Purpose: To compare commercially-available biologically-based and physically-based IMRT treatment planning systems.

Method and Materials: For representative cases of various anatomic sites, four IMRT plans were generated for each case. Two plans used physical optimization only (pIMRT): CMS Xio and Philips Pinnacle physical optimization (Pinn_Phy). Two other plans included biological optimization (bIMRT): CMS Monaco and Pinnacle’s combined biological optimization (Pinn_bio). For a given case, the same CT images and structures were used for all four plans. The numbers of beams and beam orientations were the same. The dose-volume-histogram (DVH), mean dose, minimum and maximum doses, $V_x$ (the percent volume receiving at least x dose), heterogeneity index (HI), equivalent uniform doses (EUD), and an EUD-based plan ranking index ($f_{EUD}$) were used to compare these IMRT plans. The greater $f_{EUD}$ values suggest superior plans.

Results: For all the cases studied, the four IMRT plans had acceptable target coverage and organs-at-risk (OAR) sparing. The bIMRT plans, however, led to improved OAR sparing as indicated by DVHs and EUDs. For a prostate case, the mean rectum doses for the four plans were 29.6 Gy (Xio), 24.1 Gy (Monaco), 27.9 Gy (Pinn_phy), 25.0 Gy (Pinn_bio), while the target coverage was consistent within 3.4% (ranged from 96.1% for Xio to 99.5% for Pinn_phy), the target EUDs were comparable (within 2.5%, between 76.1 Gy for Xio to 78.0 Gy for Monaco). The $f_{EUD}$s were calculated to be 0.26 (XIO), 0.31 (Monaco), 0.27 (Pinn_phy), 0.29 (Pinn_bio), indicating that bIMRTs are generally better than the pIMRTs.

Conclusion: Unlike physical optimization, biological optimization utilizes biological quantities that can work in the entire dose range in non-linear proportional fashion. The biological optimization can generate plans with equivalent target coverage but with improved critical structure sparing as compared to the physical optimization.

Conflict of Interest (only if applicable):