Accounting for the effects of carbon fibre treatment couches in the XiO treatment planning system.

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Abstract. An investigation was conducted to determine the impact of two carbon fibre couch tops on treatment planning and to establish a method by which these couch tops may be accounted for in the XiO treatment planning system. In this study, the effects of the Civco Universal and the Medical Intelligence iBeam evo carbon fibre couch tops were investigated. Customised templates were developed in Focal to mimic the effects of these patient support devices and each template was then included in calculations performed by the XiO treatment planning system. The accuracy of modelling the couch tops in this manner was investigated and it was shown that, while using the customised couch templates, XiO modelled the increase in the surface dose due to treating through the couch tops at 180^{o} to 1.0% ± 1.7%. The attenuation due to the presence of the couches was modelled to within 0.5% ± 0.4% for angles that pass through the flat central region of the couch tops and to within 1.4% ± 1.2% for angles that passed through their rapidly varying edges. When the couch templates were not included in XiO, the calculated dose at depth was recorded to be, in some cases, up to 5.3% ± 1.0% more than corresponding measured values. It was concluded that using the method described in this study it is possible to accurately model the effect of carbon fibre couch tops in the XiO treatment planning system.

1. Introduction

In the past carbon fibre therapy couch tops were assumed to be radio transparent because of their low density foam and carbon fibre composition. However, a number of studies have indicated that dose modification due to these devices can be significant [1-4]. The effects expected to be observed when treating through a carbon fibre couch with a mega-voltage photon beam include a reduction in the skin sparing effect, a shift in the point of maximum dose (d_{max}) and attenuation of the beam at depth.

Modern treatment techniques including stereotactic body radiation therapy (SBRT) [5], volumetric modulated arc therapy (VMAT) and intensity modulated radiation therapy (IMRT) have highlighted the negative effect carbon fibre couch tops can have on patient planning when the couch top isn't accounted for in the treatment planning system (TPS) [6-8]. This work quantifies the effects due to treating through these devices and examines the ability of a commercial treatment planning system (XiO v.4.70.02) in modeling these effects.

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2. Materials and Methods

2.1. Carbon fibre treatment couches

Two independently manufactured therapy couch tops, the iBeam evo carbon fibre couch top and the Civco Universal couch top were investigated. The iBeam evo couch top manufactured by Medical Intelligence (Schwabmünchen, Germany) consists of two thin carbon fibre plates, 2 mm thick, sandwiching 46 mm of foam. The carbon fibre thickness increases to 4.5 mm towards the edges of the couch (iBEAM evo Couch top User Manual, Version 11 of 2007-11-15). The Civco Universal table top is of similar construction with two thin carbon fibre plates approximately 1.8 mm thick, sandwiching approximately 46.5 mm of foam. To determine the effect due to the two couch tops, percentage depth dose (PDD) and attenuation measurements were made on both Elekta Axesse and Elekta Synergy linear accelerators.

2.2. Surface dose measurements

All PDD measurements were made in 30x30 cm^2 slabs of Virtual Water^{TM} using a PTW Advanced Markus type 34035 parallel-plate ionisation chamber. The central axis of the beam was normal to both the couch and phantom surface and PDD measurements were made at a source to surface distance (SSD) of 100 cm, at both 6 and 10 MV, and a field size of 10x10 cm^2. The ionisation current was measured with a PTW Webline electrometer. Results are displayed as the average ionisation at positive and negative polarity normalised to the point of maximum dose.

2.3. Attenuation measurements

Attenuation measurements were made in Virtual Water^{TM} (30x30 cm^2) using an IBA Farmer type ionisation chamber (FC65-G) and PTW Webline electrometer. The chamber was placed at the centre of the Virtual Water^{TM} phantom and positioned so that the centre of the chamber was at the linear accelerator's isocentre. A source to axis distance (SAD) of 100 cm was used for both 6 and 10 MV and field sizes used included 5x5 cm^2 and 10x10 cm^2. Measurements were taken at 10° intervals from 0°-350° and the attenuation due to the couch was calculated as the percentage difference of the charge measured with the couch in the path of the beam, to the charge measured with the couch out of the beam's path.

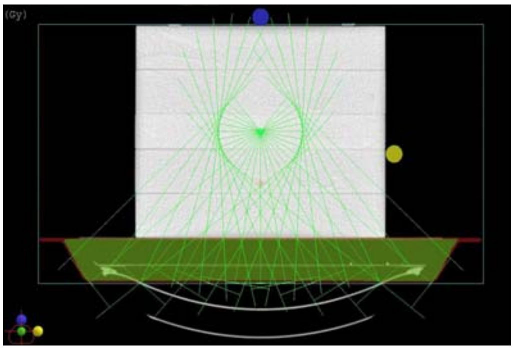

Figure 1: Customised couch template developed in Focal to mimic the MI iBeam evo Universal couch top.

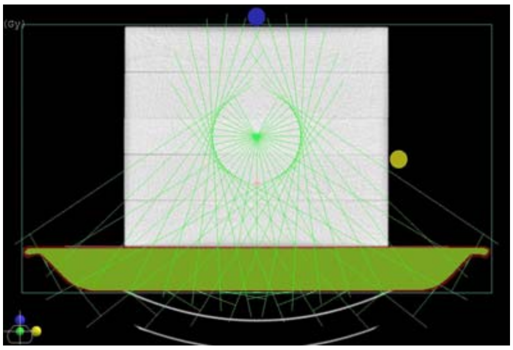

Figure 2: Customised couch template developed in Focal to mimic the Civco Universal couch top.

2.4. Treatment Planning System

To mimic the effects of the couch tops in the XiO treatment planning system, customized couch templates were developed (Figures 1 and 2). To construct the customised couch templates Elekta's distributed planning system Focal v.4.70.00 was used. A CT dataset of the iBeam evo and Civco couch tops were obtained on a Siemens Sensation Open scanner and two contours were created in Focal, one for the foam core and one for the carbon fibre. The average relative electron density of the carbon fibre (0.55) and foam (0.10) sections of the couch tops were obtained from the CT data set and each contour was forced to the relevant value. To ensure that the couch structure is included in XiO's calculations, the customised couch templates were included in the external patient contour before exporting a plan from Focal to XiO.

2.5. Template Validation
To validate the customised templates, PDD and attenuation values were calculated using the superposition algorithm in the XiO treatment planning system and compared to those measured. Three prostate IMRT plans were then calculated in XiO before and after including the customised couch templates in the patient plan. Dose maps calculated were compared with measurements taken using a 2-D diode array (MapCHECK^{TM}).

3. Results and discussion

3.1. Percentage Depth Dose
For 6 MV an increase in surface dose (Ds) of 74.7% ± 1.8% was measured for the iBeam evo couch, while for 10 MV the increase in Ds was measured to be 67.6% ± 1.7%. Using the customised iBeam evo couch template XiO was able to calculate the increase in Ds due to passing through the couch at 180^o to within 1.0% ± 1.7%. Similar results were obtained for the Civco Universal couch template. When treating through the couch tops, a shift towards the surface in d_{max} was also observed. This shift is illustrated in figure 3(a) and (b) and was measured to be 8.0 mm ± 1.4 mm for 6 MV and 7.0 mm ± 1.4 mm for 10 MV. Again this shift was accounted for when the couch templates were included in XiO's calculation.

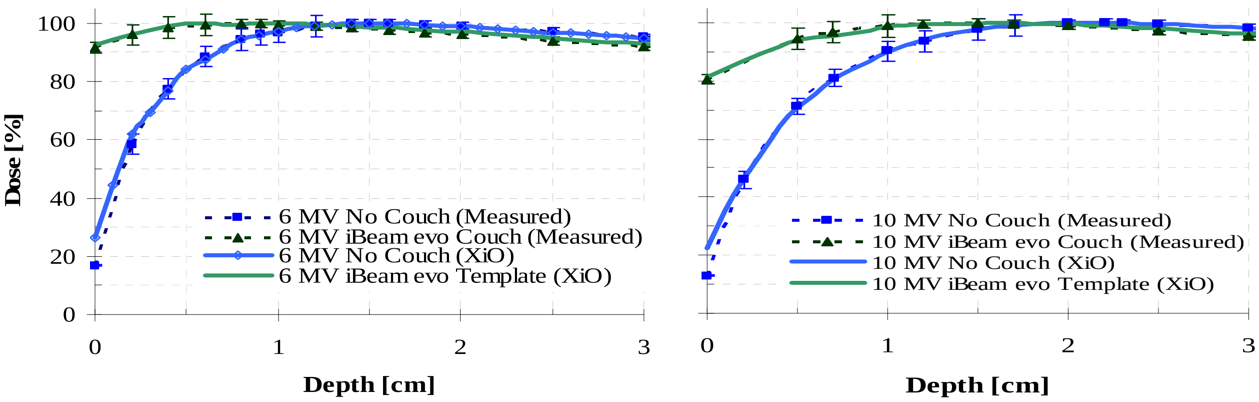

Figure 3(a), (b): 6 MV and 10 MV PDD measured (Gantry angle: 0^o, SSD: 100 cm, Field Size: 10 x 10 cm^2) and calculated in XiO before and after transmission through the iBeam evo couch and iBeam evo couch template.

3.2. Attenuation
When the iBeam evo couch was in the path of the beam the maximum attenuation observed at 12 cm depth occurred at a gantry angle of 130^o for a 5 x 5 cm^2 field size. This attenuation was 5.3% ± 1.0% for 6 MV and 4.2% ± 0.9% for 10 MV. At the same angle and depth but for a 10 x 10 cm^2 field size the attenuation recorded was 4.9% ± 0.9% for 6 MV and 3.8% ± 0.8% for 10 MV. Similar results were measured for the Civco Universal couch. From these results it was possible to conclude that attenuation due to the couch tops increases as field size is decreased, as energy is decreased and at posterior oblique angles.

When modelling the attenuation using the customised couch templates, calculated values through the flat central regions of the couch templates were within 0.5% ± 0.4% of measured values, while calculated values through the larger varying edges of the templates were within 1.4% ± 1.2% of measured values. This was attributed to the rapid change in the structure at the edge of the couches.

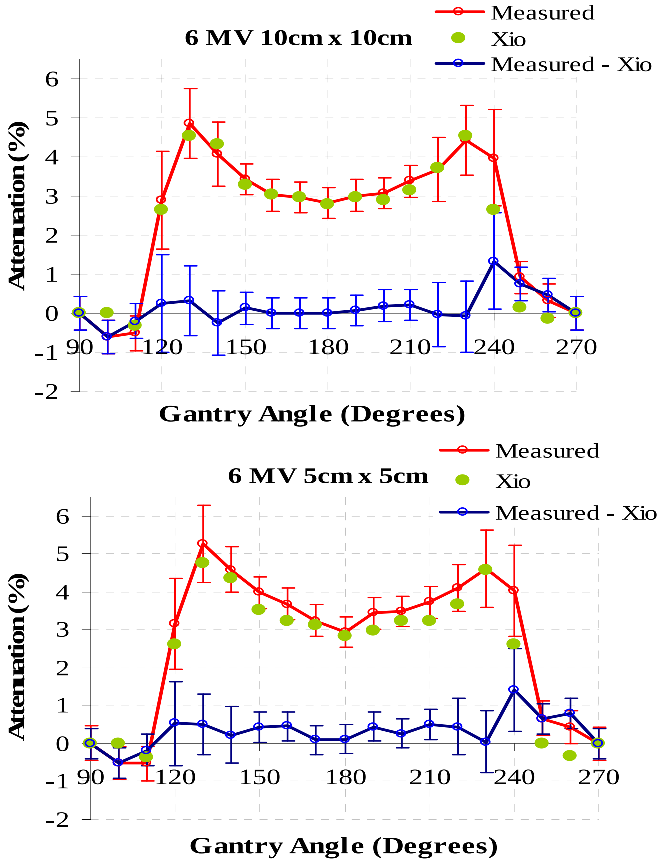

Figure 4: 6 MV and 10 MV attenuation measured in a phantom and calculated in XiO. Also displayed is the difference between measured and calculated attenuation. (Gantry angles: 0^o to 360^o, SAD: 100 cm, Measurement Depth: 12 cm, Field Sizes: 10x10 cm^2 and 5x5 cm^2).

3.3. Validation: IMRT Analysis

Results showed that calculated dose maps differed from those measured when the iBeam evo couch was not accounted for in XiO. Both planned and measured dose maps were compared using the gamma criteria of 3% dose difference and 2 mm distance to agreement (DTA), with a gamma pass rate of 90.0%. When the couch was accounted for in the measurements but not in XiO, the pass rate was 85.5%. However, when the couch was taken into account in XiO, the pass rate was 90.1%. Similar results were obtained for the Civco couch top.

4. Conclusions

This investigation has highlighted the clinically significant effect the iBeam evo and Civco Universal couch tops can have on patient planning. The dosimetric properties of both couches were quantified and a method of accounting for the couches in the XiO treatment planning system was discussed. If the customised couch templates are included in the patient plan, it has been shown that XiO v4.70.02 accurately models the attenuation due to the presence of the couch to within 1.4% ± 1.2%. It has also been shown that using this process XiO modelled the reduction in the skin sparing effect, observed by treating through the couch at 180°, to within 1.0% ± 1.7%. Furthermore, dose map analyses of IMRT plans indicate a further clinical benefit of including the customised couch templates during treatment planning.

References

[1] Smith D, Christophides D, Dean C, Naisbit M, Manson J and Morgan A 2010 Dosimetric characterization of the iBeam evo carbon fiber couch for radiotherapy *Med. Phys.* **37** 3595-3606

[2] Mihaylov I, Corry P, Yan Y, Ratanatharathorn V and Moros E 2008 Modeling of carbon fiber couch attenuation properties with a commercial treatment planning system *Med. Phys.* **35** 4982-88

[3] Simpson J and Godwin G 2011 The effect of the iBeam evo carbon fiber tabletop on skin sparing *Med. Dos.* **36** 330-3

[4] Gerig L, Niedbala M and Nyiri B 2009 Dose perturbations by two carbon fiber treatment couches and the ability of a commercial treatment planning system to predict these effects *Med. Phys.* **37** 322-8

[5] Hope B, Laser B, Kowalski A, Fontenla S, Pena-Greenberg E, Yorke E, Lovelock M, Hunt M and Rosenzweig K 2008 Acute skin toxicity following stereotactic body radiation therapy for stage 1 non-small-cell lung cancer: Who’s at risk? *Int. J. Rad. Onc. Biol. Phys.* **72** 1283-6

[6] Li H, Lee A, Johnson J, Zhu R and Kudchadker R 2011 Characterization of dose impact on IMRT and VMAT from couch attenuation for two Varian couches *J. Appl. Clin. Med. Phys.* **12** 23-31

[7] Mihaylov I, Bzdusek K and Kaus M 2011 Carbon fiber couch effects on skin dose for volumetric modulated arcs *Med. Phys.* **38** 2419-23

[8] Pulliam K, Howell R, Followill D, Luo D, White R and Kry S 2011 The clinical impact of the couch top and rails on IMRT and arc therapy *Phys. Med. Bio.* **56** 7435-47

Acknowledgments

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