

Consistent Biological Effective Dose Realization in Stereotactic Radiosurgery Treatments

Purpose: Intracranial radiosurgery commonly employs many isocenters or beams to deliver dose distributions over an extended treatment time (30-100 minutes or more). In this study, we investigate whether the sequential order of delivering these isocenters or beams would significantly influence the biological effectiveness of the treatment and how to optimize a delivery sequence based on such considerations.

Method and Materials: A group of patient cases treated with Gamma Knife Perfexion at our institution were analyzed. All permutation possibilities of the delivery sequence were reconstructed for each patient. For each possibility, the time-sequence of 3D dose accumulation within the target and the surrounding normal structures was computed. Then the equivalent uniform dose (EUD) based on a generalized linear-quadratic model formula was calculated for each possible delivery sequence. Variations in the EUD values from all combinations were calculated. Dependence of EUD values for the alpha-beta ratios ranging from 2 to 20 was also investigated for each case in order to determine its effect on the results.

Results: The maximum EUD and minimum EUD values varied approximately 10-15%, or 1-2 Gy for different order of delivery sequences depending on the target size and the target peripheral dose. The effect was found to be dependent on the total number of isocenters and dose interference among them. Furthermore, discrepancy in the EUD values was found to increase with decreasing alpha-beta values, suggesting the effect being most relevant for treating lesions such as large AVM, where alpha-beta ratio is supposedly low and a high number of isocenters are typically used.

Conclusion: Optimizing sequential order of beam delivery based on biological considerations is important in minimizing treatment-related EUD variations and ensuring consistency in treatment dosimetry.