Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 22, 2009

Beam Design Evaluation for Dose Homogeneity Improvement in Extremity Radiation Therapy

Jeong Min Seo [a b *], Chan Hyeong Kim [a] , Yeong Hwan Park [b]
[a] *Department of Nuclear Engineering, Hanyang University, Seoul, Korea*
[b] *Department of Radiation Oncology, Samsung Medical Center, Sungkyunkwan University School of Medicine, Korea*
**Corresponding Author: jmjm.seo@samsung.com*

1. Introduction

The objective of isodose planning in radiation therapy is to optimize the irradiation technique and provide the best possible dose distribution.

Ideally, radiotherapy units should be able to deliver the necessary dose to the tumor volume and spare all the other normal tissues. Because of particular beam characteristics and limitations of the radiotherapy equipments, however, a certain amount of normal tissue irradiation is usually unavoidable.

The sarcomas, which are one type of soft-tissue tumors, arise in the extra-skeletal tissue, especially in extremities. Because the cross section of an extremity is close to a circle, it is not easy to make a homogeneous isodose distribution. The lateral and median edges of the extremity, therefore, tend to receive higher doses than prescription, resulting in possible complications.

The peripheral lymphatics appear to tolerate 50 Gy in conventional fractionation[1]. Doses in excess of this value have resulted in significant edema. The reported complications include fracture, fibrosis, edema, and delayed wound healing. Although routine irradiation of the entire longitudinal extent of a compartment is not necessary, the entire transverse cross-section of a compartment is at risk for tumor involvement [2].

In the present study, the designs for simple beams in radiation therapy were investigated and compared each other in order to reduce the dose inhomogeneity and spare the circumferential tissues.

2. Methods and Results

2.1 CT-simulation

CT simulation has been performed and acquired for the lower extremity of a patient to plan the design of the MV X-ray beams. The site for radiation therapy was the right thigh. The customized foam repositioning cradle was used as immobilizing device for fixing the position of the patient.

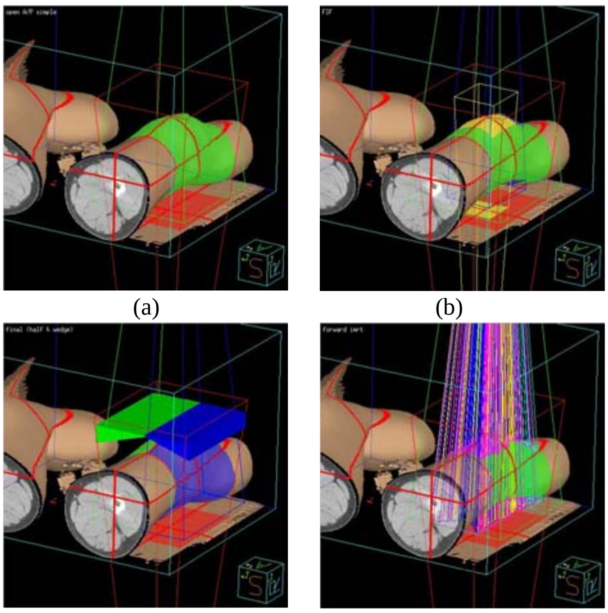
2.2 Planning Beam Design

Four different techniques of beam design were planned for the improvement of dose homogeneity with RTP (Pinnacle, Philips, US). All of the beams for evaluation were set along the anterior-posterior and posterior-anterior directions and the prescribed doses were given to the same isocenter of the target.

(a) (b) (c)

Fig. 1. (a) CT simulator (High Speed Advantage) (b) RTP system (Pinnacle 6.0, Philips, U.S.A) (c) Treatment position for the lower extremity

The beams were designed using (a) open technique (two opened opposing beams), (b) field-in-field technique (two posterior and two anterior field in field beams), (c) half-and-wedge technique (two anterior half beams with wedge filters and one posterior beam), and (d) forward IMRT technique (one posterior beam and ten anterior intensity modulated beams) (see Fig. 2.).



(a) (b) (c) (d)

Fig. 2. Four beam techniques used in the present study: (a) open technique, (b) field-in-field technique, (c) half-and-wedge technique, and (d) forward IMRT technique

2.3 Efficiencies of Beam Designs

To evaluate the efficiency of each technique, the times for planning and treatment were compared (see Table. 1.).

The dose volume histograms (DVHs), which were used for evaluating the plans, are presented in Fig. 3. The dose volume of the normal soft tissue at the edge of the thigh were significantly different for different techniques.

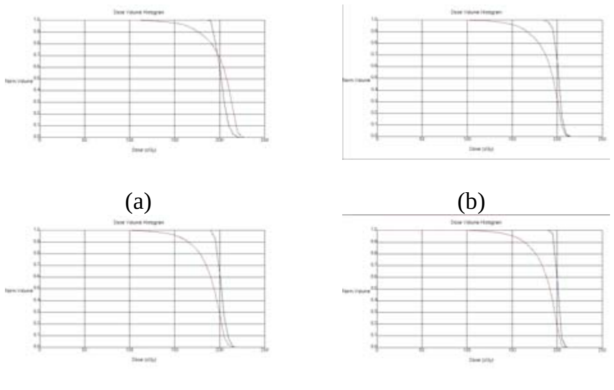
In the established reference by the open technique, the differential rate in V_{100} (100% covered dose volume) of normal soft tissue showed about 52% in the field-in-field technique, 58% in the half-and-wedge technique, 74% in the forward IMRT technique lower than the open beam technique. In case of the clinical target volume (CTV), the differential rate in V_{100} showed about 9% in the field-in-field technique, 6% in the half-and-wedge technique higher than the open beam technique, and 2% lower in the forward IMRT technique.

Table. 1. Planning and Treatment Times

	Open beam	Field in Field	Half & Wedge	Forward-IMRT
Planning time	15min	30min	35min	40min
Treatment time	190sec	300sec	300sec	360sec

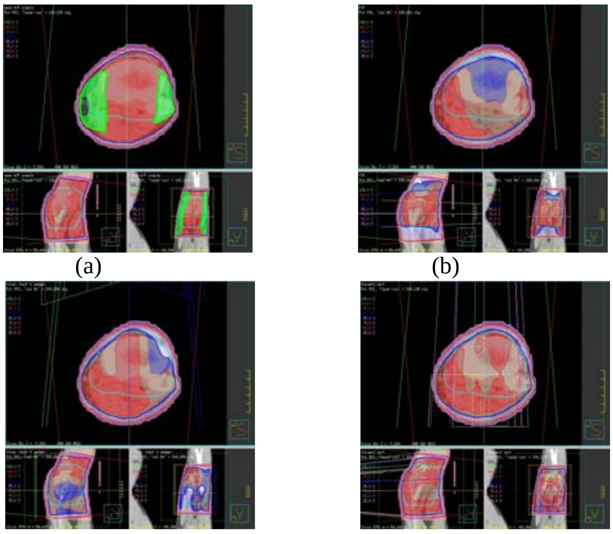
Table. 2. Dose Covered Volume of Clinical Target Volume and Normal Soft Tissue in Each Technique.

% volume		V_{95}	V_{100}	V_{105}	V_{110}
CTV	Open Beam	99.61	59.43	10.64	0.18
	Field in Field	98.07	64.75	1.91	0.00
	Half & Wedge	99.92	62.90	7.25	0.00
	Forward IMRT	99.92	58.36	0.23	0.00
Soft tissue	Open Beam	80.64	67.84	43.18	4.33
	Field in Field	64.43	32.07	0.77	0.00
	Half & Wedge	59.92	28.36	1.92	0.00
	Forward IMRT	55.76	17.31	0.00	0.00



(a) (b) (c) (d)

Fig. 3. Dose volume histograms for different techniques: (a) open technique, (b) field in field technique, (c) half and wedge technique, and (d) forward IMRT technique. The blue line is for CTV and the red line is for normal soft tissue.



(a) (b) (c) (d)

Fig. 4. Dose distribution at the central slice: (a) open technique, (b) field-in-field technique, (c) half-and-wedge technique, and (d) forward IMRT technique

3. Conclusions

In the present study, to minimize the risk of complications in the extremities, the suitable beam designs for the extremity sarcoma patients were found among the available ones.

Although the opposing open-field technique is very simple and convenient to use, the risk factor of complications can lead to a significant problem to the normal tissues of the patients.

The other techniques designed in the present study can reduce the dose inhomogeneity and enhance the dose distribution characteristics in the circumferential normal tissue of the extremities.

REFERENCES

[1] Jovanovic D. The influencd of radiation on blook vessels and circulation. Curr Top Radiat Res Q 1974; 10:85-97

[2] Tepper J, el al. Radiation therapy techniques in soft tissue sarcomas of the extremity:policies for treatment at the National Cancer Institute. Int J Radiat Oncol Biol Phys 1982;8:263-273

[3] Faiz M. Khan, Treatment Planning in Radiation Oncology , Williams & Wilkins