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Abstract

Radiosurgical Spinal Cord Volume Effects

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Objectives: The Emami paper used the same volumes for organs throughout the body in conventional fractionation: one-third, two-thirds, and whole organ; and these were refined by QUANTEC. For radiosurgery it is known that a small volume of even serial structures like spinal cord can tolerate high dose per fraction, but exact limits remain unknown. To begin to estimate dose and volume tolerance more accurately, this study examines uncertainty of Monte Carlo dose calculations of small volumes of spinal cord.

Methods: Radiosurgical spinal cases for the CyberKnife (Accuray Inc, Sunnyvale, CA) at Johns Hopkins University are planned with Monte Carlo and 2% uncertainty objective. The seven most recent cases were selected to examine accuracy of the spinal cord maximum point dose calculation in comparison to other volumes, in five fractions. Each of the plans was recalculated 5 times using Monte Carlo with 2% uncertainty objective, and the Dose Volume Histogram (DVH) of all versions were compared. Dx was defined as the dose corresponding to volume x in the spinal cord DVH.

Results: Average normalized standard deviation of Dmax was twice as high as for D0.03cc, four times higher than D0.1cc, and five times higher than D1cc. The standard deviation of all volumes examined were less than the 2% uncertainty objective, but for larger volumes the uncertainty was relatively lower. Among spinal cord contours in 130 recent spine tumor cases, the average ratio of D0.03cc/Dmax was 93%. In this study, using a small reference volume like 0.03cc had half of the dose calculation uncertainty as Dmax. For D0.03cc dose tolerance limits, the current spinal cord Dmax limits could be scaled by a factor of 0.93 to achieve a similar expected low-toxicity outcome.

Conclusions: Maximum point dose has been the most convenient "suitably small volume" for radiosurgery. However, in this study Dmax had the highest uncertainty. This study did not consider actual human dose tolerance, for which statistical dose response models have been published, but it provides insight regarding which dosimetric objectives may be most reliable, to help determine true tolerance in future studies.

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