We have used it successfully to assess the accuracy of RapidArc™ treatment on a Varian Clinac® and have designed a moving platform to allow its use to monitor the effect of movement on treatment accuracy.

METHOD

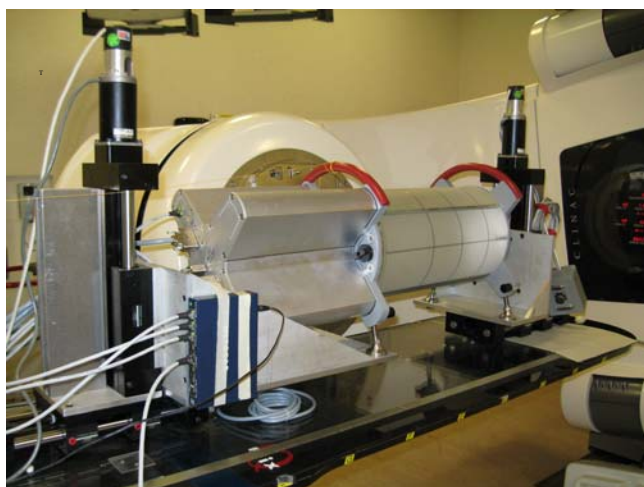


Figure 1 (above) Delta4 phantom mounted on its moving carriage. (left) Simple device to move the Varian gating block to allow generation of the linac gating signal. The string is attached to the Delta4 phantom.

Delta4 is a cylindrical phantom containing two orthogonal arrays of diodes which was designed as part of the EU funded project Invorad. A trigger pulse from the linac allows synchronisation of the measurement with the linac pulse thus reducing noise. The data from each pulse are assigned to a beam segment

which allows detailed identification of the source of any problems. For measurements of the effect of target movement the phantom was mounted on a moving carriage as shown in Figure 1. The carriage can be driven by two stepper motors to allow vertical or horizontal movement. The controller allows any chosen movement of the phantom to be programmed using a simple text file.

For RapidArc measurements a clinometer is attached to the linac gantry to allow the angle of the beam to be measured.

RESULTS

Measurement of Movement

The phantom allows the effect of delivering a step and shoot IMRT beam to a moving target to be assessed. A simple 3 field IMRT plan was created to a small peripheral lung tumour. The phantom was programmed to move in the same way as the tumour based on 4D CT scan data. Figure 2 shows the measured results. The gamma index (i.e. the percentage of diodes for which the dose was within 3% or 3mm of the expected dose) was not significantly worse when the movement amplitude was 7mm although there was an increase in the number of diodes differing by >5%. For 20mm movement the treatment would not have been acceptable.

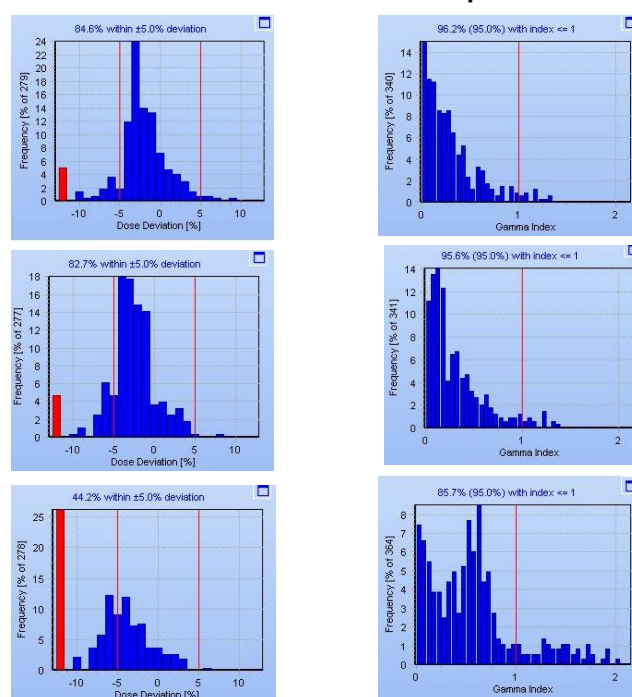


Figure 2 Dose difference (left) and gamma 3%/3mm (right) plots for an IMRT lung plan with no movement (top), 7mm movement (middle) and 20mm movement (bottom). The actual amplitude of movement for this patient was 7mm

RapidArc Measurements

A RapidArc treatment plan for a head and neck patient was calculated using the Varian Eclipse planning system. This plan was for a complete 360° rotation and is shown in Figure 2.

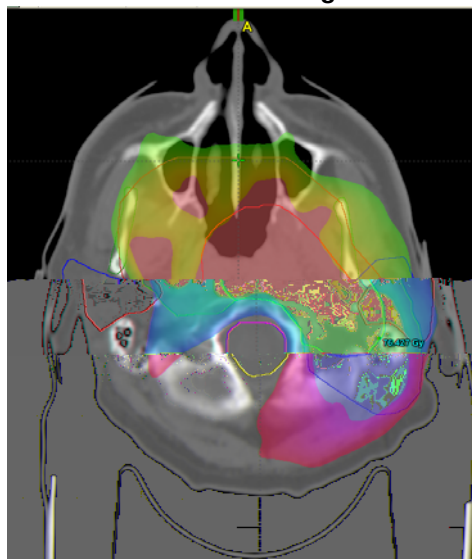


Figure 3 RapidArc plan for a Head and Neck case designed to spare the left parotid and to give a greater dose to the right side.

The plan was transferred to the Delta4 phantom and delivered. Figure 4 shows the analysis of the results from Delta4. It will be seen that 99% of the points fall within 3% and 3mm. This is better than the results for the lung step and shoot IMRT plan shown in Figure 2. Treatment delivery was completed in 1.5 minutes.

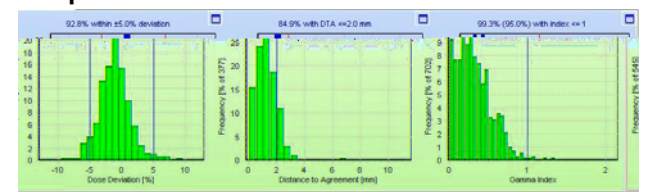


Figure 4 Measurement of the RapidArc plan shown in Figure 3.

One of the concerns with such a complex treatment delivery is that the plan might not be delivered reproducibly. Delta4 allows this to be tested directly by comparing the results of one measurement with another. As can be seen from Figure 5 the results are in fact very reproducible.

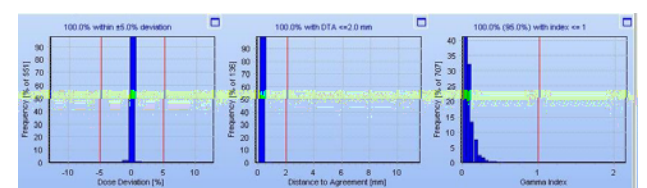


Figure 5 Repeat measurements of the RapidArc plan compared to each other. Note that for this purpose the gamma index has been set to 1%/1mm.

DISCUSSION

The results presented here show the potential that a 3D diode array provides for the QA of complex radiotherapy treatments. It must be emphasised that this work is at an early stage of development. When agreement is good QA with Delta4 is a rapid process allowing several individual patient measurements to be made with minimal access to the treatment machine. However, the main benefit of the system may be when there are problems that need to be investigated. In these circumstances it becomes possible to investigate the cause of problems in very great detail. The potential to move the phantom also allows investigations to be carried out that are not normally possible with other systems.

CONCLUSIONS

Delta4 has been shown to be a versatile tool for the measurement of complex treatments.

RapidArc not only provides a speedy method of delivering IMRT treatments but delivery also appears to be at least as accurate as step and shoot and, based on a limited measurements, reproducible.

ACKNOWLEDGEMENTS

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The assistance of Fouad Abolaban with the moving platform is gratefully acknowledged.

COMMERCIAL INTEREST

G Nilsson is President and CEO of Scandidos AB.