Concurrent optimization of seed loading and minimization of needle number in prostate implant by simulated annealing

Trauma to the prostate from multiple needle insertions in interstitial brachytherapy results in considerable swelling of the gland for up to two weeks. It may also contribute to side effects e.g., urethral constriction. Such change in target volume introduces significant uncertainties in dose coverage. Simulated annealing has been implemented here to obtain a plan delivering the prescribed dose to the prostate, while minimizing needle number. The objective function includes five additive components with weight factors that can be adjusted based on specific clinical needs. One component represents the deviation between prescribed and calculated dose at the prostate periphery. Another component is proportional to the current number of needles. A third component reflects the degree of dose uniformity within the prostate. Two additional terms are included in the objective function which impose a penalty if the calculated dose to the rectum or urethra exceed tolerance. An annealing scheme and weights were determined by extensive numerical experimentation. Temperature is defined as 0.999^{k} , where k is the iteration number. Starting with a random seed loading, the program randomly turns seeds on or off . Search terminates if 200 consecutive iterations do not decrease the objective function. This happens after about 5000 tries. Running time is about 20 seconds with an HP PII/300 computer. Comparison is made with a dosimetrist's manual plan in

terms of coverage, uniformity, number of needles and dose to critical structures.