Prioritized optimization in intensity modulated proton therapy.

In this work a prioritized optimization algorithm is adapted and applied to treatment planning for intensity modulated proton therapy (IMPT). Originally, this algorithm was developed for intensity modulated radiation therapy (IMRT) with photons. Prioritized optimization converts the clinical hierarchy of treatment goals into an effective optimization scheme for treatment planning. It presents an alternative to conventional methods that combine all optimization goals into a single optimization run with a weighted sum of all planning aims in the objective function. The highest order goal in the first step is to achieve a homogeneous dose distribution of the prescribed dose in the tumour. In subsequent steps the dose to organs at risk (OARs) is minimized dependent upon their clinical priority, whereby the results of previous steps are turned into hard constraints. The large number of degrees of freedom through the additional energy modulation of protons enables a better protection of OARs under the perpetuation of the prescribed dose in the planning target volume (PTV). The solution space of subsequent optimization steps can be extended by introducing a slip factor. This slip factor allows a slight deterioration of the homogeneity in the PTV compared to previous steps and entails much better results in IMRT planning. To investigate the relevance and necessity of the slip factor in IMPT, prioritized optimization with various slip factors is applied to a clinical patient case with a head and neck tumour. It emerges that in IMPT
the slip factor has much less impact than in IMRT through the great number of degrees of freedom. Hence, prioritized optimization is particularly well suited for proton therapy planning.