Evaluation of Hitachi 3D Treatment Planning version 1.6

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ABSTRACT

WERC (Wakasa Wan Energy Research Center) has started the proton cancer therapy since June 2002. We use Hitachi 3D treatment planning (version 1.6) that can calculate the proton dose distribution by use of the pencil beam algorithm as well as the broad beam algorithm practically fast. This treatment planning software satisfies almost functions required in the proton therapy and includes some advanced techniques such as the 3D region glowing function that can search the target region three-dimensionally based on the CT-values. In this paper, we will introduce this planning system and present our evaluation from point of view of both clinical usage and QA.

Keywords: Proton cancer therapy, treatment planning system

1 PROTON THERAPY AT WERC

The WERC accelerator complex named as W-MAST (Wakasa Multipurpose Accelerator with Synchrotron and Tandem) consists of two negative ion sources, a 5 MV tandem accelerator, a 200 MeV synchrotron, low energy transport beam lines and high-energy ones. This accelerator system has been used for the multipurpose research as physical science, engineering, biotechnology, and medical science since 2000. Since June 2002 the proton cancer therapy has been performed as the medical application of accelerators that is one of the important fields to be intensively researched. One vertical beam line and one horizontal beam line for the proton cancer therapy were installed in the high-energy irradiation room and the X-ray computed tomography system was installed close by the irradiation systems. This X-ray CT can be used for the patient positioning. The medical information system is composed of the treatment planning system, treatment manage system, and the medical image system that comprises the image server, image viewers, and image input-output devices. In this paper, we focus on the treatment planning system and introduce the adopted system, Hitachi 3D treatment planning version 1.6 (H3DTP).

2 TREATMENT PLANNING SYSTEM

The H3DTP has been developed originally as the proton planning system unlike other proton planning systems on which the proton dose calculation is implemented as an enhanced function of the usual X-ray planning system. The operating environment for the H3DTP is a common PC with two Intel Pentium III Xeon 1 GHz CPUs and 1 GB memory, and requires the open operating system, LINUX (Red Hat 6.2) and Open Motif. The H3DTP itself is not open source but commercial. The basic operation of this software consists of five phases; a data input phase, a contour input phase, a planning phase, an analysis phase, and an output phase. In the data input phase, users can search and load planning and patient data from DICOM servers or local disks, and show and select slice images of the patient data. In the contour input phase, users can extract region by use of a mouse device like usual drawing software. Users can also extract 3D region automatically by the region growing function. This function surveys voxel adjacent to the selected point by users, and extends the region if the CT value is same within the indicated value. Extracted regions can be registered as a CTV, a body contour, or interested cites. MRI images can be loaded as reference images and adjusted to the corresponding CT images by use of the simple affine transformation. ROIs indicated on the MRI images can be copied to the CT images, and ROIs on the CT images can also be copied to the MRI images. In the planning phase, firstly users select the number of irradiation fields and the direction of each field and indicate the margin size of the target and the smear size of the patient bolus. The PTV is produced automatically in the way the mergin is added to the CTV. The planning system optimize the apparatus parameters such as the incident beam energy, the fine-degrader thickness, the block-collimator width and the patient-compensator and collimator shapes, and calculates the dose distribution by use of the pencil beam algorithm or the broad beam one. After the apparatus optimization, the planning system calculates the dose distribution by use of the pencil beam algorithm or the broad beam algorithm in which users can choose the mesh size of 1 mm or 2 mm. In the analysis phase, users can show the calculated dose distribution and that of the referenced planning result, and make the line profile and DVH analysis for the CTV, the PTV, and the interested cites. The dose distributions in water can be calculated and compared with the measured data for QA. In the output phase, the system shows the CT slices and DRR images overlapped with the target, isocenter and dose distributions. After users approve the treatment planning, the planning data is transferred to the DICOM server and the treatment manage system.

3 EVALUATION

We have started the clinical trial based on the pharmaceutical law in order to confirm the safety of the treatment system including accelerators since June 2002. The treatment for two patients with prostate cancer has been finished. Through performing the treatment planning for these two patients, we evaluated the H3DTP through the clinical usage and QA. The H3DTP can add the margin indicated by users to the CTV automatically and create the PTV. However, because the margin volume is added to the CTV not isocentrically but cubically, the PTV is formed like a rectangular solid losing the original shape. And the PTV with margin is not allowed to be modified by manual operation in the H3DTP. In practice, we avoided this problem by registering the PTV as the target in the input phase and not using the margin function. This made the distinction of the CTV and PTV in the H3DTP meaningless. The modification for this problem is in progress by the maker. When the H3DTP switches to the planning phase from the contour input phase, it constructs the CT volume data from the CT images. It took about 5 minutes for the 65 CT images and this construction was performed whenever users made some change in contour input and shifted to the planning phase, which gave no small stress to users. The computation time for the dose distribution is practically fast. It took about 1 minute per one irradiation field to calculate the dose distributions of the target volume of 70 cc with the pencil beam algorithm. In the analysis phase, owing to the above-mentioned margin function problem, we could not analyze and evaluate efficiently the calculated dose distributions. As a result, we confirmed the PTV was covered with necessary dose by comparing the planning results for the different target inputs. The calculated dose distribution in water was in good agreement with measured distribution without edge scattering effect of the collimator that the pencil beam algorithm usually could not handle.

4 CONCLUSION

This planning system, H3DTP, was evaluated through the clinical trial, which is limited to the prostate cancer case. Though the almost functions required in the proton therapy was implemented on the H3DTP, these functions are not necessarily sophisticated. However, because it can calculate the dose distributions with the pencil beam algorithm practically fast and reliably, the practical employment may satisfy the clinical usage, if the above-mentioned problem was solved. The planning system and implemented software are not subjects of the clinical trial based on the pharmaceutical law in Japan. However, the planning system is crucial to the proton therapy and the advanced X-ray therapy such as IMRT, because they require the more precious and complex dose distribution calculation than those of the conventional therapy and it is not easy to perform the online or real-time QA for the dose distribution and system itself. Therefore, it is necessary that the standard guideline of QA for the planning system be established.