Purpose: To introduce a biomechanical constraint into an intensity-based deformable image registration (DIR) method in order to limit nonphysical deformations of skeletal components in the neck region.

Methods: On the reference image, vertebral bodies were segmented. A penalty term, based on the differences in squared inter-voxel distances within each vertebra before and after deformation, was introduced into a routinely used (ITK) intensity-based B-spline alignment algorithm. To assess accuracy, deformable image registration was performed on five pairs of cone-beam CT scans of a head and neck cancer patient. Surface registrations of individual vertebrae established their true displacements (translations and rotations). Orthogonal Procrustes analysis of transformed points within each vertebra established the estimated rotations and translations from the resultant deformation vector fields with and without the penalty term.

Results: The registration errors across all points within the vertebrae with the penalty term (0.2±0.2, 0.2±0.2, 0.3±0.2) [mm] were significantly lower than without (2.8±2.6, 3.2±2.9, 2.8±3.0) [mm], indicating that employing the penalty term successfully restricted local deformation in the region of the cervical vertebrae. The errors of the bulk translations and rotations of individual vertebrae were similarly reduced: (0.7±0.4, 0.9±0.7, 0.5±0.4) to (0.1±0.1, 0.1±0.1, 0.2±0.2) [mm] for translation and (3.4±2.6, 1.3±1.1, 1.4±1.1) to (0.7±0.6, 0.3±0.2, 0.3±0.3) [°] for rotation.

Conclusions: The introduction of a local rigidity penalty improved the integrity of skeletal alignment under neck articulation. Further research will explore biomechanical penalties that will more realistically constrain the changes of other tissues (e.g. muscles) in the neck region.

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