Evaluation of prostate volume and shape change after permanent prostate brachytherapy using implanted seed displacement analysis

Prostate volume and shape change both during and after permanent prostate brachytherapy, mainly due to edema. Many studies have investigated how prostate volume changes from day 1 to day 30 or later. There is no available information on how prostate volume changes from implantation completion to day 1 post-implant imaging. To determine implantation quality at end of procedure using intraoperative dynamic dosimetry techniques, the knowledge of potential prostate volume and shape changes from end of implantation to post-implant imaging time would be valuable. However, ultrasound image quality suffers from seed-created artifacts at end of implantation, and soft tissue contrast is limited in post-implant CT images. We believe using implant seed cloud as surrogate of prostate volume can provide more accurate, quantitative analysis of prostate volume and shape changes. This is particularly true if most of seeds are implanted peripherally within the prostate, as the positive correlation in Fig.1 demonstrates.

In this study, several non-isocentric fluoroscopy images were taken intraoperatively at end of implantation. Seed locations were reconstructed using similar algorithm in ref 1 with uncertainty less than 0.5 mm. The day one CT seed locations were identified by an experienced medical physicist. The seed cloud volume was calculated as its convex hull, which is the minimum convex polyhedron that contains all the seed points. Iterative closest point (ICP) algorithm was used to compute the rigid transformation needed to minimize the distance between two point clouds. In each x, y, z dimension, the surface seeds are split into upper and lower groups from the center. The seeds above the 80% quantile (i.e., 80% of the seeds coordinates in that dimension are below this level) of the upper group or below the 20% quantile of the lower group are the boundary seeds in each dimension, which can be used to characterize the prostate deformation as shown Fig.2.

This novel method to use implanted seeds as prostate surrogate may be valuable for assessing prostate volume and shape changes whenever seeds can be reconstructed by fluoroscopy, CT or cone beam CT.