AbstractID: 13090 Title: Quality Assurance (QA) for Deformable Registration: Measures for Evaluating Displacement Fields in Clinical Settings

**Purpose:** Deformable registration is an essential tool in adaptive radiotherapy, as it accounts for anatomical changes during treatment. In recent years, research has focused on proposing different deformable registration algorithms and inter-comparing their results in academic settings. We contend that finding an efficient method for quality assurance of deformable registration in clinical settings is crucial for a global acceptance of adaptive radiotherapy. This study proposes measures derived from computational fluid dynamics as a simple and efficient tool to quantify a displacement field.

**Method:** Our aim was to develop quantitative metrics of registration quality designed for routine use that are algorithm-independent, labor-efficient, and accurately identify errors in a given displacement field. The quality assurance (QA) framework identifies unrealistic anatomical motion through vortexes in the displacement field as detected using the CURL operator and presented as a vortex map overlaid on the original anatomy for a quick identification of problematic regions. Regions of compression/expansion are identified through the determinant of the Jacobian matrix. The warp energy measure is proposed as a global measure of displacement field smoothness.

**Results:** The new evaluation approach was tested on numerous inter and intra patient cases using both single and multi-modality registration algorithms. The CURL operator quantitatively detected errors in the displacement field and identified problematic regions that were invisible to classical voxel-based evaluation methods. Warping emerges above 1 indicated unrealistic displacement fields.

**Conclusions:** The proposed QA framework for deformable image registration provides increased usability and accuracy in detecting unrealistic warping over classical registration assessment methods. It is computationally efficient and provides a valuable platform for the clinical acceptance of adaptive therapy in the future.