REPORTS OF PRACTICAL ONCOLOGY AND RADIOTHERAPY 18 (2013) 209–213

Available online at www.sciencedirect.com

SciVerse ScienceDirect

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

Original research article

Volumetric modulated arc therapy for prostate cancer patients with hip prosthesis

Ramachandran Prabhakar[a,*], *Milind Kumar*[b], *Suja Cheruliyil*[b], *Silpa Jayakumar*[b], *Satheesan Balasubramanian*[b], *Jim Cramb*[a]

[a] *Peter MacCallum Cancer Centre, Victoria, Australia*
[b] *Malabar Cancer Center, Thalaserry, Kerala, India*

A R T I C L E I N F O

Article history:
Received 30 October 2012
Received in revised form
12 February 2013
Accepted 24 March 2013

Keywords:
Prostate cancer
Radiotherapy
Treatment planning
VMAT
Prosthesis

A B S T R A C T

Aim: To study the use of RapidArc techniques in the treatment of prostate cancer patients with hip prosthesis.
Background: An important aspect of treatment planning is to achieve dose homogeneity inside the planning target volume (PTV). Especially for those patients presenting with hip prosthesis, it becomes a challenging task to achieve dose uniformity inside the PTV.
Materials and methods: Five prostate patients presenting with hip prosthesis who had undergone radical radiotherapy were selected for this study. Depending on the composition of prosthesis, a predefined set of Hounsfield values were assigned to each study set. RapidArc plans were generated on an Eclipse treatment planning system. Two arcs that include clockwise and counter-clockwise arcs were used in all these cases. To avoid beams passing through the prosthesis, a simple structure was defined around it with 1 cm margin and a strict dose constraint applied to the block during VMAT optimization.
Results: The mean D2/D98 ratio of PTV for all the patients was 1.06 ± 0.01. The mean percentage rectum volume receiving 50 Gy, 60 Gy, 70 Gy and 75 Gy for all the patients were 33.1 ± 5.9, 21.7 ± 5.5, 13.8 ± 4.4 and 9.5 ± 3.0, respectively.
Conclusions: This study shows that using a double arc RapidArc technique is a simple and effective treatment method of treating prostate cancer in patients presenting with a hip prosthesis. The definition of a beam avoidance structure encompassing the prosthesis and applying strict dose constraints to it reduces the beam contribution to the prosthesis

1. Background

High dose radiotherapy has been shown to be an effective treatment modality for prostate cancers.[1–3] An important aspect of treatment planning is to achieve uniform dose inside the planning target volume with reduced dose to the surrounding critical structures. Hip replacement is a surgical procedure in which the hip joint is replaced by a prosthetic implant. Prostheses are usually made of high density material

* *Corresponding author at*: Physical Sciences, Peter MacCallum Cancer Centre, Victoria, Australia. Tel.: +61 03 5454 9234; fax: +61 03 5454 9289.
E-mail addresses: Ramachandran.Prabhakar@petermac.org, prabhakar_smr@hotmail.com (R. Prabhakar).
1507-1367/$ – see front matter
http://dx.doi.org/10.1016/j.rpor.2013.03.006

such as titanium, steel, etc. High density material poses significant problem to the incident or exiting beam. These materials not only attenuate the treatment beam but also scatter the dose which may lead to dosimetric uncertainty at the soft tissue interfaces. Hence, it becomes a challenging task to achieve dose uniformity inside the PTV for these patients who undergo radiotherapy. Besides, for those patients with unknown prosthetic material, the chances of dosimetric uncertainty are imminent. Even if the electron density of the prosthesis is known, most dose calculation algorithms have been designed and tested only for lower densities, and do not accurately model the absorption and scattering properties of metals. The Treatment Planning System (TPS) is likely to overestimate dose, particularly if the prosthesis is solid and made of stainless steel or cobalt-chromium. However, several dose calculation algorithms [4–7] have been developed over the period of time that predict dose closer to Monte Carlo computed dose for high density material. Another problem with computed tomography (CT) scan images is the presence of artifacts on images caused by prosthesis due to attenuation of X-ray beam. Hence, it has become a standard practice to avoid beams passing through these prosthetic materials.[8] In the midst of the above factors, there is a need to assess the dosimetry for patients presenting with hip prosthesis with advanced treatment techniques, such as volumetric modulated radiotherapy (VMAT). Hence, in this study, an effort has been made to demonstrate the use of volumetric modulated arc therapy for prostate patients presenting with hip prosthesis.

2. Aim

To study the use of RapidArc technique in the treatment of prostate cancer patients with hip prosthesis.

3. Materials and methods

Five prostate patients who had undergone radical radiotherapy were selected for this study. Of the five patients, four had unilateral hip prosthesis and one patient presented with bilateral hip prosthesis. All patients underwent CT scanning on Philips Brilliance CT scanner and the Dicom CT datasets were transferred to Eclipse treatment planning system (Varian Medical System, USA) for contouring. The regions of dark and bright streaking artifacts replacing the soft tissues present in the CT images due the effect of kilovoltage beams on the prosthesis were contoured and Hounsfield unit (HU) value of 0 was assigned. Depending on the type of prosthesis, the following Hounsfield values were used during planning: Bone: 800 HU; Titanium: 4500 HU; Co–Cr–Mo or stainless steel: 9500, respectively. To those prosthesis whose composition is unknown, 7000 HU was assigned. The PTV was generated from clinical target volume (CTV) on assigning a uniform margin of 1 cm in all directions except for 0.7 cm along the posterior direction. RapidArc plans were generated on Eclipse treatment planning system. Two arcs that include clockwise and counter clockwise arcs were used in all these cases. To avoid beams passing through prostheses, a simple structure known as beam avoidance structure was generated around the prosthesis with a 1 cm margin and a strict dose constraint (0% of the volume receives over 500 cGy) was applied to the block during volumetric modulated radiation therapy (VMAT) optimization to avoid dose to the prosthesis. A dose of 78 Gy was prescribed to all the patients with 95% of prescription dose covering 99% of the target volume. Collimator was rotated to 30° for the clockwise and 330° for the counter-clockwise arc. All RapidArc plans were generated with photon beam energy of 6 MV from a 21iX linear accelerator (Varian Medical Systems, Palo, Alto, CA) using Analytical Anisotropic Algorithm (AAA) dose calculation algorithm.

Table 1 – Dosimetric parameters for unilateral and bilateral hip prostate patients.

	A Bilateral	B Rt. Lateral	C Rt. Lateral	D Lt. Lateral	E Lt. Lateral
PTV					
Max. dose (%)	105.8	108.2	111.9	111.7	109.2
D2 (cGy)	8010.0	7910.0	7987.0	7951.0	7971.0
D98 (cGy)	7496.0	7549.8	7502.0	7517.0	7543.0
Bladder					
Max. dose (%)	105.8	105.6	107.6	105.5	104.3
V70 (%)	20.0	7.3	28.0	8.7	5.2
V50 (%)	31.1	14.3	49.7	13.8	13.1
Rectum					
V50 (%)	32.8	32.9	42.6	30.8	26.5
V60 (%)	21.4	24.1	29.3	19.3	14.6
V70 (%)	13.6	16.1	19.4	12.1	7.6
V75 (%)	9.4	11.7	12.8	8.5	5.1
Rt. femur					
Mean dose (cGy)	384.1	606.0	526.5	481.6	921.7
Max. dose (cGy)	2757.0	1333.0	3690.0	3472.0	1995.0
V10 (%)	16.1	0.0	4.6	5.8	46.0
Lt. femur					
Mean dose (cGy)	500.8	979.0	965.9	522.5	483.0
Max. dose (cGy)	1742.6	3254.0	3104.0	1932.0	973.0
V10 (%)	2.8	0.5	40.3	5.8	0.0