Purpose: To use point landmarks for rapid, interactive correction of local registration failures caused by significant anatomy changes.

Methods: Our landmark-based method utilizes a semi-automatic procedure. First, we define mismatched areas on reference and test images using contours, which are converted into corresponding sets of landmarks. Second, a program calculates a landmark displacement field, which is used to update an existing displacement field. We use Gaussian radial basis functions (RBF) to create a vector field which exactly interpolates landmark correspondences in the reference and test images. The calculated field is regularized by penalizing large second derivatives. The solution for regularization is stated analytically and yields an efficient computational scheme.

Results: The method was applied to register two pairs of prostate images acquired from patients at different points during treatment. These registrations are challenging due to a significant enlargement of the rectum in one case, and change of bladder filling in the other case. To improve the accuracy of automatic registration, we used an expert-defined contours of the rectum, bladder and prostate as guidance for landmark placement and applied our matching method. As a result, the organs of interest were accurately matched and the regularization assured a diffeomorphic deformation.

Conclusion: We have developed a practical method for correcting or enhancing inadequate automatic registration results for medical images containing large anatomical changes. The method integrates landmark matching and regularization.
Gaussian basis functions are used because they allow an analytical solution, leading to a very efficient computational scheme.