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A Study on Proton IMRT

Kiyoshi Yoda and Yukimasa Aoki [1)]

Mitsubishi Electric Corp., Adv. Tech. R&D Center; [1)]Univ. of Tokyo, Dept. of Radiology

INTRODUCTION

Intensity modulated radiation therapy (IMRT) has been studied mainly for photon conformal treatment to deliver high and uniform dose to an irregularly shaped concave tumor while sparing nearby organs at risk. Recently it has been reported that multi-portal mono-energetic proton beams can be used to deliver a sufficiently uniform dose onto a target. The present paper deals with this type of proton IMRT called distal edge tracking. A model calculation is shown and a practical proton IMRT method is suggested.

METHOD

Figure 1 shows a 2D verification model for the distal edge tracking proton IMRT. A concave target is located at the center of a circular water phantom having a diameter of 30cm. The target size is also shown in Fig. 1. Intensity modulated proton beams (beamlets) irradiate the target from eight equally spaced angles, where the Bragg peak of each beamlet is always matched to the distal edge of the target.

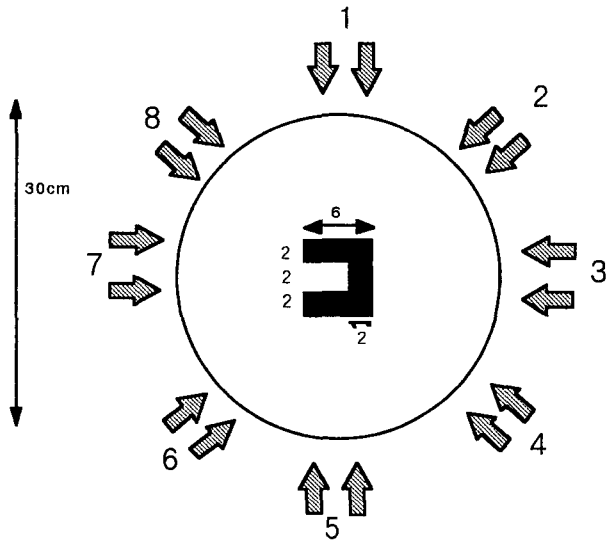
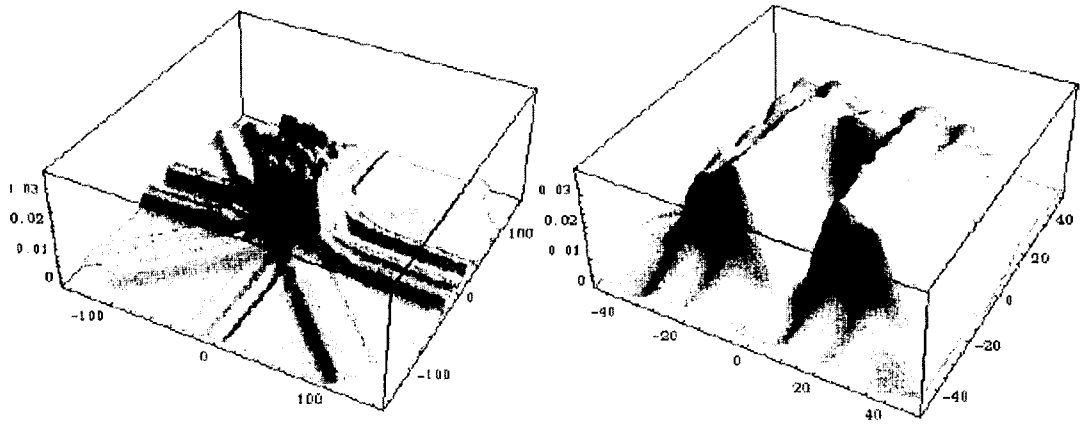


Figure 1 Proton IMRT model

RESULTS

Figures 2 (a) and (b) show resulting dose distributions for the entire phantom as well as the central target region, indicating that the mono-energetic proton IMRT provides a sufficiently uniform dose distribution inside the concave target while delivering very low dose adjacent to the target.



(a) (b)

Figure 2 Calculated dose distributions resulting from the distal edge tracking in (a) the entire phantom region and (b) the central region

DISCUSSION

The distal edge tracking has several advantages and disadvantages. Major advantages are faster treatment time and less sensitivity to organ movements because no energy modulation to the depth direction is required. Meanwhile, a disadvantage is that the dose uniformity is worse than techniques using energy modulation to the depth direction; however, the resulting dose uniformity from the distal edge tracking is still comparable to that given by photon IMRT at least for smaller targets less than a few centimeters.

There are several possible implementation methods to realize the distal edge tracking for proton IMRT: (1) beam scanning, (2) Tomotherapy-like simultaneous irradiation, and (3) multileaf collimator (MLC) based approach employed for photon IMRT. Among these three techniques, the MLC-based approach can be performed using conventional proton radiation treatment ports, thereby providing the easiest option for the first-stage proton IMRT trial.

CONCLUSION

Proton IMRT has been studied and a model calculation for distal edge tracking was performed, suggesting that the proton IMRT without energy modulation to the depth direction is promising for a concave target using multi-portal beams.