Purpose:
Traditionally, the planning task for radiotherapy offers the human planner little direct spatial control of the dose distribution. Dose painting methods exist, but they typically suffer from side effects, such as uncontrolled spilling of dose. We developed a tool that allows for local three-dimensional isodose surface manipulation which avoids this problem by employing constrained optimization and inverse planning.

Methods:
In our approach, the planner operates directly on the three-dimensional dose distribution, e.g., selecting areas to be covered with a certain iso-dose surface. The underlying mathematical model implementing constrained inverse planning prevents dose from shifting into areas that are not explicitly selected. To move towards a desired clinical goal, e.g., coverage of the target, the planner directly controls where to operate trade-offs. First, a local objective is set graphically. Second, the potential trade-offs are visualized. Third, the planner selects where to relax constraints. Notably, the relaxation steps imply quick re-optimization in an interactive manner.
We studied the use of the tool for a clinical case, where initially tight bounds on critical structures prevent sufficient target coverage. The dose bounds are then relaxed in specific areas, i.e., shaping the isodose surfaces in a controlled way.

Results
Our experiments show that local isodose manipulation is possible, with little to no dose shifting. Outside the local target area, constraints stay in place and maintain the dose distribution. When the isodose surface is deliberately remodeled to relax constraints the some areas, the coverage of the target area is improved. Initial optimization times are below 40 seconds while re-optimization is done in less than 5 seconds.

Conclusions:
The planning tool implements a novel approach to interactively shape the dose distribution, which would be of particular interest in radiosurgical planning with steep gradients. Our results illustrate that interactive multi-criteria planning in the dose space is feasible.