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Physics Contribution

Peripheral Dose Heterogeneity Due to the Thread Effect in Total Marrow Irradiation With Helical Tomotherapy

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Summary

We investigated the dose heterogeneity at different skeletal sites in total marrow irradiation with helical tomotherapy. We found that the unique characteristics of the helical beam junctioning effect, referred as to the thread effect, significantly affected dose homogeneity in the extremities, particularly for large patients. Use of a favorable pitch value and adjustment of arm position could minimize the thread effect and reduce dose heterogeneity.

Purpose: To report potential dose heterogeneity leading to underdosing at different skeletal sites in total marrow irradiation (TMI) with helical tomotherapy due to the thread effect and provide possible solutions to reduce this effect.

Methods and Materials: Nine cases were divided into 2 groups based on patient size, defined as maximum left-to-right arm distance (mLRD): small mLRD ($\leq$47 cm) and large mLRD (>47 cm). TMI treatment planning was conducted by varying the pitch and modulation factor while a jaw size (5 cm) was kept fixed. Ripple amplitude, defined as the peak-to-trough dose relative to the average dose due to the thread effect, and the dose–volume histogram (DVH) parameters for 9 cases with various mLRD was analyzed in different skeletal regions at off-axis (eg, bones of the arm or femur), at the central axis (eg, vertebrae), and planning target volume (PTV), defined as the entire skeleton plus 1-cm margin.

Results: Average ripple amplitude for a pitch of 0.430, known as one of the magic pitches that reduce thread effect, was 9.2% at 20 cm off-axis. No significant differences in DVH parameters of PTV, vertebrae, or femur were observed between small and large mLRD groups for a pitch of $\leq$0.287. Conversely, in the bones of the arm, average differences in the volume receiving 95% and 107% dose (V95 and V107, respectively) between large and small mLRD groups were 4.2% (P = .016) and 16% (P = .016), respectively. Strong correlations were found between mLRD and ripple amplitude (rs = .965), mLRD and V95 (rs = –.742), and mLRD and V107 (rs = .870) of bones of the arm.

Conclusions: Thread effect significantly influences DVH parameters in the bones of the arm for large mLRD patients. By implementing a favorable pitch value and adjusting arm position, peripheral dose heterogeneity could be reduced.

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