

Purpose: To develop a simple software tool to help determine whether a fiducial placement meets the Spacing and Collinearity criteria for CyberKnife 6D target tracking.

Methods: An Excel spreadsheet has been developed for this purpose. The spreadsheet calculates distances and angles for all possible combinations of fiducial triplets based on the fiducial coordinates entered. In general, a group of 4 fiducials forms 4 triplets; a group of 6 fiducials forms 20 triplets. Distance between any two points in 3D space can be calculated easily. Angles formed by lines joining a fiducial triplet are calculated by using the law of cosines. Calculations using scalar product of vectors method are also implemented and used as a redundancy check. Fiducial placement and CyberKnife treatment data from 78 prostate patients were analyzed.

Results: The spreadsheet checks each fiducial triplet against the Spacing & Collinearity Thresholds. Distances or angles failed to meet the thresholds are flagged. If none of the fiducial triplets meet the criteria, extra fiducials need to be implanted. Of the 78 patients studied, most patients were implanted with 4 fiducials; seven patients had 3, and twenty patients had 6 fiducials. A total of the 345 fiducials and 600+ triplets were analyzed. The study showed that 72% of the fiducial distances exceeded the 20-mm Spacing Threshold, and 99% of the fiducial angles exceeded the 15-degree Collinearity Threshold.

Conclusions: We have developed an Excel spreadsheet to verify that a fiducial placement meets the Cyberknife 6D tracking criteria before patient treatment. Analyzing past patient data helps provide guidance on how fiducial placement may be improved. It is important that at least one of the fiducial triplets exceed both Spacing and Collinearity Thresholds, as the study has found that there were cases where a fiducial triplet met the Spacing criteria but failed Collinearity criteria, and vice versa.