The Treatment of Large Extraskeletal Chondrosarcoma of the Leg: Comparison of IMRT and Conformal Radiotherapy Techniques

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Abstract — Extraskeletal Chondrosarcoma of the leg is a rare, malignant neoplasm with very few cases having been reported in the literature. A case is presented that illustrates the treatment of this malignancy, compares IMRT and conformal radiotherapy techniques, discusses treatment options of the two techniques and their planning time, and assesses the efficacy of using IMRT in other clinical applications. The advantages of IMRT for this difficult clinical application are demonstrated.

Key words — Chondrosarcoma, IMRT, radiotherapy

BACKGROUND

The majority of high grade soft tissue sarcomas surgically excised from the extremity require adjuvant radiation therapy as a component of their local management. High dose radiation, 6600 cGy, is the standard dose to the tumor bed in the setting of excision with negative margins. In the case of excision with microscopically positive margins, a dose of 7000 cGy is required. The radiation field is initially designed to extend 5-7 cm proximally and distally to the original tumor volume within the compartment of resection. This field is typically prescribed to a dose of 5000 cGy.

It is not unusual to have a tumor, which measures 30 cm in length or more, in the proximal thigh, and therefore treatment fields are accordingly very long in these cases. It is technically challenging to treat such a volume homogeneously, while sparing at least one-third of the circumference of the limb and half of the cortex of the adjacent bone. Complications of radiation therapy for extremity sarcomas include fibrosis, chronic edema, decreased range of motion and increased risk of fracture. In extreme cases, amputation has been required due to profound fibrosis and severe normal tissue complications.

Excellent extremity immobilization is the first step in planning such a challenging treatment. Previously, no treatment plan could be designed or executed that could surmount the variations in lesion shape after complete surgical excision. In particular, postoperative radiation therapy could not easily conform to tissue contour in a typical limb through a field over 30 cm in length. Neither could the muscle compartment be perfectly followed as it curves around the adjacent bone. These challenges can now be met by utilizing an IMRT approach to treatment planning and delivery.

METHODS AND MATERIALS

A case is presented of a patient with Chondrosarcoma of the lateral compartment of the leg in which the target volume is 50 cm in length and twisted around surrounding bones. The patient was positioned with the leg aligned along the horizontal axis of the linear accelerator isocenter, and the patient was immobilized using a thermal plastic mold. After CT scanning, the physician outlined the target volume and prescribed the center region as a boost volume to receive a higher dose to 66.6 Gy while the rest of the target volume was to receive 59.4 Gy at a minimum, as shown in Figure 1.

The 3D conformal therapy and IMRT planning system developed at the Memorial Sloan-Kettering Cancer Center was used. The 3D conformal plan was designed with 18 MV photons using three isocenters with two opposed wedged pairs at each isocenter. The three isocenters were used to cover the entire length and provide better control of homogeneity and partial weighting. All field borders were matched at the plane of the isocenters and were shifted by 1 cm every other day in order to avoid any hot or cold spots near the field borders as shown in Figure 2.
The IMRT plan was designed with the same energy but with only one single isocenter at an extended source-to-skin distance. There were five fields with equally spaced gantry angles (from IEC standard 320 to 180 degree anticlockwise); Gantry angles were chosen to avoid irradiation of the contralateral leg. The intensity distributions were optimized thereby the inverse planning procedure by giving the prescribed dose to the three regions of tumor, including higher dose to the boost volume, and also specifying a maximum dose constraint to the bone.

RESULTS

Both plans met physician-specified clinical criteria, such as target dose and bone sparing. The IMRT plan delivered a superior dose distribution to the patient as compared to the 3D conformal plan in terms of both conformity and homogeneity (see Figure 3). There were reductions in maximum dose to the bone in the IMRT plan, as evidenced by the dose-volume-histograms (see Figure 4). The use of IMRT technique in conjunction with the positioning device permitted the delivery of 66.6 Gy to the target with relatively low dose to the bone; 17 Gy to 50% of the bone surfaces. All IMRT fields were determined automatically by the inverse planning system. The IMRT plan also reduces hot and cold spots within the target volume, thereby eliminating the need for field abutments and feathering of the field junctions. The planning time of the 3D conformal plan was about 3-5 times longer than that of the IMRT plan. It was due to the use of wedges and manually adjusting the weightings of each field for the conventional 3D conformal plan.

CONCLUSIONS

This example demonstrates that the IMRT technique can be used not just for small tumors, but also for large and spiral-shaped tumors close to critical organs. The IMRT method is time saving, and provides better target coverage with considerable sparing of critical structures. In addition, when planning patients with multiple target volumes receiving different prescribed doses, the IMRT technique can more easily meet this requirement. This work demonstrates a useful application of IMRT for a superior treatment for patients with a large Chondrosarcoma of the leg.